The Holocene Archaeology and Palaeoecology of Northeastern Tasmania, Australia

by

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

UNIVERSITY OF TASMANIA
HOBART

December 1991

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university and contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text.

IAN THOMAS

ABSTRACT

An analysis of ethnohistorical sources, modern pollen rain, fossil pollen, contemporary vegetation patterns and the distribution of Aboriginal sites enabled a model of Holocene vegetation change in northeastern Tasmania to be developed. The influential hypotheses of fire stick farming and ecological drift are shown to be generally resiliant and worthwhile but in need of adjustment to account for local and regional variations in environmental and cultural practices. A more recent theory in which Aborigines were forced out of southwestern Tasmania at about 12,000 BP by expanding Holocene forests is re-evaluated in the light of evidence which suggests that forests may have developed earlier than previously thought and that Aborigines, forests and fire in Tasmania have had a long co-existence.

A study of all available Tasmanian ethnohistorical sources pertaining to Aboriginal burning of vegetation revealed a pattern of Aboriginal land use from *ca.* 1773 - 1830 which was more complex than previously thought. In northeastern Tasmania, fire was used in a fashion corresponding to the position of sites along an altitudinal gradient from sea level to 1,500m.

A close reading of the available information reveals that present day ecologists and archaeologists often use ethnohistorical references concerning fire in an uncritical manner. A number of crucial historical incidents in which European mariners sighted devastating fires and dense clouds of smoke are reinterpreted as defensive responses by Aborigines to the presence of Europeans, rather than a normal *modus operandi.* These sources cannot therefore be taken to indicate a traditional use of fire.

Historical sources suggest that Aboriginal life in Tasmania revolved around a complete familiarity with forests. Previous research has highlighted the importance of coastlines for settlement, and that forests, especially wet forests, were inimical to Aboriginal settlement objectives. The analysis emphasises that Aboriginal fire regimes differed across the state according to social perogatives as well as to environmental determinants.

Archaeological surveys and limited excavations were conducted in order to date the commencement of Aboriginal site formation in coastal, inland and mountainous environments. It was discovered that coastal sites in the northeast date to the last 3,000 years of the Holocene. Sites which are located on the margins of lunette fringed lagoons and shallow freshwater lagoons date from about 6,000 years BP to *ca.* 8,500 BP. In the highlands of the northeast, rockshelters are dated to 1,600 years BP.

Prior to an investigation of fossil pollen to determine vegetation changes over the same

range of times, Tauber pollen traps were placed in a selection of representative vegetation communities in the northeast. The results of this study were used to form analogues against which fossil pollen assemblages were compared. In this way it was possible to reconstruct past vegetation associations with a degree of precision not available by the analysis of fossil pollen alone.

Analyses from a coastal lagoon, an inland marsh, two highland bogs and sediment from an Aboriginal site revealed patterns of vegetation change which drew attention to the effects of Aboriginal burning on the landscape.

A 10,500 year old pollen sequence from the coastal lagoon suggested that the vegetation had changed from a pre-Holocene Poaceae dominated steppe complex, to a *Eucalyptus* forest, and finally to an *Allocasuarina* dominated coastal heathland. The final change to heathland occurred at 6,500 years BP. This date is synchronous with the stabilization of sea levels, increases in inorganic input into lagoon sediments, major peaks in *Typha* spp. pollen and the commencement of Aboriginal occupation on lagoon margins. The present day structure of the vegetation is likely to have resulted from a complex interaction between environmental variables and the burning of forests and heathlands by Aborigines.

Eucalyptus forests surrounding a small closed basin at 80 m altitude in the hinterland have existed virtually unchanged for 4,000 years. Further evidence suggests that these forests may have been extant for at least 13,000 years. Increases in regional wet forest and rainforest pollen taxa point to a change in climate at about 3,500 BP which allowed an expansion of wet forest communities. This is supported by increases in local spore percentages which show that the hydrology of the basin changed to allow the development of a *Sphagnum* bog. The humid phase is thought to have continued for a maximum of about 1,000 years, after which time drier climates prevailed. It is possible that decreases in temperature rather than increases in precipitation were responsible for the perturbation. Throughout the 4,000 year long sequence, high levels of carbonized particles indicates that burning by Aborigines was continuous.

Pollen from a short core obtained from a highland bog surrounded by wet eucalypt and rainforest communities, showed a transition from grassland or grassy woodland to wet forest at about 3,000 BP. It is thought that burning of local forests by Aborigines altered the local hydrology sufficiently to create a mire at about 5,500 years BP. Continued burning maintained an open grassy formation for 2,000 years. The abandonment of the site by Aborigines as a place for frequent burning led to the development of forests in which wet forest taxa predominated and where fires were less frequent but more intense.

Sediment from a highland buttongrass moor adjacent to a 1,600 year old Aboriginal site was analysed for pollen. The sequence displays little vegetation change since the onset of organic accumulation 1,600 years ago. Synchrony between the two dates provides the first direct palaeoecological evidence that Aboriginal burning practices were involved in the creation and maintainence of buttongrass moorlands in Tasmania.

The pollen and archaeological evidence, in combination with the analysis of ethnohistorical sources demonstrate that forests and Aborigines have a long history of coexistence. Aboriginal fires had major effects on delicately poised coastal ecosystems and lesser effects on inland lowland forests. In elevated locations with high rainfall and fertile soil, fire was employed to produce small treeless patches. Burning on poorly drained infertile sites is thought to have initiated hydrological changes which resulted in the creation of limited areas of sedgeland.

ACKNOWLEDGEMENTS

Firstly, the advice and encouragement of my supervisor, Jamie Kirkpatrick is gratefuly acknowledged. Additional support was generously provided by Guus van de Geer.

Sincere thanks are also due to: Geoff Hope, Albert Goede, Eric Colhoun, Frank Podger, Michael Macphail, Fiona Coates, Phil Cullen, Bob Gittins and Bob Ellis who were all sources of much worthwhile discussion during the course of the work.

The Tasmanian Aboriginal Centre gave permission to investigate Aboriginal sites in the study area. Steve Brown and Anne Mc Connell also provided assistance with various aspects of the project. The staff of the Repatriation Hospital X-Ray Unit, Hobart allowed the use of their equipment for core analysis.

Some of the data used in this thesis was collected for the Tasmanian Department of Parks, Wildlife and Heritage and the Tasmanian Forestry Commission. Permission to use that data is gratefully acknowledged.

Valuable contributions in the field were made by Ronnie Summers, Dyan Shaw, Darryl West and John Scotney; and in the technical and administative spheres, by Kate Charlesworth, Kerrie Green and Yvette Cross. Denis Charlesworth cheerfully and carefully prepared the pollen samples. Maps were reproduced with the permission of the Tasmanian Forestry Commission and the Tasmanian Department of Planning and Environment.

Finally, without the inspirational work of J. Muir, the task would never have been completed.

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Chapter 1

The nature of the investigation

1.1 Introduction

Tasmania, more than any other state of Australia, has been blessed with an abundance of organic deposits suitable for palaeoecological investigations. Equally so, the island is endowed with a diverse range of Aboriginal sites spanning a time period of at least 35,000 years, all of which provide ideal opportunities for interdisciplinary studies involving ecology, history, archaeology and geomorphology.

The island of Tasmania has long been regarded as a controlled situation in which hypotheses can be generated without the complications generally found on a continental sized land mass. In particular, the origin and subsequent development of Tasmanian Aboriginal societies has proceeded on the reasonable assumption that the culture has evolved in isolation from mainland Australia, and thus, forms the basis for a cultural history unaffected by mainstream Australian developments over the past 10,000 years. This degree of isolation is thought to be unparalleled in the known history of the world and emphasizes the unique perspective that Tasmanian cultural studies offer to other societies where migration and intercultural exchange form the entire basis of knowledge.

Just as the Tasmanian culture is unique, so too is the Tasmanian biota. A high degree of endemism is evident in both plants and animals and this fact allows natural scientists to plot original and often idiosyncratic courses through a landscape which is both familiar and disconcertingly alien to mainland Australian eyes.

Despite the isolation imposed over the whole of the Holocene, an almost fathomless 25,000 years existed prior to the rise of Bass Strait, during which time Tasmania was as much a part of continental developments as was Western Australia or Cape York. The period which marked the sundering of Bass Strait has been rightly viewed as a time of great importance in terms of effects on landscape and culture. Recent studies have shown that the northern Tasmanian land mass may still be equilibrating from the shock of post-glacial sea level rises and the effects of mantle hot spot processes (Murray-Wallace and Belperio, 1991) and if this is the case, it is possible that the fauna and flora might also be in a state of fundamental change. For example, the life spans of some Tasmanian forest trees can be measured in thousands of years and thus it is entirely probable that certain populations of these long lived plants, along with their soils and attendant fauna, are still dealing with post-glacial stresses.

How did biotic systems react to the severing of land bridges and the development of climates which seemed at first to promise a return to the warmer conditions of the Tertiary? How did plant communities respond when moisture was slowly withdrawn about 5,000 years ago? During this period of natural change, what were the effects of people who found themselves confined to an island? Consider the effects of people on what may still be an inherently unstable system. What changes did the Tasmanians effect and over what timescale? What changes were inevitable and which were a matter of choice? These are the general areas of fundamental interest which prompted this thesis.

1.2 Rationale

The study area in northeastern Tasmania (see Figure 1.1) was chosen for a number of reasons. Chief amongst these was that prior to this investigation the place was almost totally bereft of systematically acquired palynological and archaeological records. Two unpublished cores from the slopes of Ben Lomond (Noble, 1981) and two peat samples from inland dune systems (Bowden, 1981) constituted the entire late Pleistocene and Holocene pollen inventory. Similarly, the archaeological record was under-represented with regard to the rest of the state (Cosgrove, 1985; Kee,1987).

This thesis reports original pollen and radio-carbon evidence obtained from sediment cores, soil samples and 19 Tauber pollen traps. New archaeological evidence presented includes thermoluminescence and radio-carbon dates from excavated Aboriginal sites. Additional archaeological survey data is provided from forests, moors and heathlands in the north and northwest of the state in order to provide comparisons with environmentally similar areas in the northeast.

Recurring themes in this dissertation are the study of the effects of Aboriginal settlement on vegetation patterns, especially through the use of fire, and the role of forests in Tasmanian Aboriginal life. This thesis provides a number of case studies based on Holocene pollen and archaeological data from the north of the state. The case studies are used to develop hypotheses concerning vegetation change. Modern pollen rain data collected over a period of 3 years allowed modern analogs to be used for the interpretation of fossil pollen assemblages (*sensu* Dodson and Myers, 1986; Kodela, 1990; Macphail, 1976; Prentice, 1980). A critical examination of all commonly available Tasmanian ethnographic records forms a base of information which helps to interpret the pollen records and which clarifies certain misconceptions concerning the Aboriginal use of fire. Radio-carbon dates obtained from sediment cores and from adjacent Aboriginal sites are compared in order to tighten arguments to a local scale. Finally, the hypotheses are used to examine statements concerning Aborigines, fire and forests developed by researchers working in other parts of the state.

A compelling and valuable feature of the northeast is the variable nature of the

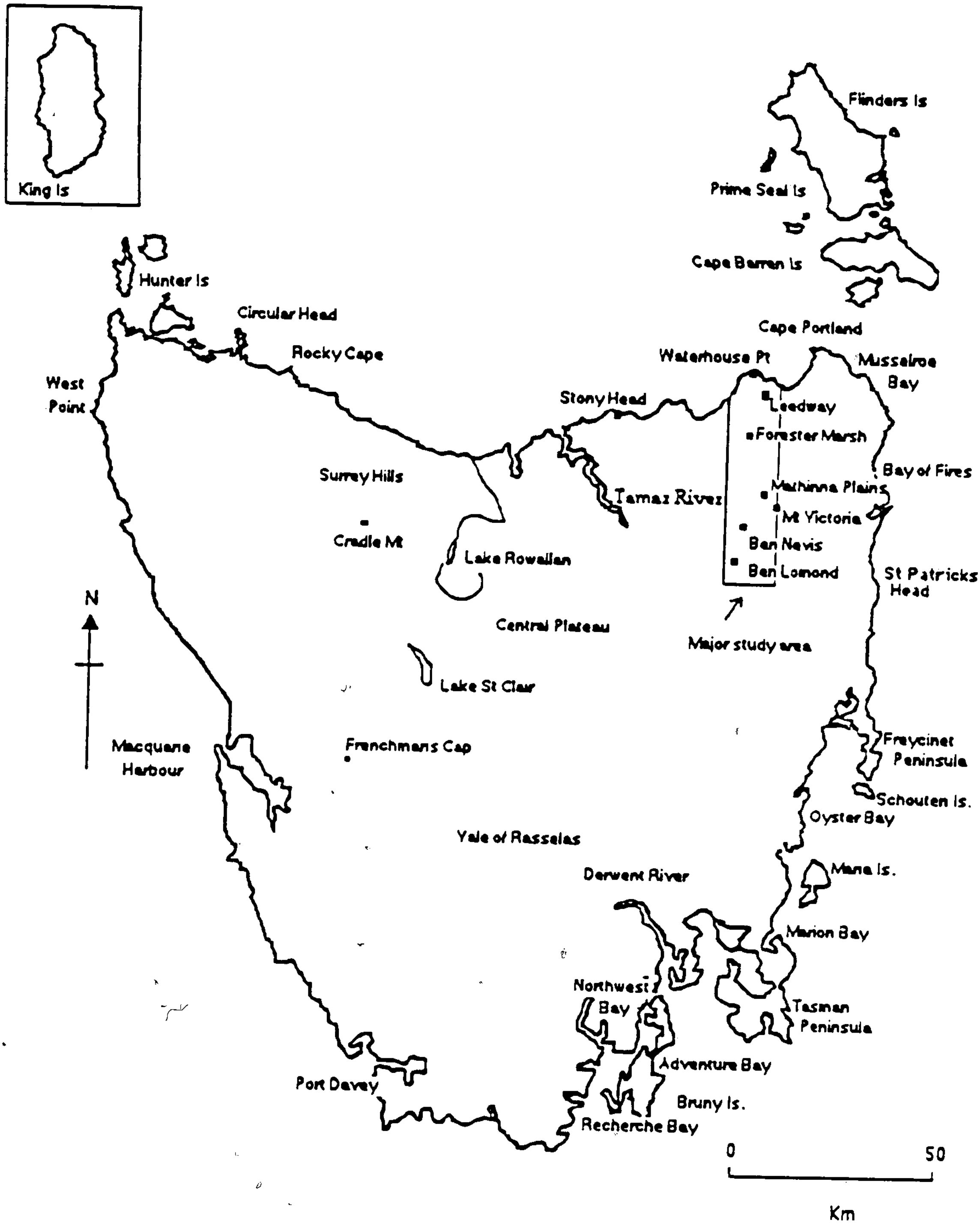


Figure 1.1 Map of Tasmania showing the major study area and places named in the text.

environment which encompasses high and low energy shorelines, alpine summits, extensive tracts of forests, heathlands and open grassy plains. In many other parts of the state, various combinations of dense vegetation, high altitude, inaccessibility and foul weather make the sampling of Aboriginal sites a daunting task. The northeast, in contrast, provides a highly accessible and varied environment. By utilizing palaeoenvironmental data collected from many locations within this varied landscape it is thought to be possible to develop hypotheses which might explain aspects of present day environmental and archaeological complexities, as well as providing a high degree of verisimilitude in regard to Holocene reconstructions.

The *bête noir* of many archaeological projects is a lack of relevant geomorphological and biological data. This is not to say that data are rare. On the contrary, a brief perusal of the major journals demonstrates a wealth of available information. The problem, in Tasmania at least, is that ecological, palaeoenvironmental and archaeological data are usually collected by independent researchers for use at different interpretive scales.

This dysfunction is related to the problems identified by Macphail (1981) and Head (1983) for pollen data. In this instance the problem of marrying disparate types and scales of evidence is magnified by the reluctance of granting bodies and researchers to invest large amounts of time in the analysis of specific local records. Unfortunately, the things which are of interest to the archaeologist may have limited appeal to the palaeoecologist who may be more interested in long term continuous climatic or evolutionary sequences. In spite of these problems, local vegetation and geomorphological dynamics are seen as the key to understanding many aspects of the vegetation and archaeological records.

An attraction of conducting research in the northeast is the background geomorphological framework developed by others for the coastal lowlands (Bowden, 1981, 1983; Bowden and Colhoun, 1984). A number of hypotheses developed by these researchers are testable with recourse to standard palynological and archaeological methods. For example, the direct dating of undated sand sheets and linear dunes should be possible by radio-carbon dating of charcoal found in Aboriginal campsites. Also, periods of dune building or phases of land surface instability should result in variations in the organic / non-organic ratio of sediments accumulating in marshes located in dune swales.

The significance of Bowden's work is that it has served to maintain a conservative approach to landscape analysis. By modelling northern Tasmanian dune building episodes on the Willandra lakes sequences of Bowler *et al.*, (1976), Bowden has essentially polarized periods of landscape instability into two climatically driven compartments *viz.* glacial and interglacial. This pattern sits comfortably with pollen evidence from western Tasmania which continues to reiterate Macphail's (1976,1979,1980) sequence in which glacial age steppes and grasslands were transformed into forests following global warming *ca* 13,000 BP.

This well accepted megasequence of late Last Glacial landscape instability followed by Holocene stability pays scant attention to Holocene climatic shifts and even less attention to vegetation change caused by Aboriginal burning practices. With very few exceptions (see Macphail, 1984), pollen based reconstructions have reinforced the notion that vegetation change has been dominated by climatic rather than cultural influences (Macphail, 1979, 1980). This thesis contends that except in unusual circumstances, pollen based reconstructions drawn from sites located in large areas of homogeneous vegetation, or from alpine mountain tops, will invariably fail to shed light on the effects of Aboriginal burning.

This thesis takes the perspective that the foregoing general model is inadequate for reconstructions based on local rather than regional scales, and is quite possibly misleading for archaeologists and ecologists whose interests are in relationships between processes at all scales, rather than simple descriptions of vegetation change. Arguments are developed which stress the interdependence of archaeological and vegetation information for Holocene timescales and spatial patterns. By selecting suitably located and sized pollen sites it is possible to highlight local developments with little loss of regionally significant information.

1.3 Philosophical underpinnings

The work in this thesis is unashamedly empirical and inductivist in parts, critically rationalist in others and where necessary, deductive. The lack of commitment to a single epistemological pathway is considered to be a truer reflection of how science operates than the formal strictures meted out by Popper (1972), Kuhn (1970), Lakatos (1963), and others. In a real sense the underlying philosophy is based on freedom of imagination constrained only by self-imposed methodological rules derived from an appreciation of what are generally considered to be valid and progressive techniques . This is similar to Feyerabend's (1975:28) pluralistic dictum of 'anything goes', but without the theatricality.

This pragmatic approach to science is deliberate and stems from the conviction that answers to questions are not usually revelational, despite Archemides well publicized experience. Answers, like fundamental questions, are mostly arrived at after various combinations of hard work, systematic measurement, misadventure, mistake, good luck, bad luck and inspiration. More often than not, a relevant question is one which addresses a gap in present knowledge rather than a completely new direction and it is at the boundaries of disciplines that advances will be made.

Inter-disciplinary science, by its very nature, is a boundary enterprise and usually accommodates the different methodologies and different world views of participant researchers. In contrast to single focus science projects, inter-disciplinary research is often driven by group enthusiasms and directions. Thus, interdisciplinary research has the advantage of being able to use as many different epistemological pathways as seem appropriate.

The following types of information are used in this thesis to develop arguments which demonstrate the interdependence of cultural and natural reconstructions of the past.

1.4 Ethnohistory

From the outset, it is claimed that no genuine ethnographies exist for Tasmania. The best observations, made by the French expeditions to the southern oceans between 1773 and 1804, are ethnohistorical in nature. The distinction made is that ethnography is the proper study of traditional societies by anthropologists familiar with the social / ritual life of a group, whereas ethnohistorical records are sets of observations, made by curious or untrained observers, of activities in isolation from the ritual and secular fabric of a group.

Ironically, it is possible that *ad hoc* ethnohistorical observations may in certain circumstances carry more weight than considered ethnographies. This stems from the certainty that ethnographers often fail "to grasp meanings that are, for native participants in a community, the stuff of everyday life and talk" (Keesing, 1989:459). In other words, the ethnographer can fail to distinguish or categorize the importance of certain events or structures. Furthermore, ethnographies are invariably and inevitably translated from the original language into 'doubly mediated' interpretations through the ethnographers personal opinions and preconceptions (Rabinow in Keesing,1989). In contrast, the ingenuous note, the private letter or the bored tone of an official signal may offer insights into the effects of Aboriginal life which may have been overlooked by scholarly judgement.

Ethnohistorical accounts are a commonly used research tool in Tasmanian anthropological studies. Throughout the very earliest period of European expansionism in the South Pacific, sea-captains utilized the journals, notes and log books of previous explorers. Many of these early accounts contain vivid descriptions of indigenes, as well as the more usual charts and sea patterns. This data set constitutes the earliest known ethnohistorical data in southeastern Australia.

In the latter part of the 19th century, a growing interest in anthropology, archaeology and social theory resulted in a proliferation of learned societies which engendered a new spirit into popular science and an increasing thirst for exotica. In Tasmania, much new information came to light through the observations of James Backhouse (1843), George Washington Walker (1898) and Ling Roth (1899). However, these achievements are more than balanced by the darker side of science - the mutilation of Aboriginal corpses, the denial and disregard of humanity and the sheer arrogance of scientific judgement.

Whereas social relationships and demographic considerations were much considered by early recorders and observers, less attention was paid to relationships between Aborigines and environment. As always, the journals of the French expeditions and G.A. Robinson have provided the best data regarding the use of fire, but as will be shown in Chapter 2, some of this information has been misused by subsequent researchers.

A number of recent studies have provided valuable references to historical passages concerning firing of the bush but few present critical evaluations of the data (Brown, 1986; Cosgrove, 1984, 1990; Kee 1990) and none have reached past the high standards set by Jones (1971a, 1974) and Plomley (1966). Nevertheless it remains disappointing that despite the numerous references to the Aboriginal use of fire, so few acute observations concerning the effects of Aboriginal burning were ever recorded, especially for inland locations (Thomas, 1984).

Bowman & Brown (1986:168) concluded that further examination of the historical record is unlikely to provide a means to elucidate past fire - vegetation interactions. This somewhat dismissive conclusion is a response to Stockton's (1982) summary of G. A. Robinson's records (Plomley, 1966) rather than a considered appraisal of all the available data. It would seem prudent to hold judgement on the issue until work is published which presents a full range of ethnohistoric references to fire and which directly addresses the problem of the use of fire and vegetation change (for a partial solution see Chapters 2, 3, 4 and 9).

The importance of baseline information on Aboriginal burning practices is not in question, although there is dispute over the most efficient way to recover such information. In Tasmania, of all the various scientific methods that might or have been employed, no technique stands out as having provided a definitive answer to the question of timing, extent, intensities or frequencies of Aboriginal burning. In fact, as Bowman & Brown (1986) point out, the results of many of these studies are contradictory.

This hardly seems surprising considering the length of time that people have occupied Tasmania and the consequent likelihood of the development of countless social inventions interacting in tandem with numerous environmental changes. The simplistic hope that a few simple fire regimes were in use over even the past 1,000 years of Aboriginal history ignores longer time scales as well as the inventiveness and needs of people, and provides an ecological complement to the simplification hypothesis as developed by Jones (1977). In that celebrated exposition, Jones came to the conclusion that the material culture of Tasmanian Aborigines was the simplest in the world and that the cultural isolation imposed on the Tasmanians by the rising of Bass Strait resulted in a progressive depauperization and simplification of not only their material world but also their intellectual world.

To take an overly simplistic position on the question of the effects of Aboriginal burning of the bush, and to demand agreement from different disciplines incorporating disparate scales of observation, is to ignore the realities of environmental and cultural complexity. For example, it would be altogether *more* remarkable and *less* believable if burning patterns reconstructed for the treeless high plateau of central Tasmania (Thomas, 1984) should *agree* with patterns deduced for the forests and woodlands of the Midland Valley (Fensham, 1989), the moorlands of western Tasmania (Jackson, 1978; Jarman *et al.*, 1988a, 1988b), or even more amazingly, the coastal eucalypt forests of the Northern Territory (see Bowman & Brown, 1986).

There is a temptation to overestimate the importance of certain records. In particular the journals and papers of G. A. Robinson (Plomley,1966) have been used in numerous accounts of Aboriginal life (Jones, 1971a, 1974; Cosgrove, 1984, 1990; Thomas, 1984, 1990; Kee, 1990; Brown, 1986; Clarke, 1983b; Stockton, 1982). Less often commented upon but far superior as genuine indicators of past Aboriginal lifeways are the notes and journals of the early mariners (Chapters 2 and 3). Especially good sources and discussions of these observations are to be had in Plomley (1983), Cornell (1974) and Jones (1988).

The gazeteer approach adopted by Brown (1986), Cosgrove (1984, 1990) and Kee (1990) lays too great an emphasis on the relevance of Robinson's testimony. The unfortunate fact is that by the time of Robinson's Mission the social structure, traditions and demographics of Aboriginal society had been totally disrupted and changed (Jones, 1971b, 1974, 1988). Comments from Aboriginal informants regarding place names, personal details, relationships and in some cases motivations are unique and invaluable. However, Robinson was not primarily interested in processes or cause and effect relationships. His prime responsibility was to secure the free Aborigines and the best way of performing that task was to ask where, not how or why.

1.5 Archaeology

The main archaeological challenge offered by the ethnohistoric data is to relate 18th century Aboriginal group size and population estimates to contemporary Aboriginal sites parameters in an attempt to understand the functional and spatial dimensions of the archaeological record. Little interest was expressed by either the French or the British in the possibility that Aborigines may have manipulated the environment to suit their own ends.

The procurement of thousands of Aboriginal artefacts from all parts of the island became fashionable towards the end of the century and today these dusty collections serve more to remind us of the peripatetic nature of white Tasmania's wealthy class than the actual extent of Aboriginal occupation. Nevertheless, the coupling of known ethnographic sightings of Aborigines, with the provenances of artefacts housed in museums, proved to be a theoretical pivot upon which much of the subsequent direction of the Aboriginal / ecological debate turned (Hiatt, 1967; Jones, 1971a; Plomley,1966).

By the 1920's, Tasmanian Aborigines had been relegated to life's garbage bin; no longer an example of the exalted state. Anthropologists proclaimed the race as backward. Scientists argued whether or not Tasmanian skulls displayed tendencies towards criminality or simply lack of intelligence. A letter from the New Zealand Anthropologist, F. L. Mouldey to H. H. Scott,director of the Queen Victoria Museum in Launceston states in relation to a Tasmanian Aboriginal skull "I was at once struck with the development and size of the cranium and was to say the least disappointed as I expected to find an undersized skull, or rather one suitable for such a race of people who manifested such a small degree of intelligence --- and my personal opinion is that it belonged to a criminal type of European" (Letter, Mouldey to Scott,1912. Scott papers, Queen Victoria. Museum, Launceston).

These antiquated themes continued to be of interest until Jones (1966) excavated at Rocky Cape and ushered in a new and modern phase of archaeology. The basis of the investigation was no longer focussed on isolated 'cultural developments', but on relationships. Environment took the center stage, and has held the spotlight ever since. All major studies throughout the 1970's and 1980's have been concerned with the relationships between people and the environment (Bowdler, 1984; Jones, 1966, 1977; Lourandos, 1970, 1977, 1983a, 1983b; Vanderwal and Horton, 1984; Cosgrove *et al.*, 1990). It is in the spirit of this approach that this thesis is structured.

1.6 Pollen studies

The use of pollen in the reconstruction of Holocene environments has a short history in Tasmania (Macphail, 1976). Pollen studies have traditionally concerned themselves with climatic reconstructions based on the percentage representation of pollen taxa (eg. Singh *et al.*, 1981; Kershaw, 1981; Dodson, 1974; Macphail, 1976, 1979; Colhoun, 1985b; Colhoun & van de Geer, 1986). This tradition is well established in Europe (see extensive references in Birks & Birks, 1980) and North America (see Huntley & Webb, 1988) and is based chiefly on the assumptions that fossil pollen reflects the vegetation present at a particular time and that specific taxa have specific climatic requirements. The development of pollen sequences for climatic purposes developed along with geomorphological studies concerned with glacial cycles. In high latitudes of the northern hemisphere the marriage of both lines of evidence has proven particularly fruitful.

In Australia, the general absence of large scale glacial activity during the Pleistocene has meant that studies of climatic change have had to concentrate on far more subtle indicators than glacial deposits. Thus, Bowler *et al.* (1976) and Bowler (1976, 1983) were able to deduce glacial and interglacial stages from hydrological and geomorphological evidence in inland western New South Wales some 1,000 km from the nearest glacial deposits.

Throughout the Pliocene and Pleistocene, Tasmania has been subjected to direct glacial activity. In a parallel to European developments, a close check has thus been available to both glacial geomorphologists and palynologists. In general the higher rainfall and lower temperature experienced in Tasmania have provided a wealth of sites suitable for palaeoecological research and in this respect the central, southern and western parts of the state have provided most pollen records.

The northeast of the state offers no glacial deposits to provide a relative chronology. Rather, a sequence of dunes and soil development provides the long term geomorphological framework. Few records exist of the drier eastern of northeastern regions.

In spite of these substantial difficulties, cores were obtained from a number of localities in the northeast. Pollen extracted from the cores was analysed with the aid of a knowledge of modern pollen dynamics derived from an extensive pollen trapping programme.

The combination of pollen and historical studies allows a greater depth of understanding of landscape changes than is available by any one line of inquiry. The major effect of people in Tasmania over the past 30,000 years is assumed to have been changes wrought by burning of forests. It is at this point that pollen studies can combine with archaeological investigations to provide insights not otherwise available.

1.7 Research Programme

The main aim of this thesis is to reconstruct Holocene vegetation patterns in northeastern Tasmania in order to examine relationships between Aborigines and fire and Aborigines and forests. Previous archaeological studies (especially Jones, 1969, 1971a; Cosgrove, 1990) indicated that relationships existed, but little data existed as to the variety or intensity of cultural practices. Colhoun (1978), Sigleo and Colhoun (1982) and Goede (1973) argued that Aboriginal burning of the Tasmanian bush resulted in episodes of localized landscape instability, but could not provide a convincing demonstration of vegetation change to accompany their geomorphological evidence.

Two theories have dominated the study of Aboriginal / vegetation dynamics to such an extent that they have achieved paradigmatic status. The notion of 'ecological drift' developed by Jackson (1965, 1968) included the effects of Aboriginal burning on vegetation as an integral part of plant community distributions and dynamics. Similarly, Jones' (1969) theory of 'firestick farming' emphasised that vegetation patterns cannot be disassociated from the effects of people. Aspects of both of these theories must be examined in any exposition of late Pleistocene or Holocene palaeoecology.

The following questions concerning Aborigines and environment are examined in the chapters to follow by using new data obtained from northeastern Tasmania and by re-examining existing archaeological and ethnohistorical data from other parts of the state.

A) Does the ethnographic record provide useful information in relation to settlement patterns and the use of fire by Tasmanian Aborigines?

B) What are the links between Holocene vegetation distributions and Aboriginal settlement patterns in northeastern Tasmania?

C) What relationships exist between Holocene vegetation distributions and Aboriginal settlement patterns in other parts of Tasmania?

D) What relationships exist between Pleistocene vegetation distributions and Aboriginal settlement patterns in northeastern Tasmania.

E) What relationships exist between Pleistocene vegetation distributions and Aboriginal settlement patterns in other parts of Tasmania

F) What support is there for the theories of ecological drift and firestick farming in the ethnographic, archaeological and palaeoecological evidence from Tasmania

The following two chapters examine these issues by following a line of reasoning which examines a wide body of ethnohistorical material, much of it never published or discussed, in order to place the above questions in a reliable framework concerning what is known about Aboriginal settlement and burning practices.

Chapter 2

Ethnohistoric sources relating to the use of fire by Aborigines in northeastern Tasmania

2.1 Introduction

The use of ethnohistorical data has been argued by an historian to provide a more useful amount of information than archaeological research (Plomley, 1987). This view conveniently ignores a large number of advances made by archaeologists that would not have occurred if research was dominated by library based studies. Ethnohistoric Information and archaeological data are not incommensurable; in fact it would be difficult to imagine any other two lines of evidence which are more complementary.

Both can provide broad sweeps and intimate glimpses. The delicate watercolours painted by Petite for the Baudin expedition (Jones, 1988) or the mythological stories recorded by Robinson (Plomley, 1966) are easily matched by the breathtaking sweep of 30,000 years of physical evidence uncovered from a single square metre (Cosgrove, 1989), or the blood red image of a human hand extended in recognition from the last ice age (Loy *et al.*, 1989).

Ethnohistoric data has been crucial in the interpretation of Tasmanian Aboriginal history. The evidence provided by European observers regarding Aboriginal customs prior to *ca* 1850 is regarded, with some justification, as the only evidence which can provide a vital picture of life in Tasmania prior to the white invasion.

The work of H. Ling Roth in particular, is the example *par excellence* of ethnohistoric documentation (Roth,1899). More recent work has broadened the scope by examining in detail the diaries of G. A. Robinson, the so called 'Conciliator', (Plomley, 1966; Jones, 1971, 1974) and the journals of the French maritime expeditions (Cornell, 1974; Labillardiere, 1800; Plomley, 1984; Jones,1974,1988).

Plomley (1987:9) has divided the entire Tasmanian ethnohistorical record into '--- the pre-settlement marine explorers and those of the settlers.' Jones (1971, 1974) had earlier devised a similar scheme in which the maritime explorers, early colonial accounts and records from 1803 - 1834, accounts of Aborigines on the government settlements and the field journals of G. A. Robinson were used as working categories.

It is clear that the early British and French expeditions were best placed to observe pre-settlement population levels and traditional customs. These accounts unfortunately suffer from a narrow coastal perspective, and generally short periods of interaction with the Aborigines. A factor which has probably been underestimated by ethnographic commentators is the effect that the maritime intrusions had on the behaviour of Aborigines. The imposition of a totally alien set of circumstances onto a traditional society must have had profound repercussions in behavioral terms. One such effect may have been a deliberate alteration in burning regimes in order to cope with the dramatically altered situation. This possibility is explored in detail below.

G. A. Robinson was the one European who managed to understand the locational determinants of Aboriginal settlement patterns and day to day subsistence techniques. He was also unique in learning the basics of a number of Aboriginal languages. The people with whom he travelled included important law makers with the authority to relate stories and to explain legends. On this basis, despite the late date, Robinson's evidence is clearly more useful than the maritime records for observations concerning the effects of fire in inland locations.

2.2 The importance of ethnohistoric sources in relation to Tasmanian ecological and archaeological studies

The need for a wide ranging and comprehensive discussion is manifest in the wide use of archaeological or ethnographic evidence by archaeologists, ecologists and palaeoecologists (for example, Bowdler, 1984; Bowman and Jackson, 1982; Bowman and Brown, 1986; Brown & Bayly-Stark, 1979; Brown, S.,1986; Colhoun, 1978; Cosgrove, 1984; Cosgrove, 1990; Cosgrove *et al.*, 1990; Cullen, 1988; Ellis, 1964; Ellis, 1985; Ellis and Thomas, 1988; Fencham, 1989; Gellie, 1980; Gilbert, 1959; Horton, 1979, Horton, 1982; Jackson, 1965, 1973; Jarman *et al.*,, 1988a; Kee, 1990; Lourandos, 1983a; Macphail and Colhoun, 1985; Mount, 1979; Jones, 1968,1971,1973, 1984, 1988; Kirkpatrick, 1977; Kirkpatrick *et al.*, 1988; Plomley, 1966, 1983, 1991; Podger *et al.*, 1988; Stockton, 1982; Thomas, 1984).

All of these authors have referred to the effects of Aboriginal burning of vegetation. Many have utilized ethnohistorical observations in order to demonstrate a particular trend or process. In some cases, the ramifications have been far reaching.

Notable in this regard is the work of Jackson (1965, 1968) and Jones (1969). These authors recognized the fundamental truth that it is impossible to speak about the distribution of major plant communities in Tasmania without regard to the effects of Aboriginal fires. The former developed a theory of vegetation dynamics based to a large extent on the assumption that Aborigines burnt large areas of western Tasmania, while the latter took elements of that research and applied them to archaeological and anthropological situations in the development of the influential hypothesis of 'fire-stick farming' (Jones, 1969, 1973).

The basis of Jacksons theory has been subjected to testing by a number of researchers

(Brown and Podger, 1982a; Mount, 1979; Macphail, 1980; Jarman *et al.*, 1988a), and no concerted effort is made to further test the ecological base of that theory from an ethnohistorical perspective, although a number of basic assumptions regarding the Aboriginal use of fire are examined. In contrast, relatively little research has been conducted with the aim of examining the basic historical tenets of 'firestick farming'. That this has never been attempted is a tribute to the usefulness and seductiveness of the theory. The historical base of the theory is examined in chapter 9 with reference to certain ethnohistorical sources referred to in this and the following chapters.

2.3 Methods

A detailed examination is presented of all major records dealing with the Aboriginal use of fire in northeastern Tasmania. In regard to the voluminous journals of G. A. Robinson, only his trip to the northeast is analysed (Plomley, 1966:242-480). Records from other parts of the state are presented in Chapter 3.

The chapter basically follows the classificatory scheme established by Jones (1971, 1974). Rather than provide an unannotated gazeteer or appendix containing short extracts from prime sources (*sensu* Cosgrove, 1984, Brown, 1986; Kee, 1991), this chapter analyses each reference to fire within a critical milieu. Each major transcription is discussed and followed by a summary, from which a reasoned judgement can be made concerning the extract's reliability or applicability to any particular area or time. This scheme, while admittedly somewhat clumsy, allows cultural and vegetation changes to be assessed in a chronological framework, while at the same time, avoiding the common problem of presenting a selection of non-representative passages.

Tribal names are taken from Plomley (1971) and are used whenever the sighting of an Aboriginal group can be located on Plomley's map of the tribes of Tasmania. The use of tribal names, adds dignity to the exercise, as well as serving to emphasise that burning regimes relate as much to local traditions as to environmental conditions. It is thought to be most unlikely that a pan-Tasmanian tradition of fire use existed in which all tribes burnt in the same manner. In this sense, the use of the term 'Aborigines' is reduced to a minimum.

The references for this chapter, and the next, are arranged in chronological order with initial date(s) referring to the actual period of exploration. Publishing and archival details are referred to in the text. The following abbreviations are used: LSD - Lands Survey Department; CSO - Colonial Secretary's Office; HRA - Historical records of Australia; AOT - Archives Office of Tasmania; UTA - University of Tasmania Archives; nd - no date.

It is stressed that the use of the the term 'plain' by early Tasmanian surveyors and explorers does not necessarily indicate a treeless expanse. More often than not, plains were any roughly level area, usually thinly wooded but quiet often forested.

2.4 The early maritime expeditions

Tobias Furneaux: 1773

To Tobias Furneaux, Captain of the 'Adventure' on Cook's 2nd expedition comes the honour of commemorating the act of burning the bush by Tasmanian Aborigines with his naming of the Bay of Fires, on the east coast where: "The country here appears to be thickly inhabited, as there is a continual fire along the shore as we sailed" (Furneaux in Cook, 1777: 114).

In the far north east of the island he wrote that "the land trenches away to the westward, which I believe forms a deep bay, as we saw from the deck, several smokes arising a-back of the islands that lay before it, when we could not see the least signs of land from the mast head" (Furneaux: 114). Here is confirmation that fires, and therefore people, were present in the far northeast during March. Here also, is one of navigations great blunders. If Furneaux had realized that his deep bay was in fact a strait, then the settlement history of southeastern Australia would almost certainly have been very different.

Certainly, a number of Furneaux's officers thought differently. James Burney thought that the evidence indicated "streights or passage" (Burney in Beaglehole, 1969: 152) while Richard Hergest recorded " So that we judge here is a streights" (Hergest in Beaglehole, 1969: 152). The ships astronomer, William Bayley, likewise thought there was good reason to suspect the presence of a strait. The strength of a westerly current led him to believe that "it seems very evident that this is the mouth of a strait which separates New Holland from Van Diemen's Land" (Bayley in Beaglehole, 1969: 153).

There is not the space to discuss who first discovered 'Bass Strait', but a word seems in order. It was Flinders who named Bass Strait in honour of his friend whom he believed had first suggested the presence of a strait. George Bass's earlier speculation as he left Westernport Bay on the 19th of January, 1798 that the westerly swell he encountered must have had its origins in open sea was in fact 25 years after the fact. Perhaps if Furneaux, or even Cook, had taken notice of the opinion of lesser officers, the strait might bear the name of Burney, Bayley or Hergest.

Summary

Furneaux's expedition was the first to indicate signs of Aboriginal occupation in northeastern Tasmania. Smokes seen from a mast head at a great distance do not constitute good evidence for the type or extent of burning. The smokes are however, evidence that burning by Aborigines was practiced during March.

Matthew Flinders and George Bass: 1798

On the 1st of November 1798, the Norfolk sighted Cape Portland in the far northeast of the state. Flinders records that the coastline was low and sandy with a hinterland that rose in a series of hills "covered with verdure", interspersed with clumps of wood (Flinders,1814 :cxlviii). Sailing past Waterhouse Point, he notes that "the land at the back of Point Waterhouse is higher than that of the island, and is composed of grassy, wooded hills, rising over each other by gentle ascents" (Flinders,1814: cli).

The first sign of fire recorded by Flinders came with smokes rising from either side of the cliffs of Stoney Point. The vegetation here is today composed of heath and *Allocasuarina / Eucalyptus* forest.

In the Tamar estuary, grassy woodlands extended down to the waters edge. Near present day George Town Bass and Flinders watched a man from the Leterremairrener tribe "who employed or amused himself by setting fire to the grass in different places" (Flinders, 1814: clv). It is uncertain if the fire making activities of the man constituted an unobserved 'normal' task, or a deliberate reaction to the presence of the 'Norfolk'.

Unrecorded by Flinders was a smoke seen inland from Waterhouse Point (Bass in Collins,1971: 161). In regard to their visit to the Tamar River, Collins writes that Bass and Flinders found Aboriginal huts "in about the same proportions as in New South Wales" (Collins, 1971: 168). He went on to say that the Aborigines had made fires near to where the sloop was at anchor. At this place was a group of 7 or 8 huts built from materials obtained from neighboring trees.

Summary

This famous expedition rarely caught sight of fire or Aborigines anywhere along the north coast. A smoke at Waterhouse Point and another at Stoney Point during summer suggests that this coast was not heavily populated during the early summer months. Curiously enough this would seem to be an ideal time to occupy the coast, as the numerous freshwater lagoons with their rich avian fauna would have provided a strong economic enticement.

The environment sighted by Bass and Flinders in the northeast consisted of extensive coastal plains and hills, separated by belts of forest. Clumps of trees broke up the monotony of what Flinders assumed to be grass covered hills. In the Tamar estuary, grassy woodlands extended, in places, down to the waters edge. Fires may have been frequent enough in such places to inhibit the growth of *Eucalyptus* seedlings.

The activities of the Leterremairrener man setting fire to vegetation at the edge of the

Tamar River is unusual enough to warrant comment. Either the man took no notice of an event so far out of daily experience that he simply could not comprehend the full import of the 'Norfolks' presence; or the action was deliberate, perhaps a warning, a signal or even a challenge.

2.5 The first settlers

Lt. Governor Paterson 1804

Paterson was appointed by King as Lt. Governor of the new settlement at Port Dalrymple near the mouth of the Tamar River. Relationships between the Europeans and Aborigines were disastrous from the start. On the 12th of November 1804, 80 Leterremairrener appeared and a skirmish erupted in which at least one Leterremairrener man was killed (Paterson, 1804 in HRA, 111/1: 605).

In a letter to King, Paterson asserts that a group of Aborigines numbering at least 200, appeared at the Western Arm (Paterson, 1804 in HRA 111/1: 610). This might be an indication of the seriousness which the Aborigines took the invasion by the British.

At the present day site of St. Leonards, Paterson noted the presence of extensive grassy plains with no trees or shrubs. It is of great interest to know that the grass plains were very rich in herbs, with Paterson mentioning the presence of buttercups (*Ranunculus*), two kinds of *Plantago* and other small herbs (Paterson, 1804 in HRA, 111/1: 616). This type of grassland is rare and threatened in Tasmania today (Kirkpatrick *et al.*, 1988).

On the 5th of December, 1804, Paterson "observed some fires in the woods upon the rising ground, but have not as yet seen any of the natives since our first interview with them at the outer cove" (Paterson, 1804 in HRA 111/1: 618).

The 12th of December found Paterson exchanging gifts with a group of about 40 Leterremairrener. He noticed that the people retired to their fire in the woods and supposed that they live chiefly in this region (Paterson, 1804 in HRA,111/1: 621).

On the 14th, Paterson sent a gift to Governor King. It was a box containing objects of natural history including plants, bird bones and "a very perfect native's head" (Paterson, 1804 in HRA,111/1: 643). This exchange does not indicate any evidence of the development of a conciliatory attitude by the Europeans.

Paterson records that in December, 1805 a group of about 50 Leterremairrener was encountered near where Launceston stands today. According to Paterson "Some of their party had fired the hills entirely around them" and he went on to state that the vegetation directly adjacent with the burnt area was "thick jungle" (Paterson, 1804 in HRA,111/1: 650). It is not clear if it was the Leterremairrener or the settlers who were surrounded by fire. Nor is it clear if the ecotone between the burnt area and the thick scrub or forest was sharp or gradual, although from Paterson's tone it appears as though the open area was clearly distinguished from the surrounding forest. This could indicate the repeated burning of an area in order to create a grassland from rainforest, similar to that documented from in the far north eastern highlands (Ellis, 1985; Ellis and Thomas, 1988).

Summary

Paterson's term of office was marked by very poor relationships with the Leterremairrener. The size of the Leterremairrener groups seems to indicate that they had already adopted a defensive posture. The presence of herb rich grasslands point to fire regimes which allowed marsupial grazing. The creation of patches of grassland within dense forest suggests a sophisticated ability to control the rate of spread of fire in forested environments.

Robert Brown: 1803-1804

Robert Brown was botanist to Matthew Flinders on the 'Investigator'. He found passage with Collins in 1804 to Port Dalrymple and the Derwent on the 'Lady Nelson'. His first love was botany and in Tasmanian studies, only Labillardiere and J. D. Hooker can claim similar emminance. If one trait can be used to define both a good botanist and a good ethnographer, it would be surely be attention to detail. By this criteria Brown should have provided a fund of ecological and ethnohistorical information.

Unfortunately, Brown described remarkably little of his time in the colony, and that which he did is characterised by a lack of enthusiasm. His biographer referred to Brown's "cold mind" (Mabberly, 1985). Nevertheless, it should be a matter of priority for future work to extend Mabberley's research by analysing Brown's Tasmanian papers in the British Museum. What is sure however, is that of all the first settlers, only Brown made a real attempt to understand the geography and natural history of Tasmania.

As part of Collins expedition to Port Dalrymple in 1804, Brown noted that on the 1st of January: "The Aborigines had set fire to much of the area and seemed troublesome" (Mabberly,1985: 115). Three days later Brown held an "interview" with a group of Leterremairrener and thus became the first known European to attempt a rational conversation with Aborigines from the north of the state. He wrote: "'On top of the hill we sat down and in a few minutes 12 natives joined us at first they conducted themselves in a peaceable manner but bye and bye they began to shew some symptoms of distrust as on my making some attempts to acquire a little of their language one of them snatched up a piece of wood and threatened to throw it at me at the same time raising his spear &

two of them shaped their spears to throw at me" (Mabberly, 1985: 116). The incident so frightened the Europeans that they fired their weapons, once into the air and once at a person. So began the frightful history of colonization in the north of the state.

It is probable that sealers had already commenced their depredations on the coastal tribes of northern Tasmania. If this were so, it is little wonder that the people were agitated and wary of the group of weapon carrying white men.

Further down the Tamar River, near Middle Island, Brown saw a group of 30 Leterremairrener who enticed the sailors into shore and then commenced to stone them. These angry exchanges form the background for the comments of Paterson discussed above.

In a letter to Governor King, Brown remarks that the land around Low Head is generally very poor and sandy, intersected with swamps and stony hills. The land fringing the middle Tamar was said to be superior to that on the Derwent and "thickly covered with fern or tall herbaceous plants" (Mabberly: 434). He noted that the trees were mostly either *Eucalyptus* or *Casuarina* (sic). Two varieties of wattle were recorded as were patches of *Tasmannia lanceolata*:

"In some places was observed very luxuriant a small kind of (?) the original species of which produces the winters bark is not uncommon on the banks of rivulets - it is seldom more than a bush every part of which but especially the seed is highly aromatic but accompanied with an exceedingly bitter & pungent taste" (Mabberly: 435).

When found at sea level, *Tasmannia*, or pepper bush , is found only in damp fire protected locations. The absence of pepper bush from the Tamar valley today may be a result of higher fire frequencies over the past 150 years.

By March 1804, Brown had tired of Van Diemen's Land and was keen to return to Port Jackson. In a letter to Col. Paterson, Brown complained that the season (flowering) was late and that the "vallies and even hills so much burnt, that without ascending the more distant mountains I cannot hope to make any more botanical aquisitions" (Brown, 1804 in HRA,111/1: 489).

Summary

Brown's reputation leads to the expectation of great and detailed records. This has not yet proven to be the case. He does indicate that the vegetation of the Tamar valley was possibly damper and more shaded along drainage lines than is the case today. His meetings with Aborigines were not amicable and set a tone of mistrust which must underscore subsequent observations by others.

By March, 1804 Brown records that much of the land was burnt and that this restricted his collecting opportunities. This could indicate either extensive burning by Aborigines or extensive burning by settlers.

There is reason to believe that an examination of Brown's personal papers might shed more light on his Van Diemen's Land interlude. It would be of interest to find records of his trip to the Huon River and another which penetrated some considerable distance up the Derwent River (Mabberly, 1985).

A. W. H. Humphrey: 1804

Humphrey was a mineralogist who accompanied Collins and Robert Brown on the 'Lady Nelson' at the time when Port Dalrymple was settled. Humphrey wrote graphically about the contact incident described by Brown above:

"When we got to the outer cove (where) we heard a noise in the bushes, and in ten minutes found ourselves nearly surrounded by fire. --- We, however, escaped the fire but were no sooner clear of it than we fell in with one of the natives of the country who screamed in a dreadful manner and ran in among the bushes. --- We soon , however, had a number of natives running after us, shouting and crying out. One of them threw a spear at us but did no hurt" (Currey,1984: 79).

This is a particularly vivid incident in which danger was posed by both fire and spear to Europeans. It may be that Humphrey and company blundered into a hunting party and suffered the consequences. Equally plausible is that Humphrey's party was actually ambushed. Considering the aforementioned atmosphere of fear, it is not surprising that premeditated ambushcades should occur.

Summary

Humphrey's account illuminates the same events as narrated by Brown. The most significant point is in regard to the attack with fire and spear on Humphrey and party. This adds to the body of circumstantial evidence which suggests that in certain circumstances Aborigines resorted to the use of fire in order to drive off the white invaders.

James Kelly: 1816

James Kelly and a small crew set out to row and sail around Tasmania in December, 1816 (see below). A single smoke near Waterhouse Point on the 12th of January was assumed to have been made by a large party of Leenerrerter who were observed walking along the beach. This is the only observation in the northeast which concerns free Aboriginal people.

A famous seal catching episode by Kelly's crew and a group of Aborigines who were familiar with the Bass Strait sealers and their methods is not described here (see Kelly, 1881). However it is notable that Kelly makes an observation which gives weight to his previous suggestion that smokes on the west coast were signals to other tribes. He wrote that a group of women who had just completed a seal kill, "now ascended to the top of a small hill, and made smokes as signals to the natives on the main that they had taken some seals" (Kelly, 1881: 15), and later: "After breakfast, started with a fine breeze at north, and steered along the shore to the southward. The natives made three smokes to say 'goodbye'" (Kelly, 1881: 16).

The use of smoke signals is, to judge from this account, a commonplace in the lives of Aborigines. It is possible that the technique was taught them by sealers, but this seems a particularly uncharitable view, especially in consideration of the numerous references to such a use contained in the journals of G. A. Robinson (Plomley, 1966).

Henry Rice:1820

Rice and a group of men were employed by Govenor Sorell to examine approaches to the east coast of Tasmania. Between St. Patrick's Head and the Break O'Day Plains the party encountered "a tract of scrubby land and some small plains" (Rice, 1820 in HRA 111/IV: 643). The small plains may have been bumt but this is not at all certain.

Mr. J. Hobbs: 1824

On his voyage of circumnavigation, Hobbs managed to conduct a considerable amount of terrestrial exploration and thus his account of Tasmanian coastal landscapes is quite valuable, more so than Kelly's for some purposes.

On the 31st of May, 1824, Hobbs and crew left Georgetown travelling past Cape Portland towards the east coast. At Waterhouse Point, Hobbs ascended what is probably Hardwicke's Hill and recorded his impressions of the surrounding countryside. He saw plains from 6 to 20 miles wide containing numerous lagoons and reedy swamps. On coastal sand dunes he found a good cover of grass while further inland the plains were covered with thick scrub. At Cape Portland he was impressed with the grassy plains and she-oak (*Allocasuarina*) covered hills. He points out that: "the timber on this part is almost entirely she-oak" (Hobbs, 1824 in 1881: 21).

Summary

From these comments there is little evidence of the fire and grazing induced sand dune blow outs which form such a conspicuous feature of the coastline around Waterhouse Point. The grassy dunes seen by Hobbs point to a different fire frequency employed by Aborigines to that in operation today. The many frontal dunes in the area are dominated by *Spinifex sericeus* but significant areas are covered by *Acacia sophorae.* In order to have a coastal environment substantially free of *Acacia*, fire frequencies might have to be either much longer or much shorter than about one fire every decade. Shorter fire frequencies would have likely resulted in the exposure of bare sand to westerly winds and thus instigated a geomorphological regime marked by eroding foredunes. Because such features were rarely commented on by European explorers, it may be assumed that the fire frequencies utilized by Aborigines on coastal dunes may have been substantially lowerr than those experienced today.

2.6 The surveyors and land owners

Ronald Gunn:1832-1849

At the time that Gunn was collecting plants for Sir William Hooker of Kew Gardens, the only European settlements in the northeast were a few isolated farms between Bridport and Cape Portland. The interior was almost totally unknown, although Gunn must have obtained a certain amount of information from others such as Thomas Lewis, John Batman and John Helder Wedge, who had all previously traversed much of that country.

in 1849, long after the removal of Aborigines from the northeast, Gunn travelled over the spine of the northeastern highlands. Burns and Skemp consider that this country was uninhabited for: "the Aborigines kept to open country and avoided thick scrub and rainforest" (Gunn:1849 in Burns and Skemp, 1962: 120-122). Gunn's letters show that the main course of his travels was through dense *Nothofagus* rainforest where "not one gramineous plant meet met eyes for days" (Burns and Skemp: 121). It appears that Gunn missed the open Mathinna and Paradise Plains although he may have approached quite close to them in 1832 (Buchanan, 1988). The lack of grass and the extensive nature of the wet forests seen by Gunn suggests that Aborigines did not practice widespread burning of forests in these mountains.

John Helder Wedge: 1824 - 1833

The diaries of Wedge (Crawford *et al.*, 1962) provide interesting detail in regard to the motivation for Aboriginal fire lighting. On the 17th of December, 1825, Wedge conducted a survey of the northeastern highlands near to Ben Nevis. He recorded that most of the country seemed to be covered in thick forest although he did observe one place "not so thickly covered with timber" (Wedge, 1825 in Crawford *et al.*, 1962: 24). This may have been the summit of Mt. Maurice or perhaps Paradise Plains.

On the hills which border the Break O'Day Plains in the Fingal Valley, Wedge observed an impressive fire lit by Aborigines: "My attention was at once fixed on a most magnificent and imposing sight - The hills a few miles (about 3) were on fire, and had been for several days, but being fann'd up by the gusts of wind had this night blazed up to an unusual extent. - a range of hills, five to six miles in extent were burning - the general blaze was obscured by the intervening trees, but here and there a streak of fire was to be seen, formed the edge of the hills, and now and then a flare of fire would burst through the volumes of dense smoke and appear above the tops of the trees occasionally - the falling of the trees would (illegible) upon the general stillness, and convey to the mind the destruction the devouring element was making" (Wedge, 1827, in Crawford *et al.*, 1962: 40).

The weather preceding the fire on the 8th of December 1827 had been very warm while the weather after the fire from the 9th to the 13th was cool and showery.

Two years later at the Georges River on the northeast coast Wedge noted the presence of "Hills freer from underwood, having been burnt by the natives" (Crawford *et al.*, 1962: 59). This seems to indicate extensive fires rather than the burning of small isolated patches. It is impossible from this data to distinguish between the effects of fires lit at different intervals, which over a period of time might cumulatively have given the appearance of a single fire.

Summary

In a footnote to the passage passage concerning the fire on the 8th of December, Wedge noted that "The natives had set the grass on fire, as is their custom, whilst hunting, and it had spread in the way described - whilst in the neighbourhood they speared upwards of a dozen of Mr. Talbot's sheep and chased his shepherds" (Crawford *et al.*, 1962: 40). The fact that Wedge heard falling trees and saw such dramatic evidence of fire could be taken to indicate that the fire was incredibly destructive and extensive. In such a potentially dangerous situation it is possible that Wedges party was safely upwind of the fire? That may be, but even small can fires produce an impressive display of pyrogenics and cause trees to fall. The fact that the fire was not mentioned on the following day indicates that the flare up had settled down during the night.

Wedge hints that the fire was lit for hunting purposes but this view is difficult to reconcile with the fact that the fire had been burning for several days. The sequence of events could indicate a number of different explanations for the fire. It may have been, as Wedge suggests, an accident in which a creeping grass fire was inflamed by increasing winds. It may also have been purposely lit to coincide with the arrival of a period of wet weather. Finally it may have been a deliberate attempt by Aborigines to drive off the white men. The spearing of sheep and the harassment of shepherds adds weight to the latter interpretation. In the valley at this time were 20,000 head of cattle and sheep (Crawford *et al.*, 1962: 40) tended by an unknown number of shepherds who were employed by a number of rich new landowners. The presence of Europeans taking over traditional hunting lands, and the timing of the fire to coincide with favourable weather conditions suggests that foresight and control were employed in the deployment of this blaze. Whatever the ultimate reason for lighting the fire, there does seem to be some evidence that it was lit in full cognizance of prevailing conditions

John Batman: 1829 - 1830

Batman is known chiefly for the controversial co-founding of the city of Melbourne with John Fawkner. Until recently, far less had been made public of his stormy and often bloodthirsty relationships with Aborigines. Extracts are taken from an excellent, recently published book which examines just this issue (Campbell, nd)

On the 1st of September, 1829, Batman and a party intercepted a number of people who were encamped in rough forested country to the east of Ben Lomond. The party had previously come across 15 Plangermairreenner / Leterremairrener (?) huts in two groups of 10 and 5. Batman commented that: "we proceeded in the same direction until we saw some smoke at a distance" (Campbell: 31). This smoke was obviously a campfire kindled in a place remote from Europeans. The Plangermairreenner / Leterremairrener group was not a war party, for in the aftermath of a deadly fusillade by Batman's group, it was found that women and children had been shot and maimed. Later, Batman personally shot two of his captives on the grounds that their wounds made it impossible for them to keep up with the European roving party.

Later, while on an expedition to the southern foothills of Ben Lomond, Batman located the fires of people whom he was attempting to capture. Batman tracked these people from the upper reaches of the South Esk River to the Pipers River near the northeast coast. Here he saw "the smoke from native fires on the east side of this river" (Campbell: 35). The route extends from what is today an area of rain forest to the open dry forests of the coastal hinterlands. This points to the familiarity that the Plangermairreenner / Leterremairrener had with both highland and lowland environments. However, it is possible that the group consisted of members of both tribes, forced together by dire circumstance, and thus having access to two funds of traditional knowledge.

Batman's next expedition early in January, 1830, was particularly noteworthy in that Campbell is convinced that through the clever use of fire, the Plangermairreenner / Leterremairrener "deliberately misled their pursuers" (Campbell: 35). According to Campbell: "As Batman approached, the Aborigines fired the bush every two or three miles ahead of him; Batman followed until evening. The Aborigines then lit fires on the far side of the South Esk River. This encouraged Batman to cross the river next morning, and he searched the hills on that side all day without success. The fires were evidently a decoy: the Aborigines had doubled back and escaped in a westerly direction along the South Esk River" (Campbell: 35). This interesting episode reveals a sophisticated ability which enabled people to use fire in a very controlled fashion without endangering their lives.

Summary

Batman's letters reveals precious little information concerning the traditional use of fire by the Plangermairreenner / Leterremairrener. They do however, sound a loud caution in regard to many previous interpretations of fire. If due regard is not given to possible culture contact effects and the probability of frequent misunderstandings (see Mulvaney, 1989), as well as increasing levels of violence, the motives for burning and its effects might be easily misinterpreted.

Perhaps the setting of fires as decoys was a traditional method used by warring parties? In any event, the successful deployment of this tactic shows that Aborigines had realized that Europeans could really only successfully locate them by observing the smokes and acting accordingly. This use of fire must be classed as a sophisticated response to European presence. The analysis of fire observations presented in Chapter 3, suggests that similar methods were employed by the southeastern Portmairrenmener people at the time of their first substantial contact with Europeans some 58 years earlier.

Thomas Lewis: 1829-1831

In 1829 Thomas Lewis constructed an accurate map of northeastern Tasmania following a series of important but little appreciated journeys into largely unexplored territory.

Lewis's annotations to his map (reproduced in Jennings, 1983) show that the coastal fringe from the Tamar to Cape Portland was characterised by sandy undulating hills covered in grassy woodland. At Waterhouse Point, Lewis noted that between the coast and the "thickly wooded hills" of the interior were a set of "grassy oak hill". Between the coast and what later became known as Hardwicke's Hill, he noted the presence of "bare hills". If Lewis could see Waterhouse Point today after an interval of 160 years, the landscape would almost certainly provoke the same response. His identification of expanses of "bare sand" at the mouth of the Boobyalla River indicates that a significant area of sand was mobile by 1829. Today, a considerable area of the coastal dune system is under threat from wind erosion induced from over burning and over grazing. It is possible that Lewis recorded just one area of "bare sand" from many more which may have existed, but this seems strange considering the detail which Lewis included on his map. Where on his map are the great sand blows of Waterhouse Beach, Cape Portland

and Double Sandy Cape?. A reasonable interpretation is that erosion and sand movement was present at that time but considerably reduced in relation to the area under threat today.

On the 14th of October, 1829 Lewis set off to follow the course of the North Esk River. He attempted to ascend Ben Lomond and by skirting the western cliff line eventually came across a number of "large plains and marshes each several miles in extent" (Lewis, 1829: CSO 1/420/9442: 157). These are probably the Ben Lomond Marshes at approximately 800 asl. Kee (1987) has recorded a number of Aboriginal sites at this place. He appears to have reached the summit plateau of Ben Lomond, for he describes the summit lake from which the Nile River takes its source and comments on the abundance of kangaroo on the plateau.

On the 1st of November on the banks of the North Esk, Lewis cached a supply of provisions in a hollow tree "around which the country had been burnt" (Lewis, 1829 CSO 1/420/9442: 158). From the St Patrick's River, Lewis decided to head north on a course parallel with the Tamar River and strike out for Bass Strait. After 3 weeks he reached George Town on the 18th of November, 1829. During this journey he passed across the foothills of the northeastern highlands. In dense forest he came across clear spots of considerable extent. Of these he wrote that "on the whole the soil is indifferent---some spots have excellent soil (?) hilly plains (?) in these places there was an abundance of grass" (Lewis, 1829: CSO 1/420/9442: 158). Near the foot of Mt. Arthur, Lewis traversed across a limited extent of open forest which had been recently burnt (Lewis, 1829: CSO 1/420/9442: 159).

Two years later, in a letter to the Surveyor General George Frankland, Lewis described the country between George Town and St. Helens on the east coast (Lewis, 1831: CSO 1/420/9442). After crossing the Forester River, Lewis ascended what is now Hardwicke's Hill and observed a rushy lagoon on a very large plain. These are the Waterhouse Point heathlands and a large unnamed lagoon which today supports a dense population of the sedge *Baumea arthrophylla*. Other nearby lagoons supported an abundance of waterfowl, while the surrounding undulating country abounded with kangaroo and emu.

He described the country between Bridport and Musselroe Bay as containing areas with no grass and others with 'much kangaroo grass'. In places, he encountered eucalypt forests with dense shrubby understories (Lewis, 1831: CSO 1/420/9442). On the east coast, possibly near to Georges Bay, he wrote that "I must observe that this bay seems to have been much visited by the natives, judging by the numerous remains of their fire stones scattered in every direction across it" (Lewis, 1831: CSO 1/420/9442). It is not sure if this observation relates to hearthstones or to artefacts, which Lewis mistakenly identified as flints for making fire.

In the hill country behind St. Helens he observed that the western side of some hills were grassy. He observed a number of grassy plains about 1 mile long and 1/2 mile wide. Grassy woodlands were estimated to be about 500 acres in extent. For the most part, the vegetation was forest which alternated between shrubby and grassy understories. Hillslopes were often dominated by the native hop (*Dodonea viscosa*).

Summary

The letters and map of Thomas Lewis add considerable to our knowledge of the distribution forests and plains in the northeast. It is clear that the near coastal sandy country was covered in a mosaic of heaths and grasses under a scattered woodland of *Allocasuarina*, *Banksia* and *Eucalyptus*. The hilly country between 100m and 300m altitude was virtually a continuous open forest with occasional grassy plains except along streams where forests became dense with very scrubby understories. In the higher country, dense forests were occasionally broken by small grassy plains.

It is significant to note that even though the understories of forests were burnt, Lewis never recorded burnt canopy dominants or trees killed by fire.

James Scott: 1852

Although Scott's comments fall out of the range of direct Aboriginal influences, his descriptions of the vegetation encountered between Cape Portland and Launceston *via* the highlands are of interest. (Scott, 1852: CSO 24/191/7043).

He crossed the Maurice Plateau and noted that the summit of Mt. Maurice was clear of trees (it still is) and that land surrounding the mountain included a number of plains which measured some 300 acres in extent. Other than these patches, Scott did not encounter any open country until he came to the dry sclerophyll forests near to Mt. Cameron.

Arriving at the coast. he set fires in many places but on account of inclement weather, he experienced difficulty in keeping the fires alight. In this place somewhere between Cape Portland and Tomahawk, he wrote that he saw "no mark of fire ever having been there before" (Scott, 1852: CSO 24/191/7043).

Scott describes the extensive nature of the swamps along the Forester River. He stated that half a mile from the river on a patch of good soil he encountered a relatively dry place which was covered with scrub and nettles. This may indicate a former fire which has opened the canopy to provide the conditions necessary for *Urtica* to prosper.
He wrote that on the 16th of March: "I set fire to the scrub in many places but not above one mile in the whole was burned, being too green and damp and no mark of fire ever having been there before" (Scott, CSO 24/191/7043).

Summary

Scott's evidence comes from a period 15 years after the Aborigines were removed to Flinders Island. In this period, the slow growing rainforests and mature eucalypt forests had changed little. It is not clear if the clearings containing *Urtica* were caused by Aboriginal fires, European fires or by natural events such as tree fall or floods.

Scott was in the habit of lighting fires whenever he had the opportunity and in his very long association with the northeast it is reasonable to assume that he lit many. Multiply the impact of Scott's fires by the increasing number of settlers pushing into 'Scotts New Country' (now Scottsdale) and it is easy to appreciate the masking effect that European fires must have on the Aboriginal landscape.

Charles Gould: 1864

In Gould's travels in the northeast he encountered fully grassed hills with wattle (*Acacia*) scrub near to the coast; eucalypt forest with an understorey of coarse grass and bracken fern on the inland hills, and dense rainforest across the highlands. In the fertile Scottsdale Valley, he encountered very tall *E. obliqua* forests with a dense understorey of *Pomaderris apetala, Dicksonia antarctica, Olearia argyphylla, Coprosma quadrifida,* ground ferns and nettles (Gould, 1864: 4-6). In the vicinity of the great bend of the Ringarooma River near Branxholme, Gould mentions that the forests are composed of wattle and swamp gum (*E. regnans/E. ovata*?) with a remarkably clear understorey of ferns and tree ferns (*Dicksonia*).

Summary

The presence of Tall Wet Eucalyptus Forest (*sensu*, Kirkpatrick *et al.*, 1988) is *prima facie* evidence that fire had at some stage created conditions suitable for the establishment of *Eucalyptus*. The great size of the trees suggests that this must relate to a fire at least 150 years before. The dense tall shrubby understorey of the Scottsdale forest points to an absence of fire for a period of 10 - 50 years. However, the presence of nettles (*Urtica*) and wattle indicates that the canopy had recently opened sufficiently, perhaps through fire or treefall, for the regeneration of these species. In other words, quite infrequent fires could easily have maintained wet eucalypt forests. In fact, the sparse understories of unburnt forests may have conferred significant advantages for travel and hunting purposes.

2.7 G. A. Robinson and his mission to the northeast: 1830 - 1831

An analysis of Robinson's year long journey to the northeast (Plomley, 1966: 245-480) provides a wealth of data relating to the distribution of vegetation communities which may owe their existence to Aboriginal fire regimes. In spite of the wide use of Robinson's journals as a source of first hand ethnohistorical data, there are difficulties in interpretation which are not often addressed by either archaeologists or ecologists (Thomas, 1984). .

It cannot be argued that Robinson's testimony is without value simply because his charter happened to be in the final decade of fully traditional Aboriginal life. No other European person lived for so long with Tasmanian Aborigines and on that basis alone Robinson occupies a special place in the field of ethnohistory. In spite of the complaint that he was self interested and patronizing, there was a genuine rapport between he and Worrady, Manalargenna, Trugernanna and other Aborigines. The rapport may have based on a moral sense of superiority, but was nevertheless real.

To his credit, it cannot be denied that he at least, took a path unstained by blood. The same cannot be said for Paterson, Jorgenson, Batman, Arthur, Kelly, Curr and many others. Robinson was neither good nor evil: he was simply a stubborn average man with all of the human frailties which that entails. A case could probably be made that all free Britons in Van Diemen's Land were out to feather their own nests, and in this sense, Robinson was no different to the rest. Interestingly enough, there is ample evidence that even in the face of his duplicity (Pybus, 1991) he was tricked and manipulated in turn by the Aborigines travelling with him.This should not be taken to indicate that he was especially dull or stupid, for the same had happened to Batman, and after all, in the famous episode of the Black Line, every able bodied man in the colony was made to look a fool (Turnbull, 1948).

Having made a case that Robinson's journals are filled with a unique knowledge gained from 5 years of living with Aborigines, it has to be said that there are considerable difficulties to be overcome in the use of the data. Archaeologists (eg. Brown, 1986; Cosgrove, 1984; 1988. Kee,1990) and ecologists (eg. Kirkpatrick, 1977; Podger *et al.*, 1988) both, are only too happy to select whatever quote from the journals suits their particular needs . Neither discipline has demonstrated a particularly critical approach to the papers, nor to any other source for that matter. Ironically, entry into the journals has possibly been made too easy by Plomley (1966), whose excellent editing and compendious notes mean that the expeditions can be easily skimmed for information rather than read as complete documents. The major exceptions to this are Jones (1971, 1974) and Plomley himself, whose research form the basis of our understanding of Aboriginal society as it existed during the early part of the 19th century.

Accompanying Robinson for his year in the northeast was a group of people (fluctuating in size) which totalled 34 Europeans (including his son and the wife of Robinson's carpenter) and 9 Tasmanian Aborigines. In the course of the expedition up to 60

Aborigines were captured or transferred from jail in Robinson's custody (Plomley, 1966: 477-480). The size of the group is important because it hints that in regard to fire lighting, the group dynamics of the party would have precluded any traditional use of fire. The party was continually pushed to achieve Robinson's goals, with little time available to set fires in accord with traditional goals and objectives. Additionally, the Aborigines with Robinson came from tribes as far apart as the southwest, Robbins Island and Little Swanport (Plomley, 1966: 478-480). Finally, the people who were captured by Robinson were an amalgam of different tribes and it seems reasonable to assume that those people might not know (or even care) of the correct method of burning when out of their own country.

In the tense atmosphere of the 1830's, normal relationships between Aborigines and their land could not possibly have existed. The Aboriginal population had almost reached its nadir in this decade, and it would seem improbable that people were regularly using traditional subsistence patterns at this time. The evidence from Wedge and Batman show that Aborigines were deliberately using fire in ways which were designed to confuse and alarm Europeans. Robinson's journals strongly suggest that many of his observed smokes were lit with similar objectives in mind.

Rather than analyse in depth the actual fires and smokes seen by Robinson, it is considered more useful to draw information from his observations of vegetation types. Although many of the burnt patches he recorded were recent events, many seem not to have been. Considering that the first European incursions into the northeast occurred less than a decade earlier, his descriptions of vegetation types probably relate to Aboriginal rather than European fire regimes, but this cannot be certain.

The following analysis uses references to fire which do not relate to Robinson's party. Observations concerning the domestic uses of fire, such as camp fires, are not analysed, neither are repetitive descriptions of the same fire, nor smokes which obviously emanated from the Aborigines pursued by Robinson. Descriptions of relevant vegetation types are discussed. All transcriptions are taken from Plomley(1966).

11/Oct/1830: Inland from Stony Head, Robinson: "travelled over some burnt ground to within two miles of Pipers River". This could easily have been a fire lit by Europeans.

13/Oct/1830: From Double Sandy Cape to Waterhouse Point, the country appeared to be: "open forest with heathy plains". The party crossed some patches of burnt ground. These appear to be recent burns and cannot be used to infer a traditional burning regime.

15-16/Oct/1830: From Waterhouse Point Robinson: "Decried the native fires at Cape Portland. They were very large and numerous. The report of so many natives being seen is unfounded". These fires cannot have been forest fires for he makes it clear elsewhere that Cape Portland was not forested. The fires may well indicate the firing of open grassy expanses. Alternatively they may simply be a large number of camp fires.

17/Oct/1830: Near Tomahawk to the east of Waterhouse Point, Robinson noted that: "The country through which we came from the River consists of heathy plains, thinly wooded and with several lagoons, and to the north-east is a range of grassy hills. In the lagoon or marshes the natives gathered among the rushes a root which they eat---. Perceiving several smokes in a SE direction, I altered my course". He came across a treeless plain of about 2,000 acres in extent which was dominated by the Kangaroo grass, *Themeda triandra.* Surrounding the plain was an open forest of *Allocasuarina.* Robinson notes that the people he was seeking had: "commenced their first fires burning off the scrub". Little credence can be placed in Robinson's interpretation of the fire, especially because his own description makes it quite clear that the countryside was open and easy to travel through.

18/Oct/1830: As the party neared the east coast near to Musselroe Bay, they proceeded over burnt ground where they saw a number of dogs which Woorrady and Tom said were wild, while Robinson insisted they belonged to the Aborigines. It is likely that Woorrady and Tom were fully aware that the dogs belonged to the free Aborigines; they simply did not wish Robinson to know this. After observing some smokes they set off and for the whole of the morning: "The country as far as we had come was all burnt off and there was fires in all directions". Later, along the forested coast, they came across: "a tract of burnt ground---. Travelled on for about half a mile over the burnt ground, a great many trees still on fire".

The country appears to have been burnt for an area measured in many square kilometres. If this account is typical of the normal annual method of burning this low coastal country then it has been very severely burnt indeed. Robinson's other comment that the entire coast was forested does not support this proposition. It is possible that such burns were undertaken only after considerable intervals. The fire frequency cannot be discerned from these accounts. In fact, if the fires were lit not for land management purposes, but to confuse Robinson, then nothing at all can be said concerning traditional practices.

20/Oct/1830: At Musselroe Bay: "on the south bank the bush had been burnt where the natives had had their fires when procuring swan's eggs". The country about here was heathy with small plains and grassy expanses. This burnt area probably indicates fires lit by people to clear away the reeds where the swans nest. If the same areas were burnt annually it would be unusual for swans to return year after year. The abundance of small lagoons in the northeast could enable a scheduled burning policy to operate in which individual lagoons could be burnt every few years without unduly affecting plant communities.

21/Oct/1830: At Cape Portland, Robinson described a varied environment, rich in animal resources and composed of grassy plains interspersed with *Allocasuarina* forest containing *Banksia* and probably, *Eucalyptus pauciflora*. Here the party made their way over a considerable amount of burnt ground.

31/Oct/1830: Inland from St. Helens, Robinson: "discovered the track of the natives and a stick on fire. Went on and found the bush on fire for a considerable distance, but the natives had gone". This is a strange occurrence and can be interpreted as some sort of signal or sign left by the Aborigines, perhaps for Robinson's party. The country side was forest with a heathy undestorey.

2/Nov/1830: In the same area Robinson: "travelled over some upland plains between two ranges of mountains. All of this ground had been recently burnt off and was the principal resort of the natives". The timing of the burning may or may not be significant without further understanding of what Robinson means by his use of the word 'recently'. The location of the burn indicates that upland plains might have been burnt quite often.

2/Nov/1830: Upon reaching the summit of the present day Mt. William, Robinson noted that: "Here they had recently made a fire and all the bushes had been broken for this purpose". This appears to have been a signal fire similar to those recorded by James Kelly.

3/Nov/1830: Robinson recounts that the Aborigines: "was angry with Trugernanna for making the baskets or pulling the grass for this purpose; said it would make the rain come. Would not let them roast goanna as it would make the rain come. The wind happening to shift, one man got a fire stick and stood up and thrust the burnt end towards the wind the way they would have the wind to go". This story emphasises that fire was not simply a tool for burning vegetation , but that it had powerful properties in regard to other environmental manipulations.

21/Nov/1830: Two older Aborigines, called 'chiefs' by Robinson, tried to convince him that a large smoke which appeared to be moving towards the party was the result of well armed party of Aborigines approaching from the east. It seems as though they tried to convince Robinson that he should visit the islands on an errand, thus, allowing them to abscond or communicate with free Aborigines.

26/Nov/1830: On Swan Island Robinson had a hut constructed (the remains of this earliest of Robinson's impoundments might still exist). The vegetation on the island was *Banksia marginata* scrub.

2/12/1830: Robinson marched southwards towards a range of high hills. He came across a grassy plain of about 1,000 acres in extent. In general the vegetation consisted of a mosaic of grass and forest patches, with occasional swamps. They then: "passed over a large tract of ground where the bush had been burnt by the natives". In the context of the surrounding countryside, this comment clearly indicates that burning on the northeastern plains was carried out in a fashion which resulted in broadscale mosaics of grass and forest.

5/12/1830: In the course of this day Robinson encountered a wide variety of vegetation types which emphasises the variety of plant communities and landscapes in the northeast. At Mt. Cameron he pushed through thick dry sclerophyll forest before moving southwards through open forest, some of which had been burnt. After a few hours walking the party entered a dark wet forest of tall *Eucalyptus obliqua*: "of gigantic growth and there was a thick undergrowth". Later the same day, the forest was left well behind as Robinson led his party across: "heathy hills interspersed with tea-tree, and forest, and sword grass plains". In gullies, the party encountered great difficulty forcing their way through: "cutting grass thickets".

Once again the variety of plant communities is emphasised. The close proximity of unburnt tall wet forests to burnt heathy hills and sedge choked gullies, all on uniform geology, strongly suggests that fire is the agent responsible for the general distribution of the communities.

6/12/30: The party moved on towards Mt. Horror (a small marsh at the base of this mountain is examined for pollen in Chapter 6). Before the party reached the peak, the Aborigines came across groves of *Cyathea* sp., an edible fern found in rainforests. On Mt. Horror itself they encountered thick mixed forests with *Nothofagus*, *Atherosperma*, *Eucalyptus*, *Acacia*, *Zieria*, *Leptospermum*, *Dicksonia*, *Cyathea* and *Gahnia grandis*. After descending the mountain on the north side, Robinson pushed through a dense *Leptospermum* and *Acacia* forest before entering a: "large swordgrass plain (*Lomandra*? *Lepidosperma*?). This led into country which had been burnt by the natives".

This description suggests that the steeper slopes of the mountain were not subjected to regular burning. However, the northern footslopes must have been burnt in the previous 50 years or so to produce a forest of tea tree and wattle, while the sword grass plains and open forests were probably subjected to regular burning.

7/12/30: On this day the party was moving through undulating hilly country towards Waterhouse Point. Much of the country had been burnt and consisted of a forest dominated by *Eucalyptus amygdalina* and *Banksia marginata*.

8/12/1830: The party approached a fire on the *Allocasuarina* and *Banksia* covered plains to the east of Waterhouse Point. When they arrived at the fire, trees of

Allocasuaria were still burning, but there was no sign of Aborigines.

9/12/1830: In the open country, travelling was pleasant and fast. The party made good time back towards Cape Portland where they came across large expanses of open grassy woodlands with *Allocasuarina* and *Banksia* dominating over a ground cover of *Themeda*. Robinson made a number of similar observations in this area (eg. 23/7/31, 11/8/31).

23/12/1830: Robinson noted that: "when the hair of the natives becomes hard and plaited, they then soften it by warming it with a fire stick, and then dress it". From this, it can be assumed that firesticks were multifunctional objects.

1/6/1831: In the headwaters of the Tomahawk River, Robinson moved south towards Ben Lomond across: "a succession of hills covered with thick forest, but which had been rendered tolerable easy travelling by the recent burning of the bush by the natives. The trees consist of peppermint gum, honeysuckle, sheoak etc.--- These hills are covered with fern". This probably describes a good proportion of the dry hilly country to the south of Waterhouse Point. The fern was probably *Pteridium esculentum* which is commonly found in burnt forests in the northeastern lowlands.

2/7/1830: Robinson lists some of the 'amusements of the natives', one of which involves obtaining: "the large stalk of the fern leaf, which they heat in the fire and then stick it in the ground, which makes an explosion like muskets". This game well illustrates the point that fire was used for the profane as well as the sacred.

4 -5/7/31: On the south side of Mt. Horror, the party encountered extensive wet sclerophyll forests. In one place: "a large forest of mimosa (*Acacia*), some measuring six and eight feet round and from sixty to seventy feet high. --- The country as far as I could see consisted of hills covered with forest. There were some small plains covered with the common fern, which was above our heads". The majority of these forests were extensive tracts of *E. obiqua* dominated wet forest (Jennings, 1983), while the *Acacia* forests demonstrate that fires had removed eucalypts in place, thus allowing the rapid regeneration of wattles, which thereafter grew in the absence of major disturbance. The small fern covered plains may have been regularly burn, every year or so.

7/7/1831: To the north of present day Scottsdale, Robinson broke out of thick forest onto pleasantly open plains. The ferns and trees had been freshly burnt.

8/7/31: The plains referred to above were estimated at about 2,000 acres. Game abounded and *Nothofagus* was abundant in the surrounding forest. There seems no edaphic reason for open plains to exist at this location, so it seems likely that they were created by Aboriginal burning of *Nothofagus* rainforest.

12/7/31: At Mt. Stronacht near Scottsdale, the party passed through miles of forest which had been burnt some time previously. Blackened sticks and poles were still obvious as was the fire boundary, for there, the party met with an impenetrable wall of green scrub.

13/7/31: In the same country, Robinson passed through alternating expanses of 'brown' forest and 'green' forest. These were *Eucalyptus* and *Nothofagus* forests respectively. Robinson may have borrowed his nomenclature from Henry Hellyer, the Van Diemen's Land Company surveyor.

14/7/31: The party travelled through: "an immense green forest" after which they encountered open forest which had been burnt. Here they found traces of emu. Robinson comments that: "The natives can subsist in green forest on fern tree, wombat, porcupine etc". The presence of emu in forests is interesting for it is sometimes thought that the presence of emu shell or bones in archaeological deposits indicates the former presence of grasslands (Brown, 1988; Cosgrove *et al.*, 1990)

15/7/31: Still in the midst of a rainforest, the people with Robinson informed him that the tearing down of a large number of fern trees had been done, not by them, but: "by the blacks who once inhabited these lonesome forests and whose chief subsistence was on roots, animals etc. These tribes are now defunct". These comments probably do not mean that a tribe lived for all of their lives in rainforest. It is likely that a group had ownership or foraging rights and visited the forests on some sort of a seasonal basis.

17/7/31: On the plains near the mouth of the Forester River, Robinson commented that: "This part of the country had been fresh burnt by the natives. --- All the country fifteen miles inland from the coast had been burnt and is good hunting ground". Robinson was convinced that an Aboriginal path led across the lowland plains towards Launceston. The fact that the country was so well burnt, reinforced this idea.

22/7/31: Upon returning to the Tomahawk River, Robinson noted that:"The whole of the brush had been well burnt off by the natives and was good walking". The vegetation at this place was dry sclerophyll forest with heathy hill tops and shrubby slopes.

24/7/31: The party passed over several sword grass plains and grassy thinly wooded hills in the vicinity of Mt. Cameron. In the same area, they passed over: "a large open plain, thinly wooded. It had a park like appearance and was of several miles extent on either side - I could not see a boundary". The plains were not treeless, but they were almost certainly subject to a high fire frequency. The surviving trees were most probably *Allocasuarina*.

24/7/31: Robinson provides a general description for all of the low country between

Georges Bay on the east coast and the Tamar River to the west. The whole is thinly wooded, consisting of open forest of stunted peppermint, gum, cherry, oak and honeysuckle trees: and abounds with opossum and kangaroo of various kinds". This reinforces the notion that the northern plains, especially those parts underlain by infertile sands, were generally subjected to a moderate frequency of fire. It is expected that these sorts of communities could be transformed into either denser woodlands or grassland/ heathlands, depending on fire frequencies.

16/8/31: In the course of a conversation concerning religious beliefs, Robinson records that a chief (Mannalargenna) believed that: "The devil live in the fire - some said on the Big Hill".

18/8/31: During a thunder storm, the people with Robinson deliberately set fire to a tree in the belief that this act would moderate the wind. On the day before, Robinson had difficulty in keeeping the people quiet, and it seems likely that they were trying to communicate their position to the free Aborigines. The fire in the tree may have been a traditional belief, but it may also have functioned as a signal.

27/9/31: Inland from Double Sandy Point, Robinson's party crossed country which consisted of: "heathy and sword grass plains and open forest which had been burnt by the natives". This land is presently subject to a high frequency of fires and can still be described in the same fashion.

Summary

Robinson's accounts are significant in that they provide good evidence for the state of the vegetation at 1830 - 1831. The nature of the interaction between Robinson, the captured guides and the free Aborigines means that records of recent fires at that time cannot be taken to indicate a traditional pattern of burning. The reasons for burning cannot be clearly discerned. Nevertheless, the types of plant communities described by Robinson give some clues to the burning regime.

The descriptions of extensive tracts of grasslands with scattered *Eucalyptus, Banksia* and *Allocasuarina* within 20 km of the coast hints at a fire regime characterized by frequent fires, which in some cases might have the potential to eliminate trees and create grasslands. Equally as important as the grasslands were the heathlands and heathy forests which would also have been subject to high frequencies, but which existed on less fertile soils than the grassy formations.

Around isolated mountains such as Mt. Horror, rainforest and wet forests existed with an inflammable boundary of *Leptospermum* and *Acacia* separating wet sclerophyll from dry sclerophyll. It is not clear if forest expansion or attrition was taking place. It can however, be assumed that the presence of very old stands of *Acacia* and *Leptospermum* indicate long fire free intervals.

In more elevated locations further inland, rainforests and extensive wet sclerophyll forests were dominant (Robinson's lonely forests). People had formerly lived for at least part of the year in these wet forests. Limited areas of open ground within the forests were covered in bracken fern suggesting that high fire frequencies had been applied. Elsewhere, the extensive wet understoreys suggest that fire must have been an infrequent event.

2.8 Conclusions

The foregoing accounts show fairly clearly that fire was widely used in the northeast, throughout the year, from coastal plains to upland plateaux. The nature of the early mariners accounts of fire in the northeast is such that little detail can be recovered. The most significant accounts are those of Bass and Flinders, Humphrey, Brown, Wedge and Batman which all suggest that Aborigines deliberately used fire as a weapon of defense. The fires seen by these observers are in some cases likely to represent direct action by Aborigines to either warn away the invaders or to warn kinfolk of the invaders presence.

Collins makes it clear that grasslands were burnt adjacent to rainforest even at low altitudes, whereas the vegetation described by Hobbs and Lewis seems to be characteristic of widespread burning with little regard to the maintainence of vegetation boundaries.

Most important of all, Robinson's evidence shows that burning practices differed according to distance inland from the coast. This effectively defines a precipitation and altitudinal gradient along which fires were common and widespread on the coastal plains, whereas further inland, on more fertile soils and in places with higher rainfalls, fires were more restricted in their effects and certainly not as frequent.

Chapter 3

Ethnohistoric records relating to the use of fire by Aborigines in other parts of Tasmania

3.1 Introduction

A number of Aboriginal explanations for the origin of fire can be found in historical documents, chiefly in the journals of G. A. Robinson (Plomley, 1966). Most of these allude to lightning as the agent which produced fire (Plomley, 1966: 399). Bowman and Brown (1986) suggested that ethnographic data concerning fire might be obtainable from Aborigines living on the Furneaux Islands. This sort of information could then be used in the development of fire ecology theory, in the same manner as Jones (1968, 1975) has detailed the use of fire by people living in the Northern Territory.

Considering the long history of extremely high fire frequencies on Flinders and Cape Barren Islands engendered by pastoral interests, it is probable that most of the information would be inapplicable to the Tasmanian mainland situation, where a far more diverse landscape and flora exist. The major benefit of ethnographically collected data would be to reiterate the fact that Aboriginal people, beliefs or customs did not perish with the death of Trugernanna 1876. The stories quoted below are intended to underline the above point and to emphasise the ritual use of fire in Aboriginal society.

Three stories

1) A most interesting Laremairremener / Loontitetermairrelehoinner belief in regard to the origin of fire comes from Milligan (in Roth, 1899: 84-85). A part transcription of this legend is as follows: "My father, my grandfather, all of them lived a long time ago. All over the country, they had no fire. Two blackfellows came, they slept at the foot of a hill - a hill in my own country. On the summit of a hill they were seen by my fathers, my countrymen, on the top of a hill they were seen standing: they threw fire like a star, - it fell among the blackmen, my countrymen. They were frightened - they fled away, all of them; after a while they returned,- they hastened and made a fire,- a fire with wood; no more was fire lost in our land".

2) In the course of a conversation concerning religous beliefs in 1831, G. A. Robinson recorded that the northeastern Aborigines believed that "The devil live in the fire - some said on the Big Hill" (Plomley, 1966: 403).

3) On Cape Barren Island today, a custom called the 'The Christmas Fires' is practiced. On Christmas Eve, young men are sent to the summit of a nearby hill. Young children are

brought outside and told to watch. Presently fires begin to descend the hill in the shape of a Christmas tree. The young children are told that the Kutikina (a spirit figure) is about and that they had better get to bed in a hurry or else they will not receive any presents the next morning. Upon waking, they receive their Christmas gifts (*pers. comm.* R. Summers, Cape Barren Island).

The hill, the young men, the descent of fire and the spirit figures, have counterparts in the two 19th century stories. The symbolism encapsulated in the giving and receiving of fire cannot go unnoticed. The gift of fire must have been central to life in a society which rarely or never made fire. Just as the exchanging of gifts on Christmas day in Christian societies is regarded as symbolic of peace and understanding, so the giving of fire to a neighbouring band must have ranked as an occasion of great significance.

It is not claimed that this modern custom is identical to the older stories told to Milligan and Robinson. The people from Cape Barren do not need a white archaeologist to pompously state that their custom is based on a tradition far older than Christianity. Nevertheless, it is important to stress that in spite of obvious Christian transformation, some of the old lore concerning fire still exists.

The ethnohistoric record for Tasmania as a whole is capable of supplying good records of vegetation associations in the state for the late 18th and early 19th centuries although there are a number of significant biases which should be taken into account, the most significant being the preponderance of coastal observations compared to those from inland locations. Even so, it is important to gain an appreciation of the general 'fire ethos', from a point of view which is independent of the ubiquitous G. A. Robinson.

To a large extent, ecologists and archaeologists have based their fire interpretations and reconstructions upon the statements of Jackson (1965, 1968) and Jones (1969, 1975), without ever seeking to test the basic assumptions. Especially interesting is the use made of the observations of Francois Peron, anthropologist on the Baudin expedition. Jones (1969: 225) states that: "Explorers from Tasman onwards, seeing Australia from the sea, reported that the coastlines were dotted with fires. Peron, in 1802, sailing up the Derwent in southeast Tasmania, said that "wherever we turned our eyes, we beheld the forests on fire". Jones went on to note that G.A. Robinson: "has hundreds of descriptions of their setting fire to the bush, of distant Aboriginal fires, and of large areas of countryside freshly burnt by them". The power of these quotes, the former in regard to fire intensity and the latter with regard to fire frequency, has been such that few researchers have felt the need to question such apparently basic and useful statements. This chapter seeks to address issues such as these.

Finally, the statewide accounts enable the record from northeastern Tasmania to be put into a general context to allow a more comprehensive appreciation of fire / vegetation relationships.

3.2 Methods

The chapter extends the methods of Chapter 2 to the rest of Tasmania. By continuing the annotated approach, extracts are available for immediate analysis instead of consigned to an uncertain fate in the appendices. This is considered to be important, for ethnohistoric data presented in gazeteer form, often fails to do justice to the observational and literacy skills of the early mariners and explorers.

Particular attention is paid to the context of passages, especially in regard to details regarding the motivation for setting fires, local vegetation and weather conditions. As in chapter 2, the order is basically chronological, thus giving a feeling for accelerated vegetation change wrought by Europeans. The scheme naturally tends to separate the observations into the groups devised by Jones (1971,1974): *viz*. early mariners, later mariners, official correspondence, private accounts of early settlers, the first government surveyors and the la\ter private surveyors.

3.3 The early maritime expeditions

Tasman: 1642

On the 2nd of December, 1642, a small expedition commanded by Abel Tasman, anchored at Blackman Bay in a good harbour near Marion Bay on the south east coast of Tasmania. The celebrated pilot, Francoys Jacobsz Vissher, set out to shore with a party of armed men in order to resupply their ships. For the first time in perhaps 50,000 years, a person from another continent had stepped onto Tasmanian soil.

The owners of the land were the Portmairremener although Vissher was not cognizant of this fact, for he never saw the inhabitants. What he saw was high land: "covered with vegetation---, an abundance of excellent timber, and a gentle sloping watercourse in a barren valley" (Heeres, 1985: 29). Vissher heard human voices which resembled the music of a trumpet or a small gong. He saw two large trees with notches made from flint implements and assumed that the people who made the notches must have been of exceptional stature, for the notches were fully 5 feet apart (Heeres, 1985: 29).

The landing party noted that: "The land is pretty generally covered with trees, standing so far apart that they allow a passage everywhere --- unhindered by dense shrubbery or underwood---" (Heeres, 1985: 30). Interestingly enough, the party made a discovery regarding fire which over 100 years later took on the the aspect of a minor controversy. They found in the interior: "numerous trees which had deep holes burnt into them at the upper end of the foot, while the earth had here and there been dug out with the fist so as to form a fireplace, the surrounding soil having become as hard as flint through the action of fire" (Heeres, 1985: 30).

Later that day, Vissher saw: "clouds of dense smoke rising up from the land", and his land crew noted at various times: "clouds of smoke ascending" (Heeres, 1985: 30). The final observation of note from this very first European visit was made on the 3rd of December when Tasman himself decided to visit the shore in order to raise a flagpole as a memorial to the visit. Unfortunately for Tasman, the surf was rough enough to dissuade him from stepping ashore and so he ordered his carpenter, Pieter Jacobsz, to swim ashore and raise the pole. This he did, and while working there alone, he noted that one of a group of trees near to him was burnt near to the ground (Heeres, 1985 31).

Summary

Tasman and Vissher established that people lived in the southland and that fire was an element in the landscape. Fires were sufficiently intense to cause damage to the bases of trees. The underwood appeared to be remarkably open. This indicates a local fire frequency in which fires were reasonably common but at low intensity.

The countryside seems to consist of a mosaic of forest and shallow valleys with open vegetation. The open understories in the forests suggest fire as a cause, while the open nature of the valleys may relate to a combination of fire with frost or drainage effects.

Captain Marion Du Fresne: 1772

This is the least well documented of the major maritime expeditions. Unlike the D'Entrecasteaux or Baudin expeditions, the material has not been widely circulated and thus, what is available is considered in some detail. The following extracts are taken from translations by Isabel Ollivier (1985) and Roth (1891).

Julien Crozet, who became commandor of the Mascarin after the death of Du Fresne in New Zealand, noted that along the coast of Van Diemen's Land near to Marion Bay he saw:"a lot of fires along the coast" (Ollivier, 1985: 7). After setting anchor, a landing party was sent ashore to where a group of Aborigines were observed. This marked the first meeting of Europeans with Tasmanian Aborigines, probably of the Portmairrenmener tribe. After 130 years, the disembodied bell like voices heard in 1642, had at last been given corporeality.

It is significant that as the Portmairremener came forward, in a portentous gesture, they offered fire to Du Fresne and his party. Some kind of misunderstanding ensued, which ended in the taking up of arms. Spears and stones were hurled at the French. Du Fresne himself was wounded and the retaliation by French sailors killed one Aborigine and wounded several others. It seems as if some tradition relating to the offering of fire had been violated with fatal results.

Crozet examined the corpse of the unfortunate Portmairremener man and concluded that his dark skin was purposely blackened by smoke. He also noted that:

"The trees in this country are burnt at the foot. There seems to be only one kind of pine, much smaller than ours, which is exempt from this. The ground is burnt everywhere and we found in some places it was burnt to a depth of six inches. In the woods there is a lot of wild sorrel and of fern like the European one. Game in general is not common; we presume that it is the fire these natives make that drives it into the interior" (Ollivier, 1985: 8).

Later, Crozet located a campsite and saw that the people built large fires at night (Ollivier, 1985: 8).

Roth's account of Crozet's journal (Roth: 1891) is more expansive than the extracts by Ollivier. According to Roth, Crozet deduced from the number of fires sighted along the coastline that the country was thickly populated. He also describes in detail the landing party and subsequent incident. Instead of simply offering fire to the French, it appears as though a considerable campfire was built, with an invitation to ignite the woodpile. This was done and cordialities commenced. When Du Fresne tried to land in the second boat, a second opportunity was given to light a prepared fire. Du Fresne duly completed the task only to realize that instead of reinforcing friendship, the ceremony had somehow gone awry. At this point the Portmairremener attacked and the French retaliated.

In the days that followed no face to face contacts were made. Crozet notes that the soil was light and sandy and that traces of fire could be found everywhere, the ground being covered with ashes. In the middle of a grove of trees which had been de-barked and which had been burnt at their bases, an undamaged pine like tree was found. Crozet assumed that the tree was purposely left untouched and that it might contribute something useful to the Aborigines.

An account of the same series of incidents by the junior officer, Paul Chevillard De Mantesson sheds more light on the attack. He recalls that the attack commenced when the officer in charge of a third boat neglected to hide his weapons (Ollivier, 1985: 219).

A further account, by 1st Lieutenant Mr. Le Dez, indicates that they saw several fires along the coast, only one of which was considerable. This particular fire was atop the summit of a mountain and appeared: "more like a volcano or a conflagration than a fire deliberately built". Three other fires were thought to have been made by people. Le Dez thought it unlikely that the fires had been deliberately lit in response to the French visit. These fires seem to have been located on the far southeastern coast. Later, in the vicinity of Marion bay, more smoke was sighted in a landscape which had trees growing down to the ocean edge.

Le Dez writes that it was the approach of a third boat filled with armed sailors that alarmed the Aborigines and created an atmosphere which erupted in violence. He considered the offering of fire to be a friendly gesture from people to whom fire seemed to have an extraordinary significance. Later, Le Dez was astonished at: "how many places we have found where they have lit a fire and how much the woods are devastated by it. We have seen few trees that were not damaged at the foot and it was the same throughout the whole day" (Ollivier, 1985: 276).

Summary

The numerous fires seen indicate that the southeast coast was frequented during late summer. The sandy soils supporting a cover of *Pteridium esculentum*, or possibly a native *Rumex*. *Pteridium* is a fern which thrives in light soils, especially where frequent fires promote aggressive growth from rhizomes which are insulated from fire by soil.

The fact that trees were only burned at their base suggests low fire intensity. The astonishment evinced by Le Dez is probably the reaction of a man with little experience of forest fires, and with no inkling that in a far off quarter of the globe, there existed a salamander like family of trees which actually depended on fire for existence.

The pine like trees might be *Exocarpos cupressiformis* or *Allocasuarina littoralis*. Alternatively, they could represent a now extinct population of *Callitris rhomboidea*. In Tasmania it is a notable feature of these species that fallen cladodes tend to accumulate and inhibit the growth of understorey competitors. This has the effect of lowering the local incidence of fire, which results in individual trees remaining undamaged by even quite extensive fires (J.B. Kirkpatrick, *pers comm*).

A more likely explanation is that the trees may have been the rainforest and mixed forest species, *Phyllocladus aspleniifolius*. Over 40 years later, in 1818, the botanist, Allan Cunningham (see below) noted that this species was commonly referred to by settlers as 'Adventure Bay Pine' (Cunningham in King, 1818). Just as Du Fresne was interested in finding pine trees suitable for the construction of masts and spars, so Phillip Parker King and Allen Cunningham did in fact use the 'Adventure Bay Pine for just such a purpose.

If the trees were *Phyllocladus*, then it really is remarkable that they should survive a fire which burnt neighbouring trees as *Phyllocladus* is invariably killed outright by fire (Kirkpatrick, 1977). The fact that they were untouched amongst groves of fire damaged and de-barked trees suggested to Crozet and others that the Aborigines had deliberately protected and nurtured the specimens. Jones (1969) and Mulvaney (1989) have commented that the practice of manipulating flora by utilizing specific fire regimes was commonplace on mainland Australia.

The role of fire prior to the shooting incident is taken by all observers to indicate the symbolic importance that Aborigines attached to fire. If, as has been suggested, Tasmanians did not have or require the technology to create fire, then the offering of fire may have constituted a supremely significant act. That the French might have frightened the Portmairremener or unknowingly transgressed an important custom, can be seen to symbolize the troubled future of Aboriginal / European relationships, and to set the ambiguous tone regarding the use of fire as recorded by other maritime explorers.

Captain Tobias Furneaux: 1773

Furneaux was captain of the 'Adventure' in Cooks 2nd voyage to the south seas. After becoming separated from Cook in the 'Resolution', Furneaux hove to off Louisa Bay on the south coast. Here, a cutter was sent ashore where the landing party observed several Aboriginal fireplaces surrounded by abalone shells (Furneaux, in Cook, 1777: 110). Except where noted, the following extracts are taken from Cook's printing of Furneaux's account. No substantial difference exists between these and the same passages in Furneaux's original narrative, reproduced in Beaglehole (1969: 729-745).

At Adventure Bay, Furneaux noted Aboriginal fireplaces with food refuse strewn about. He noted that the soil appeared to be rich, the hillslopes were clothed with wood and that: "the trees are mostly burnt, or scratched near the ground, occasioned by the natives setting fire to the underwood in the most frequented places; and by this means they have rendered it easy walking" (Cook, 1777: 112). In the ships log (Beaglehole, 1969: 151), Furneaux records that at this place "they make large fire(s) of the woods so that most of the trees are burnt near the ground."

The shooting of what appeared to be a white goshawk, suggests the presence of nearby wet forest or rainforest, for the birds are restricted to those places for breeding (R. Green, Queen Victoria Museum and Art Gallery, pers. comm).

Furneaux also recorded "several smokes and large fires, about eight or ten miles in shore" to the north of Adventure Bay (Cook, 1777: 113). According to his narrative, Furneaux never met with any Aborigines (the Nuenonne), though he frequently came across their camping sites. However, in the ships log, Furneaux wrote: "The trees seems most of 'em to have burnt down, for their was not the least appearance of any ingenuitty. We see their fires in a sandy bay to the n'ward of us, but no way inclineable to near us. But seem'd rather to fly from us" (Beaglehole, 1969: 151). This account suggests that Furneaux might have actually sighted the Nuenonne, who may have been reluctant to make contact with Europeans. This is not surprising considering that only a year earlier, Du Fresne had left south eastern Tasmania with Portmairemener blood on his hands.

In a Nuenonne hut, Furneaux found: "the stone they strike fire with, and tinder made of bark, but of what tree could not be distinguished" (Cook, 1777: 113). He assumed that the inhabitants seemed to have the custom of laying: "on the ground, or dried grass, round the fire" (Cook, 1777: 113-114).

Summary

The chief value of Furneaux's observations are to emphasise that burning was carried out along the entire east coast during late summer. The effect of the fires at Adventure Bay was to allow a reduction of the understorey, without radically affecting the dominant trees which may have been either *E. globulus* or *E. obliqua* (Beaglehole, 1969: 734).

That the Nuenonne were camped at the neck on Bruny island may have been a response to Furneax's expedition invading the sheltered Adventure Bay. Alternatively the heathlands at the neck may provided more congenial living places than the forests at Adventure Bay.

If Furneaux did indeed sight the Nuenonne, then he should be credited with the second European interaction with Tasmanian Aborigines instead of that distinction being accorded to Cook on his third voyage in 1777.

James Burney: 1773

Burney was second lieutenant to Furneaux. He was in charge of the party which landed on the south coast on the 10th of March, 1773.

The very first thing which attracted Burney's attention was: "some wood ashes the remains of a fire which had been kindled there & a great number of scallop shells -We saw none of the inhabitants - there was a path leading through the woods which would probably have led us to their huts" (Burney in Beaglehole, 1969: 746). Burney returned to the ship taking with him some samples of burnt wood and a number of shells.

In relation to the smoke and large fires referred to by Furneaux, Burney is a little more expansive, pointing out that: "we saw fires continually on the north side of the Bay where the land is lower & and not so much over run with trees and underwood as the part we lay in" (Beaglehole, 1969: 747). The country to the north was probably near to what is now referred to as the neck. This place is presently vegetated by coastal heaths and patches of open forest with thickets of *Leptospermum* around swampy areas and freshwater lagoons.

Burney records that the forests at Adventure Bay itself were composed of tall trees with a reasonably dense understory. In these forests, Burney found: "several of their huts -& large hollow trees in which they had lived-there were paths which led along the woods, but almost overgrown with bushes" (Beaglehole, 1969: 747). It may be that the overgrown paths were actually the 'runs' made by territorial wombats or forest dwelling wallabies.

Burney provides an excellent description of the floral and faunal resources of Adventure Bay. His list of terrestrial, aquatic and avian animals suggests an environment richly endowed with food resources. From the top of a hill, Burney sighted mainland Tasmania across the D'Entrecasteaux Channel and noted that by: "the many fires we saw there, must be well inhabited" (Beaglehole, 1969: 748).

Summary

Burney's account adds valuable detail to that provided by Furneaux. Especially significant is his observation that pathways led up into forests from fireplaces kindled on or near to the beach at Louisa Bay. Also important is his sighting of fires on the western shore of the D'Entrecasteax Channel. This demonstrates that during late summer people occupied both shores of the channel concurrently.

Captain James Cook: 1777

On his 3rd and final voyage, Captain Cook in the 'Resolution' and accompanied by the 'Discovery', weighed anchor in Adventure Bay (Cook, 1785). From the time of his approaching the coast, Cook saw columns of smoke rising from the wooded hills.

He took interest in fire hollowed trunks of large trees which he assumed acted as shelters for Aborigines. In or near to these habitations he noted the presence of heaps of shells and the marks of fire thus providing him with proof that the people did not eat their food raw (Cook, 1785: 101).

His surgeon, Mr. Anderson, added that hearths made of clay were to be found on the ground in the middle of the hollow trunks. He further deduced that: "the care they take to leave one side of the tree sound, which is sufficient to keep it growing as luxuriantly as those which remain untouched" (Cook, 1785: 101).

Anderson notes that the forests on some hill slopes were thin, with a coarser grass like understorey.

Summary

Cook and Anderson shed a little extra light on fires and the environment at Adventure

Bay. The coarse grass noted by Anderson as occurring on some lightly timbered hillslopes may have been a genuine grass, perhaps the lily, *Lomandra longifolia*, or one of a number of sedges, perhaps *Ghania grandis*. This would indicate a frequency of fires high enough to discourage tree establishment and encourage the growth of grasses and /or graminoids. The use of fire hollowed trees as habitations by Aborigines was first raised by Visshers on Tasman 's expedition. The observations by Cook and Anderson were to stimulate an interest in the same question by Cook's young sailing master, William Bligh.

Lt. William Bligh: 1788

Bligh arrived at Adventure Bay in August, 1788 *en route* to larger and more celebrated adventures in Tahiti (Bligh, 1798). The 'Bounty' spent 12 days at anchor and during this time, Bligh located evidence of the earlier voyage of Furneaux in 1773, and of his own passage with Cook in 1777. From the trunks of trees which had been cut down in 1777, Bligh noted that about 25 feet of coppice growth had emerged.

He thought that the successful planting of fruit trees was likely to be jeopardized by dry season fires lit by Aborigines. He wrote that: "the fires made by the natives are apt to communicate to the dried grass and underwood, and to spread in such a manner as to endanger everything that cannot bear a serious scorching" (Bligh, 1798: 49).

On the 1st of September, Bligh observed indications of Aborigines for the first time, with sightings of fires on the lowlands near Cape Fredrick Henry.

In spite of Bligh's notion that fire caused the thinning of understories, he was quite impressed with the size of the forest trees which: "are lofty and large. The underwood grows so close together, that in many places it is impassable" (Bligh, 1798: 52). He also noted that the vegetation was much more luxuriant on the south sides of hillslopes.

Additional evidence is provided by the Log of the Bounty (1975). Here, Bligh expresses some reservations regarding an observation of smoke made on the 21st August. He writes that: "There were several places in the woods where there was the appearance of smoke; but I am doubtful if it was any more than some exhalation of the sun" (Bligh,1975: 280).

Bligh vigorously attacks the problem of fire created hollows in trees supposedly used for habitation. He eventually decides that the form of the hollows, their limited size, the general uncomfortable nature and the close proximity of 'wigwams' mitigated against the hollows being deliberately made for domestic purposes.

Summary

On this voyage, Bligh makes a number of significant environmental observations. Especially interesting is the fact that to some extent the distribution of vegetation is controlled by factors other than fire. The restriction, of what appears to be rainforest, to south facing slopes is in accordance with the known preference of rainforest for moist shaded situations. This tendency may have been reinforced by Nuenonne burning patterns.

Also, the density of the understory vegetation might indicates a fire free period of at least 11 years, the time since Cook's visit in 1777. This probably correlates with the age of the new coppice growth. The lack of grass seems to indicate that the understorey is composed of wet forest shrubs, possibly *Pomaderris*, *Zieria* or *Olearia.* Although it would be improper to suggest that the 'exhalations of the sun' observed by Bligh could seriously be mistaken for large fires, there is no doubt that mists about Mt. Wellington do bear a considerable resemblance to smoke and even today, the phenomenon still manages to cause occasional false alarms at the Hobart Fire Brigade.

Captain John, Henry Cox: 1789

Cox anchored his boat, the 'Mercury' in Oyster Bay on the 7th of July, 1789. An officer in the Royal Marines, Lt. George Mortimer, recorded the events of the visit. He saw that: "here were also evident marks of inhabitants, most of the large trees being hollowed by fire, so as to form a shelter from the weather, and great quantities of shells heaped about them" (Mortimer, 1975: 17). Two days later, Mortimer wrote that: "a smoke was observed on the opposite side of the Bay from that where she (the 'Mercury') was stationed. --- on landing, saw several of them moving off with pieces of lighted wood in their hands" (Mortimer, 1975: 18).

Following this brief encounter: "The next morning we again saw a smoke. ---As we approached the shore, we observed several of the natives about the fire, and walking among the trees, some of them carrying very large poles and pieces of lighted wood in their hands". A short time later, Mortimer saw another smoke, this time on a hill, where: "We found they had kindled a large fire, and next to it lay several little baskets made of rushes, in which were most of the articles we had given them, carefully tied up with a few flints and stones, and a little dried grass; from which circumstance I conclude they produce fire by collision" (Mortimer, 1975: 20).

Summary

Mortimer provides a quite touching glimpse of the reaction of an Aboriginal family (possibly the Laremairremener or Loontitetermairrelehoinner) to what must have been an extraordinary circumstance. Nothing in the account suggests widespread burning on the central east coast during mid-winter.

His conclusion that fire could be made by collision seems reasonable in the light of the contents of the baskets. It is not clear if Mortimer discriminates between Aboriginal flints and Aboriginal stone tools, or whether gun flints had been distributed as gifts by the British.

Captain William Bligh: 1792

As Bligh's punative expedition neared the Tasmanian coast on the 8th of February, 1792, a number of large smokes from Aboriginal fires were seen on the mainland in the vicinity of South Cape (Bligh,1976).

At Adventure Bay, Bligh picked up handfuls of fine shavings of wood which he believed were used by Aborigines to prepare their fires. He also noted a bundle of: "dried inside bark tied up two feet long, intended as a flambeau" (Bligh, 1976: 9/2/1792). A few days later a single fire was seen on the northwest side of Fredrick Henry Bay (Bligh, 1976: 13/2/1792).

Unlike the traditional stolid, unimaginative image of a British sea captain, Bligh was a thinking man who seemed never to be short of a hypothesis. For example, the thickness of forest on the slopes of a hill and the absence of marks of fire on its summit prompted him to: "readily suppose the natives do not take the trouble to go near it" (Bligh,1976: 17/2/1792). He further supposed that: "The country looked in all parts pleasant and covered with wood. We saw numerous fires as if the country was fuller of inhabitants than has hitherto been supposed, and particularly about the shore of the Table Mountain, where it is certainly the finest part of the country, and most likely place to find rivers (Bligh, 1976: 22/2/1792).

In relation to a lack of game to be found, Bligh suspected: "that the great fires which the natives make about the coast is the cause of keeping away many animals, the native inhabitants of this country" (Bligh, 1976: remarks).

The mode of fire making practiced by the Aborigines fascinated Bligh. The above mentioned remark concerning his discovery of a firestick or flambeau, prompted him to expand on the subject in his remarks. He wrote:

"It has been remarked from small baskets being found containing flints that they got fire by collision, but I have not heard of any fungus discovered, or any substitute that will contain the sparks made by collision. - I have found rolls of peculiar bark which is taken from the trees of the smallest species of the Metrocedera that I conceived would affect this purpose, but with the fairest trials I could not accomplish it, although a small particle of collected fire put among it will soon generate such a body as to secure the end in the wettest weather. It appears that they have some trouble making fire, for besides this dry bark, they use shavings of some dry wood which has the likeness of being taken off by a plane iron of an eigth of an inch wide. -Several handfulls of these shavings lay about most of the wigwams I saw - I apprehend they are formed by the sharp end of the muscle shell" (Bligh, 1976: remarks).

The final observations concerning fire include some recent marks of fire about a native hut and several fires away to the northwest (Bligh, 1976: 24/2/1792). As the 'Providence' and the 'Assistant' sailed past the north end of Maria Island, he marked on his chart a point of land which he named 'Smoaking Cape'.

Summary

Bligh's observations include some of the earliest hypotheses concerning the use of fire by Aborigines. Especially interesting are the descriptions of fire sticks, and his attempts to produce fire by percussion - surely the earliest example of ethnoarchaeological experimentation in Tasmania and possibly Australia.

Bligh was correct in supposing that the coast at the foot of the table mountain (presumed to be Mt. Wellington) was well inhabited by people.The frequency of fire in that area would have had major effects on the vegetation. The fact that tall wet eucalypt and *Atherosperma* forests were restricted to fire protected locations at the time of settlement suggests that fires had played a major part in the evolution of vegetation patterns of the Hobart area. This opinion is verified by the later opinions of a prominent Tasmanian horticulturalist (Bunce, 1857). The open grassy nature of *Eucalyptus* and *Allocasuarina* woodlands on surrounding hill slopes suggests a high frequency of low intensity burns (see Collins, 1803 in 1971).

Bruny D'Entrecasteaux 1792 - 1793

This famous expedition has formed the basis for much discussion concerning Aboriginal life (Jones, 1971, 1974, 1984,1988; Plomley, 1983; 1987). The fame of the expedition lies chiefly with its great naturalist, Jacques de Labillardiere, whose authority forms the basis for many of the first detailed, systematic botanical observations in the state (Buchanan *et al.*, 1989). The following comments are taken from the English translation of Labillardiere's account of D'Entrecasteaux's expedition (Labillardiere,1800) which visited Van Diemen's Land during April / May 1792 and February 1793.

The observations concerning fire and environment are many and varied. At Recherche Bay, he (Labillardiere) was: "astonished in contemplating the prodigious size of these trees, amongst which there were some myrtles more than 25 fathoms in height" (Labill., 1800: 94). He described a classic rainforest in which: "We found some rudiment of huts in these woods, consisting of a framework made of the branches of young trees, and designed to be afterwards filled up with pieces of the bark, which the natives always use to cover the outside of their cabins" (Labill., 1800: 97).

Labillardiere enters the debate first mentioned by Tasman, then Cook, Anderson and Bligh in turn, concerning the use of burnt out tree trunks as shelters. Labillardiere, having read Anderson's account, agrees that the trees were indeed used for shelter and offers the evidence of shell fish being located in some of the cavities. He is certain that the cavities were deliberately fashioned by Aborigines and thus he invested Aborigines with the ability to use fire in a most sophisticated fashion (Labill., 1800: 99). Later, he suggests that these particular shelter trees were only located in the vicinity of the coast (Labill., 1800: 103).

He frequently came across the remains of native huts, some located in forest (eg. Labill., 1800: 97,102) with others on forest edges (Labill., 1800: 101,129). Groups of huts were seen in sheltered *Acacia* forests which bordered saline inlets (Labill., 1800: 103). In addition, Labillardiere and his party often came across pathways or 'roads' leading through forests (Labill., 1800: 102, 103, 134, 319, 321).

The expedition also found the first evidence of the use of fire for the purposes of cremation (Labill., 1800: 117, 121).

Early in May, Labillardiere observed: "a thick smoke ascending from the distant country to the northward of the great lake, and soon decried five of the natives walking away from a fire which they had been kindling on the shore: one of them carried a fire brand in his hand with which he lighted the flames in different places, where the fire presently caught and was almost as soon extinguished " (Labill.1800: 123). It is important to note here that large columns of smoke can be produced from entirely controlled fires. If the Aborigines had not been sighted, the observation could easily be misinterpreted as a dramatic bushfire instead of a series of small fires, one of which was a campfire on the shore.

In this light, a later observation that over 20 fires were seen kindled on the coast to the south (Labill., 1800: 130, 131) could be taken to indicate a series of controlled burns and / or campfires, rather than 20 raging bushfires.

On Bruny Island, a party about to land observed: "several small fires at a small distance from the shore, they determined to land; when as soon as they had entered the woods, they found four savages employed in laying fuel upon tree small fires, about which they were sitting. The savages fled ---, leaving their crabs and shell-fish broiling upon the coals. Near this place they saw other fires and huts. It appears that this spot is much frequented, as fourteen fire-places were discovered" (Labill., 1800: 127).

Labillardiere deduced from the presence of flints and soft bark carefully placed in soft baskets made of rushes, that the Aborigines: "undoubtedly , procure themselves fire by striking two pieces of flint together" (Labill., 1800: 127). In this extensive forest campsite, about 30 woven baskets were found, each filled with food or other goods.

Upon returning to the D'Entrecasteaux Channel in 1793, Labillardiere noted the presence of several fires on the coast of mainland Tasmania (Labill., 1800: 316, 317, 318). Finally, he observed food refuse on the floors of smoke stained caves situated on steep hill slopes near Adventure Bay.

Summary

The considered tone of Labillardiere's prose and his attention to detail give his observations a high degree of credibility. The most significant point is that during Autumn (April to May) and late Summer (February) no intensive or massive burning was carried out in the vicinity of Recherche Bay or the D'Entrecasteaux Channel. In spite of numerous fires being sighted, they appeared to be, in the main, controlled small burns, perhaps campfires rather than bushfires.

Labillardiere recorded extensive stands of *Nothofagus* rainforest as well as tall eucalypt forests, heathlands and coastal scrubs. The variety of plant communities reflects the complex relationships that exist between, climate, site characteristics and fire regimes.

An interesting point is that Labillardiere recorded Mellukerdee huts and living areas within rainforest. All campsites were either in or on the margins of forest. Pathways were purposely beaten through dense understories and usually led to habitations or resource centres within forests.

Lt. John Hayes: 1793 - 1794

A paragraph in the Madras Courier (2/1/1795) noted the completion of a secret voyage of discovery in the 'Duke of Clarence' and the 'Dutchess' under command of Capt. Hayes. It went on to say that: "The country is covered with an abundance of large trees, one in particular much resembling the English Oak."

The secret expedition was in fact an escapade, the result of a wager between two naval officers attached to the East India Company (Taylor, 1973). The unfortunate aspect of this voyage is that in spite of 6 weeks spent in the Derwent Estuary, almost no written records survive. A chart in the possession of the the British Admiralty is the single most valuable extant record. It is possible that the original journals may one day be located somewhere in the French archives, for Taylor maintains that they were confiscated from a vessel *en route* to England (Taylor,1973: 49).

Lee (1912) notes that Hayes discovered an open plain ('King Georges Plains') near to the present day suburb of Glenorchy . Later,in 1804, Lt. Collins remarked, "Mr Hayes called 300 acres, King Georges Plains! Could this have been in derision? "(see Collins, 1804 in 1971: 185).

Summary

That six weeks of observations were tragically reduced to a chart and a single paragraph in an Indian newspaper, makes this the most disappointing record from any of the expeditions to Tasmania.

The King Georges Plains represent the only indication that patches of open ground existed on the forested western shore of the Derwent. Whether the plain was caused by Aboriginal burning is unknown. Present day observations show that open grassy woodlands increase in frequency upstream from Hobart towards and beyond Glenorchy where the plains once existed. Collin's (1804 in 1971: 185) indicates that the miserly area of 300 acres which comprised King Georges Plain scarcely warranted a royal appellation. From this it might be possible to sustain a view that the western side of the Derwent was, for the most part, covered in forest.

Matthew Flinders and George Bass: 1798

After surveying the northeast coast of Tasmania, this expedition completed the first circumnavigation of the Island. At Circular Head on the northwest coast, Bass found difficulty in pushing through tall scrub: "although it had been partially burnt not long before" (Flinders: clxx). Few indications of fire were sighted along the long reach down the west coast. A single smoke was seen emanating from a river valley leading up to the Norfolk ranges.

The comments of George Bass are included in Collins' account of the early settlement of Australia (1804, in 1971). This record adds some few details to Flinders reminiscences. The partially burnt scrub observed by Flinders at Circular Head was estimated by Bass to have been burnt: "many months ago" (Collins, 1804: 171). As the sloop passed the De Witt Islands, Bass noted that there were vestiges of fire on the two inner-most islands. He was interested in the fact that the vegetation appeared to have burnt only in patches and concluded that people must have been responsible. A large smoke was seen on the mainland behind the islands, proving to Bass that the southwest coast was inhabited. Similar burnt patches were observed on a small group of islands called the Friars, off Tasman's Peninsular (Collins, 1804: 171-181).

Near Risdon Cove, opposite King Georges Plains, Bass described the hills as stoney with an abundance of tall, timber which diminish in size down slope to eventually thin out to a few scattered she-oaks and gum trees, interspersed with small copses of the beautiful flowering fern. (Collins, 1804: 186).

Summary

Neither Bass nor Flinders record large bushfires. In fact the absence of fires and smokes seems remarkable, especially in the light of the considerable archaeological deposits found on almost all parts of the Tasmanian coast.

The pattern of burning on the islands of the south coast indicates that fires did not consume all the vegetation in one event. The fires appeared to have been patchy in nature.

The heavily forested ridges and lightly timbered lower slopes of the Risdon Cove area suggests that Aboriginal burning had major effects on the vegetation nearest to the economically important shore of the Derwent. This pattern is reflected in the archaeological record for the area where middens are frequently encountered within 400 m of the shore whereas both middens and artefact scatters are rarely encountered on ridge tops.

Negative evidence provided by Bass and Flinders concerning the lack of evidence for smoke on the Furneaux Islands has been used as evidence that those places were uninhabited at the time of European contact (Jones, 1971, 1977; Taylor, 1973). Although this inference has since been proven to be correct, the same reasoning does not hold and cannot be applied to other parts of the Tasmanian coastline where few smokes were observed.

The Baudin expedition

The following transcriptions are taken from Cornell's translation of Baudin's personal journal (Cornell, 1974) and Peron's account of the same events (Peron, 1809). Plomley's sumptuous dissection of the Baudin expedition is used to provide evidence from other officers aboard the 'Naturaliste' and 'Geographe' (Plomley, 1983).

Jones (1988: 40) correctly points out that style of Baudin's writing in his journal stems from a classic tradition in which harmony and order rule; whereas Peron's highly personal account reveals his Romantic leanings and a willingness to put Degrando's instructions to the test. The palpable tension between the rigid naval Commander and the carefree citizen naturalist is to some extent, a reflection of differing levels of responsibility, but within a larger context, their differences symbolize the great movements which were propelling Europe to modernity. The observations must therefore be interpreted in the light of the protagonists outlook and philosophical convictions.

Captain Nicolas Baudin: 1800-1804

On the 13th of January 1802, the expedition sighted land and edged into the D'Entrecasteaux Channel. Almost immediately, a group of 15 to 20 Aborigines was sighted, and later that night, Baudin: "saw several fires in various parts of this large Bay" (Cornell, 1974: 301). It is unclear if these people were Nuenonne or Mellukerdee. On Partridge Island four Aborigines dissapeared into *Eucalyptus* forest which covered the island. Curiously, Labillardiere (Labill., 1800: 126), in 1792, described the vegetation of Partridge Island as consisting of *Allocasuarina*, *Apium*, various ferns and a type of pea, *Glycine*. Labillardiere mentions that the soil seemed to be exceedingly 'humid' but notwithstanding this, the *Allocasuarina* seem to thrive. It is not possible for a forest of *Eucalyptus* to grow in the space of 10 years and thus it seems that Labillardiere's account might be less than thorough.

This becomes even more obvious when Baudin describes a forest of enormous trees on the island, all of which had: "been evenly burnt out to a height of 7 or 8 feet, and the chamber that had thus been made could easily hold eight or ten people" (Cornell, 1974:303). From this comment it seems probable that Baudin was aware of the ongoing minor controversy concerning the possible use for shelter of fire hollowed trees by Aborigines

The following curious incident on the 15th January, 1802 may bear some relevance to the lighting of fires by Aborigines. A number of officers and a large group of Nuenonne had gathered around a substantial fire kindled on a beach. Gifts had been distributed to the Aborigines. During the cordialities, Citizen Maurouard embarked upon a game of arm strength, in which two of the most sturdy Nuenonne were bested. Moments later, as Maurouard was about to board a boat to return to the 'Naturaliste', a spear was thrown which struck him in the neck and shoulder.

A perplexed Baudin thought that either, one of the bested Nuenonne sought to atone for humiliation suffered at the hands of Maurouard, or that some basic treachery was afoot. He further noted that the Nuenonne were well acquainted with the purpose of firearms and showed great nervousness if a weapon was simply touched. Also, it should not go unmentioned that some degree of sexual contact occurred between the French and Aboriginal women (Cornell, 1974: 305). From this it is clear that a significant degree of tension born of fear, frustration, jealousy or the unknowing breaking of a custom had occurred.

The next day it became apparent that the Nuenonne were no longer in the neighborhood, there was no sign either of people or of fire. In the ensuing pregnant atmosphere, Captain Hamelin of the 'Naturaliste' encountered:

"about thirty of them when he was sounding along the northern side of the bay. When they saw his boat approaching the shore, they no doubt thought he was going to land and seemed to want to prevent him. They were all armed with spears, and so that there should be no lack of weapons, several were carrying large bundles of them. One man was walking on in front and carrying a brand with which he set fire to everything as they went along. This, I believe, is customary when they want to stave off or begin a war amongst themselves" (Cornell, 1974: 307).

Whatever the reason for the spear throwing incident, the relationship had clearly soured. The speed at which the Aborigines decamped and the absence of women and children from the armed party encountered the next day, clearly points towards an atmosphere of fear and distrust. The carrying of bundles of spears and the aggression shown towards Hamelin reinforce this view. From the point of view of this thesis, it is of great interest to note the appointment of an older person who appears to have sole responsibility for the lighting of fire. This incident is remarkably similar in many respects to the actions of a man observed near Georgetown on the Tamar estuary in northern Tasmania by Matthew Flinders (Flinders,1814: clv). The fire appears to be intimately related to some type of ritual use in regard to aggression or fear. The use of fire as a defensive weapon is suggested.

The atmosphere of distrust continued. On the 19th of January, four people in a canoe refused to engage in communication by staying well out of gun shot range. Over the next few days, numerous fires were seen along the shores of the channel (Cornell, 1974: 309, 310, 311, 312, 346). After landing on Bruny Island, one group of Nuenonne: "set fire to the growth along the shore as they went. No doubt they do this for fear of their footprints being seen in the grass" (Cornell, 1974: 312). This last comment suggested to Baudin that the Nuenonne were indeed wary and that the setting of fires might in some instances be a defensive reaction.

On an expedition to the base of the Table Mountain, native huts were seen in a forest composed for a large part of large burnt trees: "ready to topple at the slightest puff of wind" (Cornell, 1974: 314). Just as the French were fishing at night with the assistance of torches, so a group of Aborigines were also observed fishing in the same manner. This note begs the question as to whether or not scale fish were being hunted (Jones, 1966, 1971,1977).

Clouds of dense smoke emanating from high hill on north Bruny Island were assumed by Baudin to indicate the presence of a campsite to which Nuenonne women and children had retreated for safety . He comments that trees everywhere appear to have been burnt, especially those growing on sandy soils (Cornell, 1974: 318, 319).

A third significant encounter occurred on the 30th of January in which Hamelin and his crew were pelted with stones after the artist, M. Petit had a painting ripped from his grasp by an angry Mellukerdee man (Cornell, 1974: 321). Baudin, conscious of the possibility of injury or worse, wisely forbade his crew from fishing near to the place where the incident took place where: "several spirals of smoke indicated the presence of natives" (Cornell, 1974: 322).

Interestingly enough, a month later at Maria Island, a group of Pydairrerme also took exception to Petit's activities, with Peron making the comment that: " M. Petit also experienced much difficulty in finishing the sketches which he had begun" (Peron: 220).

A warm blast of northerly wind at 3 am on the 6th of February, caused Baudin to suppose that it rose from a blaze in the mountains which: "had been constantly on fire since our arrival"(Cornell, 1974: 331). Baudin noted a temperature rise from 12.5^{O} to 18^{O} C in less than 15 minutes. Winds of this kind are today not uncommon during the generally hot month of February and it seems highly unlikely that the wind was generated by distant fires.

The 6th of February provides dramatic evidence for the intensity of at least some fires lit by Aborigines. Baudin wrote that:

"Throughout the day we saw large fires a little way inland. They spread so much with the violence of the wind, that by midday the entire coast to port was ablaze. The fire on the starboard side, although considerable in itself, was smaller. There is no doubt of its being the natives who are responsible for this great conflagration, for the wind , as it was, would not have blown it in the direction that we saw it following. It is possible not just for the pleasure of destroying that they set fire to their forests in this way, and it is reasonable to suppose that there is some useful purpose behind it. The fire may, perhaps, have been started merely to burn off the grass and other undergrowth making walking painful and difficult, or may have been for hunting some quadrupeds sighted in the area" (Cornell, 1974: 322).

A useful remark was made by Midshipman Breton who wrote regarding this fire: "The natives lit many fires around the port. We saw five of them on the nearest shore, each one holding a firebrand and setting fire to everything" (Plomley, 1983: 110).

The most intense period of burning lasted for less than one day. The wind patterns during this episode are interesting. On the morning of the 6th of February, winds were cold, gusty and from the west. After midday, winds changed to the south and tended to come from the southeast during the afternoon. After sunset, the breezes dropped to a dead calm.

Considerable damage to the forests appear to have been caused by this fire. Nevertheless, the short duration of the fire and the fact that it was, in part, burning from an entirely unexpected direction could lead to the conclusion that the event was controlled or at least not as dramatic as a number of recent fires in the same area. The fires of 1967 for example, raged for over a week and in the process destroyed over a thousand homes and killed 50 people. Certainly, it would be unusual for a wildfire to spread under cold southerly conditions. Baudin seemed to be impressed with the blaze but not unduly concerned.

An unusual circumstance was the fact that fire appeared on both the port and starboard sides of the ship. This could only have occurred if the fire had been deliberately lit on at least two fronts or if it were so severe that the fire 'spotted' burning embers across the bay.

Captain Hamelin wrote that: "the natives had been setting fire to the coast on both sides of the bay along the shore ---. They set fire to the grass and bushes and then sat on the cliff edge to watch it. They were each carrying a lighted torch and a lance" (Plomley: 126). This may have been a simple hunting exercise or perhaps even another example of a fire calculated to damage or instill fear in the French? Whatever the case, by next morning, the conflagration was not even a cause for comment. Baudin simply notes that he: "had not seen any smoke in the area where the natives had settled" (Cornell, 1974: 332). The fire seems not to have been as disastrous or as widespread as Baudin's description initially suggests.

By the 18th of February, the expedition was underway and cruising past the Tasman Peninsular which appeared to be wooded in places and sparsely covered elsewhere. Baudin found that the country north of Cape Fredrik Henrik (sic) was: "more attractive. This, perhaps, is because the natives visit the area less often, and so the trees are not half-burnt as they are in all other places. The eucalypt and the *Casuarina* appeared everywhere to dominate" (Cornell, 1974: 348).

The ships anchored off Maria Island where numerous burnt shells on the shoreline testified to the presence of Aborigines. Here, Peron and Leschenault each discovered cremation structures containing burnt human remains (Cornell, 1974: 341, 349).

From Maria Island north to St. Helens, no fires, smokes or people were sighted, proving to Baudin that: "the whole stretch of coast--- is only inhabited at certain times" (Cornell, 1974: 351). The coast was well wooded at most points although a prominent cape (Cape Lodi?) near St Patrick Head appeared to be devoid of vegetation. On the 11th of March, some smoke was seen on mountain tops in the distance, possibly in the vicinity of Thompson's Marshes above the Douglas River.

By the 19th of March, the 'Geographe' had rounded Cape Portland in an attempt to find the 'Naturaliste' which had disappeared after heading in the opposite direction. A confounded Baudin lamented: "I am not too sure how to interpret this manouvre" (Cornell, 1974: 357)! Waterhouse Island on the north coast is described as being: "sparsely-wooded, and what trees there are are not very tall and grow only on the east coast" (Cornell, 1974: 363). The islands of Bass Strait, with the exception of parts of Flinders Island were described by Baudin as arid and generally bare of vegetation (Cornell, 1974: 366).

After a two month long absence surveying southern Australian waters, Baudin returned to Bruny island on the 20th of May. Recent rains had so rejuvenated the vegetation that Baudin was forced to reconsider an earlier opinion concerning the drab appearance of the burnt forests. He now admitted: "that all the trees were covered in foliage of a beautiful green, infinitely more attractive to look at than when we first ran in for the strait in the middle of summer" (Cornell, 1974: 407).

No sign was seen of the Nuenonne, although the ships doctor, M. L'haridon, located some charred bones which may have cooking refuse. Baudin thought the size of the bones indicated a creature larger than an elephant. This may be evidence for the utilization of beached whales or some other large marine mammal, perhaps an elephant seal (Cornell, 1974: 407).

Summary of Baudin's Journals

Baudin's account demonstrates that people were camped on the east coast from the southeast to the northeast during midsummer. If the number of smokes is used as an indication of population levels, then the north seems to have been considerably less populated than the south. However, recalling the problems of using such arguments, this is an untenable position to adopt.

The expedition stayed for a longer period in the south than in the north and thus there were more opportunities for expedition members to communicate with Aborigines. From the number of aggressive incidents which occurred during the expedition's stay in D'Entrecasteaux Channel, it seems reasonable to postulate a relationship between increased burning activities and the imposition of a dangerous alien presence (the French). The burning can thus be reasonably interpreted as a reaction to actual or perceived danger. Considering the ritual significance attached to fire by Tasmanian Aborigines (Roth, 1899), the use of fire in this context could be viewed as the use of a weapon, which was thought to be as effective against spirits, as against things physical.

Alternatively, the coincidence of the expedition occupying the same living space as an Aboriginal group who must, of necessity, continue a normal day to day routine, including the setting of frequent fires, might explain the sequence of events. However, there seems to be a clear relationship between the appearance of the armed fire party on the 16th of January and the previous days aggressive encounter. It seems unlikely that a relaxed party should be so heavily armed in order to set fire to coastal vegetation.

A reasonable interpretation is to take the middle path and admit that while the Aborigines may have had to continue their hunting with the use of fire, they also had to defend and uphold their obligations as owners of the land, protectors of their group and caretakers of tradition. In these circumstances, the Aborigines reacted to a threat with commendable restraint. The French, however, failed to recognize the potential impacts that their month long presence might have had on the economy or the psyche of the Aborigines.

The fires recorded by Baudin seem not to be so disastrous as to have caused concern for life or property, certainly Baudin's first lurid descriptions are at odds with his actions and subsequent evaluations. If the frequency of bushfires during January and February was higher than usual because of the unusual circumstances, the intensities seem to have been controlled to the extent that fires did not escape and develop into real conflagrations.

Peron's Account

In company with M. Freycinet and M. Lesueur, Peron visited the mouth of the Huon River at Port Cygnet on the 18th of January (Peron, 1809). The entire countryside was clothed in dense forest, impenetrable in places, with a magnificent, romantic aspect. The group met with a two Aborigines of the Mellukerdee (?), one of whom: "carried in his hand a kind of torch of lighted bark" (Peron, 1809: 173). Hidden some way off were two women who soon approached after the eldest man was satisfied that the French presented no danger. Upon observing that the sailors desired to construct a fire, the younger man soon bundled together a large pile of kindling and set fire to it with a torch (Peron, 1809: 175).

Near to this place the French discovered some native huts in front of which was the remains of a recently extinguished fire. The Aboriginal family seated themselves and cooked a meal of shellfish on a quickly lit fire (Peron, 1809: 177). Subsequent coquetry displayed between an attractive young Aboriginal women and the French has been amply dealt with by Plomley (1984). Before farewelling Peron's party, the Aborigines made a large campfire and indicated that they would remain there the next day (Peron, 1809: 180).

Peron was deeply affected by the forests which fringed Port Cygnet. He accurately described the rotting primeval aspect of a rainforest floor and the cathederal like atmosphere of a tall wet *Eucalyptus* forest. He writes with rapture of a varied landscape containing in different places,*Mimosae* (*Acacia*), *Metriosideros* (*Callistemon*), *Correa, Banksia, Leptospermae, Casuarina*(*Allocasuarina*) *Exocarpos, Xanthorea*(sic), *Cycas, Protea* (*Lomatia*), *Thesium, Conchyum* (*Hakea*) and *Evodia* (*Boronia*), (Peron, 1809: 182). Plomley (1983) recognized that Peron was mistaken concerning the occurrence of *Cycas* in Tasmania. Leschenault (Plomley, 1983: 134) noted that *Xanthorrhoea* was not present at Port Cygnet and was restricted to Bruny Island. *Thesium* almost certainly never occurred in: "charming groves" (Peron, 1809: 182).

There is some discrepancy between Baudin and Peron concerning the sequence of timing of events in relation to fires. Baudin records the spearing of Maurouard on 15th of January, followed Hamelin's sighting of an armed Nuenonne party and the lighting of fires by an older man. Later, on the 29th of January, a second armed party of Nuenonne was encountered. After a fracas involving the expeditions painter, M. Petit, the party, including Baudin and Hamelin was attacked with a volley of stones. Five days later, a sizable fire was seen to be ignited on either side of Northwest Bay where the expedition lay at anchor.

Peron agrees with Baudin that Maurouard was speared on the 15th of January. He differs by placing the stoning of Baudin and Hamelin: "a short time after our return", which was on the 17th or 18th. According to Baudin this event took place on the 30th of January.

Peron vividly describes some apparently massive fires that he observed on the 19th. Baudin makes no mention of these. This fire was almost certainly the major blaze reported by Baudin on the 6th of February. The interest lies mainly in the fact that regardless of who was correct in regard to the date of the fire, the blaze was not as destructive as made out by either description, particularly that of Peron who wrote that the:

"multiplicity of fires which we perceived. In every direction immense columns of flame and smoke arose; all the opposite sides of the mountains, which form the bottom of the port N.W. were burning for an extent of several leagues. Thus were destroyed these ancient and venerable forest, which the scythe of time had respected through the course of so many centuries, only to fall a sacrifice to the destructive instinct of their ferocious inhabitants" (Peron, 1809: 187).

The next morning, like Baudin, Peron makes no mention of the conflagration. It clearly posed no threat and presented no further spectacle. The mountains which Peron describes as forming the bottom of the port N.W. (Northwest Bay) are merely low hills. The blaze lasted less than a single night and seemed to be closely controlled by the prevailing weather conditions. Whether or not the timing of the fire to coincide with with favourable temperatures and winds was under the full control of the Nuenonne /

Mellukerdee is unsure, although a reasonable argument could be made for such a case.

On the 24th of January, Peron and M. H. Freycinet made a journey up the Derwent past the present day site of Bridgewater. Near Bellerive Bluff on the eastern shore of the river, Peron thought that: "The forests in this part of Diemen's land are not so thick and large as in the interior of the channel; they appeared to have been partially destroyed by fire" (Peron, 1809: 189). In Plomley's translation of the manuscript this description appears as: "The forests hereabouts are much less dense than in the channel itself, and moreover they appeared to have been devastated by fire" (Plomley, 1983: 27).

Somewhere near Mt. Direction Peron came across a Mouheneenner campsite consisting of about 14 huts with several fires still burning. On the return from near Bridgewater, at the same place, Peron and Freycinet observed large fires where:

"In every direction, black columns of smoke arose; and wherever we turned our eyes, we beheld the forests on fire: the savage inhabitants of these regions appared (sic) to wish, even at this price, to drive us from their shores. They had retreated to a high mountain, which also appeared like an enormous pyramid of flame and smoke; from this spot their shouts were distinctly heard, and the people who flocked to them seemed to be very numerous. We resolved to walk thither and to spend the rest of the day in that undertaking --- The spectacle was horrible: the flames had destroyed all the herbage; most of the small trees and shrubs had experienced the same fate; and the tallest trees were burnt to a considerable height; in some places they had fallen to the earth by the violence of the flames, and vast fires raged among the rubbish; it was with great difficulty and fatigue that we advanced ---. The nearer we approached the top of the mountain, the more the noise increased, and we expected to be attacked by the savages, when in a moment the cries ceased: we came to the spot (where Mouheneenner voices were heard), and we saw with astonishment that the natives had fled, leaving their miserable huts " (Peron, 1809: 191-192).

The foregoing description appears at first glance to be a wildfire out of control and yet some considerable doubt remains. Certainly, one must accept the burning of a considerable amount of understorey and the destruction of a number of adult trees, but the extent of the fire must be questioned. For example, how is it that a number of bark huts on the upper, more dangerous front of a large fire escaped incineration? Plomley regards the fire as one of a series of extensive bushfires that: "caused the natives to abandon their huts on this occasion" (Plomley,1983: 36).

A more plausible explanation is that the Mouheneenner abandoned the campsite as the French approached. Peron himself was: 'astonished' that the people had fled. In other words, the extent or intensity of the fire was not so great as to lead Peron to suppose that it should pose a danger to the Mouheneenner.

If the fire was lit for traditional reasons, the shouting employed by the Aborigines may have been used to drive game forward. This could have confused and frightened the French who, to judge from Peron's statement, fully expected an attack. Alternatively the noise may have been purposely directed towards the French, in which case the episode might stand as a further example of fire used defensively. From this data it is impossible to decide one way or the other.

Plomley considers that during this outing, Peron's party climbed Mt. Hull, Mt. Connection and Collins Bonnet. This seems to be an unduly optimistic assessment. Collins Bonnet for example is virtually sub-alpine and many kilometres distant. Nothing in the account leads to this conclusion. It seems more likely that Mt. Direction and perhaps Gunners Quoin were ascended; but these are mountains in name only, hills being the more appropriate term.

Jones (1988: 46) points out that Peron underwent a transformation following the spearing of Maurouard and that this is reflected in changes of tone from delight to disgust. Jones hints that Peron's descriptions of bushfires were coloured by this new perspective. An important point here is to appreciate the effect that language has on scale. The descriptive phrases, mountains on fire, pyramids of flame and burning mountains should be rescaled to account for the real stature of the hills surrounding the Derwent. If this is done, then not only are the mountaineering accomplishments of the sailors reduced to more human levels, but also, the intensities and extents of the fires must be reconsidered.

On crossing back to the west side of the river, the party made towards present day Sandy Bay, below Mt. Nelson where Freycinet commented that:

"This conflagration --- made us hope that, that we should find the natives collected somewhere near the spot; we therefore landed, and immediately proceeded towards the neighbouring mountain (Mt. Nelson). We had had scarcely reached the ascent, when we beheld the country, which we at first thought so pleasant, with a totally different aspect: it now appeared to be only a large desert, ravaged by fire- the other side of the mountain was in flames" (Peron, 1809: 193).

Once again, the mountain is actually a hill and the fire not so as dramatic as first appears. Peron and company seemed to be quite at ease despite the proximity of the 'conflagration'. In fact, they occupied themselves collecting mineral and plant specimens before returning to their boat. The wind was blowing from the northeast which usually brings damp conditions to the Hobart district. The papers of M. Louis-Henri Freycinet agree with Peron in most respects regarding the aforementioned fires (Plomley, 1983: 113-116).

On the 3rd of February, Peron noticed some people moving towards a large fire kindled on the beach. Nearly two weeks elapsed before the expedition hoisted anchor and sailed to the north by way of the Tasman Peninsular. Arriving at Maria Island, Peron describes a diverse collection of plant taxa from both wet and dry forests including *Eucalyptus globulus*, *Casuarina* (sic), *Leptosperma* (*Leptospermum*), *Metrosideros* (*Callistemon*), *Exocarpos*, *Styphelia* (*Cyathodes*), *Banksia*, *Aletris* (*Blandfordia*), *Pteris* and *Fagara* (Rutaceae, possibly *Zieria* or *Phebalium*).

In an extremely significant series of discoveries the expedition documented a number of Aboriginal cremation sites. In response to this, Peron mused that: "Fire in these countries, although probably not worshipped as formerly, seems to be esteemed as something very superior to all other objects of nature" (Peron, 1809: 211).

On the 19th of February, while surveying the coast of Oyster Bay, the French came across a large fire, built on the beach, around which 14 to 20 Laremairremener / Loontitetermairrelehoinner people were seated. Travelling further north, Peron notes that the hills around St Patricks Head: "seem well wooded, and pleasant valleys may be distinguished between the mountains. All this part of the coast was covered with fires and smoke when we passed it" (Peron, 1809: 236).

Summary of Peron's account

Peron's account is both persuasive and theatrical. In comparison to Baudin's journal, Peron's account, with additions by Freycinet, is not as highly organized nor as immediately informative. Dates and details are sometimes confused, hyperbole is apparent in places. Nevertheless as Jones (1984) and Plomley (1983) recognize, he manages to bring a human touch, a sensitivity which is missing from Baudin's harsher account. Unfortunately, his sensitivity seems far too heightened in the passages concerned with bushfires. These sections comprise some of the more exaggerated passages in the whole corpus of Tasmanian ethnohistoric literature.

If allowances are made for poetic license, Peron's descriptions of the shores of the Northwest and Derwent Rivers indicate fires in eucalypt forests, with an intensity great enough to clear away a large part of the understorey. Tree-trunks were often burnt to a considerable height. Occasional trees were brought down by fire. The greatest damage appeared to be on sites with sandy soils. Fires of this type can be locally intense and in favourable conditions, may explode into full scale major conflagrations which may burn thousands of hectares of forest. That the fires observed by the French did not transform into long lived disasters invite the hypotheses that 1) Mouheneenner were lucky or 2) Mouheneenner were fully in control of the fire events.

The major fires noted by Peron were obviously not of the disastrous kind. In all cases the fires ceased to elicit comment after a single day. Peron often found it safe to wander close to and even into the actual area on fire. In all cases, the French were confident that the sighting of a fire correlated with the presence of Aborigines. In at least one case a supposed conflagration was burning around a set of occupied Mouheneenner huts, which even Peron thought to be safe from harm.

On the basis of these observations Plomley considers that the summer of 1802: "was a period of extensive and intensive bushfires in south eastern Tasmania, with large tracts of country devastated" (Plomley, 1983: 202). He goes on to posit a general relationship between the amount of burning and the dryness of the countryside. (Plomley, 1983: 202). Implicit in this statement are the assumptions that Aborigines did not moderate their burning regimes to accord with weather conditions and that wildfires constituted a significant hazard. If, as is argued above, the first assumption is rejected, then the second becomes far more probable.

In January and February of 1802, weather conditions in southeast Tasmania varied from cold and wet to dry and hot. Uncontrolled wildfires usually take off after periods of northerly weather during which strong dessicating winds can rapidly dry out even rainforests. Under these conditions fires in *Eucalyptus* forests can be explosive and unpredictable, with blazing brands circulated up to 10 km in front of the fire.

On the occasions of the two largest fires described above, wind conditions were predominantly easterly. On the 6th of February, winds swung around from cold westerlies to damp easterlies. The fire on Mt Nelson occurred under northeasterly conditions. These patterns are today regarded as being the safest during which to burn. This hints at a premeditated plan by Aborigines and a high degree of control exercised during fire setting.

It is interesting to recall that George Bass described the general vegetation in the vicinity of Mt. Direction just 2 years earlier. George Bass noted that: "The country, which is unusually thin of timber, is fairly rounded into grassy hills of various moderate ascent" (Bass, in Collins: 1971). This forces a reconsideration of the fires in relation to the vegetation type in which the fires occurred. From Bass's description it is conceivable that the fires observed by Peron were actually grass fires and not forest fires. An occasional tree would have been burnt along with thickets of shrubs. Even light burns in grassy forests can produce enormous amounts of smoke. To a European, unused to apparently uncontrolled fires, grass or woodland fires would have presented a major and novel spectacle. Uncontrolled forest fires would have been so terrifying as to test even the descriptive powers of Peron.

The information provided by Peron regarding plant distributions is not particularly useful in an ecological sense. Peron fails to distinguish habitats when listing plants with the result that a large number of possible plant communities are represented.

Accounts by others on the Baudin expedition

Brief translations of some of the lesser papers accumulated by the Baudin expedition provide little or no extra detail to those of Baudin and Peron (Plomley, 1983). The major exception are the papers of the naturalist Leschenault. Mention has previously been made of comments by Hamelin, Freycinet and Breton.

Jean-Baptiste Louis-Claude Theodore Leschenault De La Tour was a naturalist colleague of Peron (Plomley, 1983: 129). In a more restrained fashion he should be regarded as a more reliable interpreter of the natural history of Tasmania than his more illustrious compatriot. His species lists seem to have been made on a community basis and have more ecological utility than the mixed lists provided by Peron. On Partridge Island he records a *Eucalyptus* forest, with a abundance of *Casuarina equisitifiolia* (*Allocasuarina verticillata*? *A. littoralis*?) and an: "undergrowth of *Banksia*" (Plomley, 1983: 129). On the sea shore were communities consisting of *Apium* spp. and *Atriplex* spp. Further inland were examples of *Phyladelphus* (*Leptospermum*), *Melaleuca*, *Xris* (*Xyris*), *Clematis*, *Geranium*, *Godenia* (*Goodenia*) and *Styphelia* (*Cyathodes*).

At Bruny Island, he records a forest of *E. globulus* and *E. obliqua* which grew on sandy soils with a fern understorey and less common occurrences of *Casuarina*. In damp places were thickets of *Leptospermum* with the fern *Lonchitus* (*Rumohra*?).

On the shores of Northwest Bay, sailors found uses for the tall straight stems of a species of Labiateae (Lamiaceae) which grew in sandy soils with *Exocarpos cupressiformis* and an understorey of bracken fern. Nearby were examples of *Dodonea*, *Bossiaea*, *Spinifex* and a grass with a large spiked head, somewhat reminiscent of wheat (probably a species of *Festuca*). In fact Leschenault believed that this grass had potential for cultivation and collected samples with that purpose in mind. This community, with the inevitable eucalypts, on which *Exocarpos* is parasitic, constitutes a open forest in which fire frequencies are usually quite high.

A collecting trip up the northwest river resulted in the identification of Rubiaceae (*Coprosma* spp.), *Pimelea*, *Billardiera*, *Embothrium* (*Lomatia*), Mimosae (*Acacia*) and *Indigo* (*Indigofera australis*). This group may be referable to wetter communities with lower fire frequencies than the dry communities closer to the coast although there is a great deal of overlap in the ecological tolerances of these species.

A little further south at Oyster Bay Creek (Oyster Cove?), he recorded communities which included a creek bank fringed with small ferns and the tree fern, Dicksonia antarctica. Other taxa include, *Bignonia* (*Pandorea pandorana*), *Pteris*, Mimosae (*Acacia*), *Tetratheca*, *Personia* (*Persoonia*), *Bauera*, *Styphelia* (*Cyathodes*), *Veronica*, *Samolus* and *Sida* (*Lawrencia*). This mix includes some taxa which are characteristic of saline mudflats and damp creek margins.

Summary of the papers by other members of the expedition

Leschenault suggests that the reason why the Nuenonne / Mellukerdee deliberately set fire to the coastal vegetation was so that they could observe the French without fear of being surprised themselves (Plomley, 1983: 133). This amounts to a variant of the use of fire for defense hypothesis. Of the fires at Mt Nelson, Leschenault notes that: "Here the soil is a little better, but all the low plants had been burnt recently by the natives " (Plomley, 1983: 134). This observation from the taciturn naturalist indicates that the fires were not as intense as suggested by Peron and Freycinet.

Amaso Delano: 1804

Delano was the skipper of the sealer 'Perseverance'. His widespread activities epitomize the speed at which Bass Strait was exploited. On the shores of Storm Bay he was impressed by the size and density of trees which formed forests in those parts. He estimated that hundreds of stringy barked trees (*Eucalyptus obliqua*), each over 100 feet in height, grew in an area of one square mile (Delano, 1973: 18).

About 20 miles south of Sullivan's Cove, probably near to the Northwest River, Delano observed: "a party of the natives on the Van Diemen's side, going along the shore on the borders of the wood, which they were endeavoring to set fire to, in a number of places" (Delano, 1973: 18).

Summary

Delano's account contains an abbreviated description of fire setting by Aborigines which appears very similar to that recorded by the Baudin expedition. It is interesting that the burning of the forest edge occurred near to Northwest Bay; the same place as similar behaviour was observed by Baudin.

It is possible that the act of burning coastal forests from the beach front was a traditional Nuenonne / Mellukerdee annual activity. Alternatively, this may indicate the repetition of the ploy used so successfully against the French two years earlier: successful, because the French did after all hoist sail and leave soon after the burning commenced.

Dumont D'Urville: 1827

In the 'Astrolabe', D'Urville entered the D'Entrecasteaux Channel on the 16th of December. He thought that: "--- the colour of the vegetation is dreary and burned like that of Provence in August. We cannot see any signs of population, either civilized or savage, with the exception of one lonely plume of smoke rising above Huon Island" (D'Urville,1987: 164).

On the 17th, a sudden rise in temperature caused D'Urville to: "share the opinion of some members of Baudin's expedition who believed that this sudden rise in temperature was due to the burning of forests carried out by the natives. During the following day I was able to check that, to facilitate land clearings, the colonists of Van Diemen's Land had set alight vast tracts of ground covered with bush, scrub and tall grass" (D'Urville, 1987: 165).

"On every side, and notably on Bruny Island, huge fires are burning out the dried grass and scrub. As the natives have entirely moved out of this area, we can only attribute this blaze to the colonists who use this means of clearing the land they intend to put under cultivation" (D'Urville, 1987: 166).

Summary

D'Urville's sad comment completes the marine tradition starting with Tasman. The lonely fire on Huon Island may not have been Aboriginal, but the comparison between it and the ravaging fires lit by the settlers acts as a symbol for the change in land tenure. These, and all subsequent fires, have since modified many of the original vegetation patterns which resulted from Aboriginal burning practices.

3.4 The first settlers

Reverend Robert Knopwood: 1804 - 1815

The diary of 'Bobbie' Knopwood is one of the key documents in Tasmanian history (Knopwood in Nicholls, 1977). His notes contain much detail concerning the day to day minutia of early Hobart. A number of observations relate to Aborigines and fire or environment, some explicit, while others are more cryptic.

7th March, 1804:

While Mr Brown (the botanist) went up the mountain 'a - botanizing' Knopwood recalled a previous walk during which: "we saw a great many native huts and the fires they made; no doubt but they see us. In the eve the natives made a fire near where we slep (sic) on the west side of the river".

Comment: Probably refers to camp fires kindled outside of the huts. The people were obviously reluctant to establish contact.

14th June, 1804:

"A gun was fired from Hunters Island as a signal that a fire was seen upon Betsy's Island".

25th November, 1804:

"We observed many of the native fires".

16th February, 1805:

"At 8 the drum beat to arms; it was supposd (sic) that the corn stacks were set on fire by reason of the great fires. It was only the natives".

Comment: A curious comment which discriminates between burning referred to as the 'great fires' and fires caused by 'Aborigines'. Knopwood does not make it clear if the burning of the stacks was a deliberate or accidental happening.

16th July, 1805:

"a fire broke out at the home of Francis Cobb, a prisoner, which consumed the same in a short time. It is very remarkable that we have always had a fire when a strange sail has been in sight, or very near the Derwent".

Comment: The mysterious fires are either coincidence or a deliberate sequence. Knopwood seems to suspect a conspiracy of sorts, perhaps among the prisoners. A further possibility is that the fires are the product of a systematic attempt by Aborigines to upset the settlers. Although this hypothesis is not amenable to testing, it is interesting to speculate on an apparent coincidence between the appearance of sails and the commencement of trouble.

12th January, 1806:

"At 1/2 past 6 the Royal Marine Barracks caught fire and one end was consumed, -. The country on fire at the SE side of the river and likewise on the NW by Millars and the government farm, by the natives".

Comment: The extensive fires were lit by Aborigines,. Presumably for hunting purposes. Fels (1982: 55) makes a reasoned case that Aborigines were at this time subject to considerable resource stress on account of the activities of European kangaroo hunters. Fels notes that Aborigines were around the settlement for most of the year and that weather conditions varied from the extremes of drought and cold. Fels strongly supports Jones's (1969) 'firestick farming hypothesis' and suggests that in Tasmania, the human response to changing post glacial climates was 'modified pastoralism' in which Aborigines controlled the habits of kangaroos by manipulating the environment.

Strangely enough, on the 10th, a young Aboriginal girl who had been brought into Hobart and imprisoned by a Marine named Wiggens, had managed to clamber out of a window and escape from her captor (Knopwood: 10/1/1806). Under these circumstances, is it too far fetched to view the burning of the Marine barracks two days later as an act of revenge by relatives of the kidnapped girl?

Between July 1805 and the 10th of March 1815 Knopwood makes 11 observations about fire which might reasonably link Aborigines with the incidence of fire in the Hobart district. However, it is noticeable that as time progresses, entries concerned with Aborigines diminish in frequency.

For the most part, Knopwood simply notes that the grass was on fire "by the natives" (4/5/05, 21/7/05, 11/12/06, 26/12/06, 1/1/07, 20/1/07, 18/2/07, 2/3/07, 16/1/08, 17/2/14, 16/11/15).

Summary

The earlier entries demonstrate an understandable shyness on the part of the Mouheneenner. It is interesting that by 1806, the Mouheneenner were seen about Hobart for most of the year (Fels,1982: 55). This is unusual behaviour for people who are thought to have been engaged on a seasonal round which encompassed a sizable territory (Walker, 1876; Roth, 1899; Jones,1974). What is apparent from Knopwood's diaries is that Mouheneenner appeared to favour the burning of grassy places rather than forests.

By the start of 1807 Knopwood had encountered trouble with the Mouheneenner, especially in regard to hunting for Kangaroo. Fels regards this period as a harbinger of future horrors. It is significant that the summers of 1804 to 1807 appear to have been dreadfully hot. This seems to vindicate Plomley's notion that the incidence of fire is related to periods of drought (Plomley,1983: 202). However it should be considered that the Mouheneenner may have had to radically alter their normal patterns of behaviour in order to accommodate the imposition of a huge cast of players on what seems to have been a particularly productive area of land.

A. W. Humphreys: 1804

As mentioned earlier, Humphrey was a trained mineralogist who accompanied Lt. Gov. Patterson and Robert Brown to found Port Dalrymple in 1804. Later, that year at Sullivan's Cove on the Derwent River near the present day site of Hobart, Humphrey notes that the land was "thickly wooded down to the waters edge" (Humphrey in Currey,1984: 98).

Humphrey the mineralogist and Brown the botanist scaled Mt. Wellington, with the former ironically providing more detailed information about the extant plant communities than the latter. He describes forests of tall tree ferns (*Dicksonia antarctica*) and groves of 'sassafras trees' (*Atherosperma moschatum*). More impressive still were the tall eucalypts (*E. obliqua*) which were truly gigantic. One of these was so large that Humphrey joked that: "a coach and six might be drawn along it" (Currey, 1984: 103).

Summary

The description of rainforests or mixed forests on Mt. Wellington make it clear that places on the mountain had not been subjected to fire for a very long period of time; certainly since well before the fires recorded by Du Fresne and subsequent maritime explorers. The gigantic trees which so impressed Humphrey could well have been 300 years old in 1804. At the time of fires in the 1930's and 60's some few surviving remnants of these trees might still have existed. It is possible that the extent of eucalypts seen on Mt. Wellington today owes more to the post settlement burning of the mountain than to fires by Aborigines. The sclerophylly seen today could result from a successional pathway which allows rainforest to 'drift' towards sclerophylly after a fire, providing a suitable seed source exists (Jackson, 1968, 1978; Hill and Read, 1984).

Lt. William Laycock: 1807

At the start of 1807, the northern settlement at Port Dalrymple was starving. Lt. Laycock was ordered to pioneer a path to the settlement on the Derwent in order to organize relief supplies. Unfortunately for the northerners, Hobart Town was also in a precarious position (Fels: 1982) and Laycock had to return empty handed.

Laycock walked south via the Lake River, Woods Lake and the Bothwell area to the Derwent River near Bridgewater. He travelled over much rocky ground and past a quantity of: "fine open grazing country" (Laycock, 1807 in HRA,111/1: 746).

On the 9th of February, Laycock met with the Derwent River: "about 3 miles to the westward of where the salt water flows" (Laycock, 1807 in HRA,111/1: 746). In order to save time he cut across country rather than follow the rivers sinuous course. From here: "I steered E. about seven miles, leaving the river about two or three miles to the southward of me, there being a body of high mountains near it which appeared difficult to penetrate (Mt. Dromedary). On the side of the mountains I found a number of very fine pine trees, as far as I can judge, not having measured them, from 5 to 6 feet in diameter and upwards of 100 ft high " (Laycock, 1807 in HRA,111/1: 745). After a final 10 miles, Laycock was in Hobart Town.

Returning to Port Dalrymple on the 16th of February, Laycock was unable to proceed any further north because: "The weather was so hot, and the country on fire, that on the third day, I could not proceed at all" (Laycock, 1807 in HRA,111/1: 745).

Summary

Laycock was the first European to traverse the island from north to south. The choice of route is interesting because instead of following the Midland Valley, he preferred a high route which led over the eastern margins of the Central Plateau. The open grassy country seems to have been in the vicinity of Bothwell. Laycock seems not to have encountered either Aborigines or their huts, although the fires on the Central Plateau must have been set by the Larmairremener or Marwemairrener.

The large pine like trees are a curiosity. They could only represent either *Athrotaxis cupressoides*, *A. selaginoides*, *Phyllocladus aspleniifolius* or *Callitris rhomboidea*. Today, none of these species are known to exist anywhere near to Mt. Dromedary where Laycock must have been on the 10th of February. All four species are fire sensitive, especially the former three and must therefore have been growing in patches of ground where fire was infrequent. It is possible that his observation represents disjunct or outlying populations which have been removed or burnt in the intervening 180 years since settlement.

The preference for western rainforest habitats displayed by *A. selaginoides* make it an unlikely candidate, although populations did exist into recent times in the Huon Valley and still do on Mt. Field. *A. cupressoides* is a montane rainforest species presently restricted to subalpine and alpine locations. Recent surveys have discovered relict pockets of *Nothofagus* rainforest in the southern Midlands Valley (M. Neyland, Tas. Dept. Parks & Wildlife, pers. comm). This outlying stand depends on favourable microtopographic factors and the absence of fire (Neyland, 1990). From this, it is remotely possible to argue that a similar isolated population of *A. selaginoides* or *A. cupressoides* managed to survive from earlier times on the elevated, fire protected southern slopes of Mt. Dromedary.

P. aspleniifolius is tanother likely candidate. Seeds of this species are dispersed by birds and will grow in any well watered situation from sea level to subalpine locations. It is unlikely that *Callitris rhomboidea* could grow so large or so far out of its mostly coastal range (Harris and Kirkpatrick, 1991). In any event, the lack of pine like trees at Mt. Dromedary today argues for a major change in fire regimes over the past 200 years.

Governor Lachlan Macquarie: 1810

Macquarie conducted many extensive tours of the colonies, including a trip from Launceston to Hobart in 1810. As he passed the southern extremities of the Great Western Tiers he commented: "I saw many fires on the faces of the mountains but saw none of them (Aborigines)" (Macquarie,1956: 64).

James Kelly: 1815-1816

The boating exploits of James Kelly live on in Tasmania where re-enactments and dedications of his voyage occur with monotonous regularity. He and his four man crew left Hobart in a five-oared whaleboat on the 12th of December 1815 in a successful voyage which circumnavigated the island. The first port of call was Recherche Bay where Kelly's party was: "prevented from landing by a large body of natives giving us a tremendous volley of stones and spears" (Kelly: 1881).

From the 14th to the 25th Kelly sailed past various: 'grassy' islands and sighted a number of groups of Ninene people on the mainland.

On Boxing day, 1815, the boat was nearing Macquarie Harbour with a southeasterly breeze. At this point was made of the most celebrated of observations concerning Aborigines and fire. Kelly wrote:

"The whole face of the coast was on fire. - a lucky circumstance for us. The smoke was so thick we could not see a hundred yards ahead of the boat. On pulling into the 'Narrows' at the small entrance island, we heard a large number of natives shouting and making a great noise, as if they were hunting kangaroo. It was highly fortunate the smoke was thick; for, had the natives seen the boat pass through the narrow entrance, it is possible they would have killed every person on board by discharging, in their usual way, volleys of spears and stones. In the afternoon the smoke cleared off a little, and we found ourselves in a large sheet of water near a small island, where we landed, and found plenty of black swans on their nests, and plenty of eggs" (Kelly, 1881: 9).

This account has two reasonable explanations. Kelly may simply have chanced to be at one of the most exposed locations (in terms of vulnerability to attack) on the whole of the Tasmanian coast at the same time as Lowreenne (?) people were setting fires for the purpose of hunting kangaroo or collecting swan eggs. Alternatively, the Lowreenne might have sighted the boat some way off and prepared an ambush. Intelligence from the Ninene might have forewarned the Lowreenne of potential trouble to come. The dense clouds of smoke seem to indicate a large fire and this is substantiated by Kelly's comment that "The whole face of the coast was on fire".

Whatever the reason for initiating the fire, three general possibilities exist to explain the fire. 1) Frequent burning in all southwestern coastal vegetation communities was a regular occurrence. 2) Intensive burns were conducted at long intervals. 3) The fire was an isolated event specifically directed at a perceived threat.

The common occurrence of sedgeland communities in western Tasmania is thought to be a result of plant community evolution in an acid, nutrient poor environment with a high frequency of fires (Jackson, 1968,1973; Brown and Podger, 1982). On this basis, and considering the earlier attack on Kelly by people who are known to have had contact with the Lowreenne (Jones, 1974), it is possible that a traditional fire regime used for burning the sedgelands could have easily been adapted for defensive purposes. Curiously, Kelly never again sighted Lowreenne or smoke in the Harbour during this trip, which suggests that the Lowreenne knew of Kelly's presence and had retired to consider their options.

The episodes at Recherche Bay and Macquarie Harbour justifiably introduced caution, even paranoia, into Kelly's subsequent actions. All Aborigines were suspected of potential treachery. Along the coast north of the Pieman River Kelly saw a great number of smokes which he thought: "were intended as signals to the tribes" (Kelly, 1881: 9). This area is known to be remarkably rich in occupation and ritual archaeological sites (Cane, 1980; Cosgrove, 1983: Jones, 1966, 1971, 1977) and thus it seems just as probable that the fires merely represented a large number of camp fires.

A further aggressive encounter occurred at Hunter Island where at least 50 armed men jeered and threatened the crew. Kelly notes that this part of the coast had "a great many fires along the shore" (Kelly, 1881: 10). On this occasion the Aborigines tried to lure Kelly's men into a false sense of security before attacking them with stones. The crew opened fire and wounded a number of people.

Summary

Almost all of Kelly's encounters with Aborigines were characterised by potential or actual violence. Observations of smokes seem to indicate that the western coasts were well used during December. The northern coast from Circular Head to Cape Portland had few smokes which might reflect the effects that sealers and others had on settlement and population patterns at this time (Plomley, 1966; Jones, 1971). The major fire at Macquarie Harbour seems very likely to represent another example of fire being used as a weapon of confusion against invaders who were known for their aggressive behaviour.

James Ross, ca 1816

In the Hobart Town Almanac of 1830, James Ross published his version of a settlers life in the upper Derwent Valley fourteen years earlier (Ross, 1830).

His house on the banks of the Clyde River was a focus for visitors to this remote part of the settlement. To Ross's credit, Aborigines of the Larmairremener tribe were as welcome as Europeans and his reminiscences contain a number of fine observations concerning the use of fire by the Larmairremener.

Ross wrote that "It was the very next day after the escape of my eagle, that I was alarmed by the appearance of fires in three or four situations on the opposite side of the river, and soon after a scattered crowd of about 60 Aborigines walked up to my cottage. --- and as the grass all round at that season was dry and covered with sticks, dead wood of the most combustible nature, I was afraid that the flames would destroy this last remnant (his crop) as well as the fern that surrounded it" (Ross,1830: 145).

The fires had by this time jumped over the river and Ross was able to enlist the aid of the Larmairremener:

"We were doing our best to extinguish it by beating the flames out with the green boughs, but our efforts would have been in vain, such was the extent of the line of flames assisted by the wind as it crept upon the ground, had not the whole of the blacks all at once come forward to assist me. Even some hours afterwards when the flames again broke out in two or three places, they was on the alert in a moment and put them out" (Ross, 1830: 145-146).

Summary

The fire lit in the bush around Ross's property was initially lit on 3 or 4 fronts. The fuel load of dry grass and dead wood demonstrates that the fires were lit in a grassy forest. The dead wood probably accumulated as limb fall and refuse from previous fires. Ross notes that the fire 'crept' along the ground, thus indicating a ground fire which had not managed to ignite trees. In other words the fire was a cool burn despite being lit in a sclerophyll forest in summer. This episode demonstrates that without modern fire fighting aids, people were able to contain certain types of fire, especially cool burns. The willingness of the Larmairremener to help Ross illustrates the good relations which existed between them as well as familiarity by Larmairremener to the concepts and methods of fire control.

John Beaumont: 1817

Under examination by Commissioner J. T. Bigge in regard to the state of the colony, Beaumont gave evidence that in 1817 he travelled to the western country (Central Plateau) where he saw: "several fires but none of the natives" (Beaumont, 1817 in HRA,111/111: 343). In his journal for that trip, Beaumont records travelling past Great

Lake and the open country beyond (Liaweene Moor). South of Great Lake near St. Patricks Plains, he noticed a number of trees (cider gum - *Eucalyptus gunnii*) which appeared to be dying on account of their being damaged by Aborigines who had gouged holes into them in order to extract the sweet sap (Beaumont, 1817 in HRA, 111/111: 586).

Allan Cunningham: 1818

This well known botanist visited Macquarie Harbour with Phillip Parker King as part of an extensive series of voyages which surveyed the coastlines of many inaccessible parts of Australia. At Macquarie Harbour in January 1818, the party met with a group of Lowreenne who appeared to be friendly in all respects save that: "spears were concealed close at hand" (Cunningham in King, 1818). In spite of the suspicious atmosphere, the meeting was quite cordial and if earlier events had created an atmosphere of tension, then relationships had at least partially healed; even to the extent that Kelly was back in the 'Sophia' cutting and loading Huon Pine at the same time.

Cunningham describes the harbour banks as damp and heavily forested. He wrote that: " This swampy nature of the soil is to be attributed to the crowded state of the trees; for they grow so close to each other, as to prevent the rays of the sun from penetrating to the soil" (King, 1818: 156).

The party cut a number of huon pine and celery top pine spars for later use which prompted Cunningham to note that "*Podocarpus aspleniifolius*, Labil.; was known to the settlers as 'Adventure Bay Pine', and grows on Bruny Island in Storm Bay; but it is there very inferior in size to those of the pine cove" (King, 1818: 157-158).

Summary

King's voyage indicates that destruction of the Aboriginal southwestern environment was well under way by 1818. The dense nature of the rainforest suggests that the massive fires sighted by Kelly at Macquarie Harbour might not have been as destructive as originally indicated.The identification of celery top pine as 'Adventure Bay Pine' might throw light on the identification of the 'pine' trees seen by Crozet in 1773. Rather than relict *Callitris*, they were almost certainly the fire sensitive *Phyllocladus*.

J. Gordon: 1820

At a session of the Bigge committee, Mr. Gordon gave evidence that in the interior he believed that "there were a good many (Aborigines) from the fires that I have seen, but I have never fallen in with them. There are more I believe on the coast" (Gordon, 1820 in HRA,111/111: 223).

Henry Rice: 1820

A short note by Rice attached to the record of a longer journey to the northeast states that at Port Davey "The country where burnt, as it is in many places, is entirely white with quartz; as to grass I have not seen a tuft since we left Hobart Town" (Rice, 1820 in HRA 111/IV: 643).

G. T. Lloyd: 1820

In a book detailing his 33 years in Tasmania and Victoria, Lloyd recalls that in hunting kangaroo, Tasmanian Aborigines would stalk their game by hiding: "behind trees and stumps blackened by the raging bushfires" (Lloyd,1862: 49). He notes that: "their mode of hunting in the ferns, scrubs and underwood was by clearing a patch of about 20 feet square" (Lloyd, 1862: 49). He remembers that certain dances commenced after preliminary fire making with a women issuing a challenge to which a man would respond by leaping through: "the midst of a flaming brushwood fire". Subsequently up to 40 or 50 people would: "bound successively through the furious flames into the sacred arena" (Lloyd, 1862: 50).

Lloyd notes that men would feed on oysters and possum cooked on hot coals. He believed that it was possible to tell Aboriginal fires by the characteristic column of smoke which rose from the sides of hills (Lloyd, 1862: 51).

Summary

Lloyd provides little new information. It is interesting though that he describes various hunting techniques utilized by Aborigines which do not depend on fire. He describes a method in which marsupials were hunted in forests which had reasonably dense understories.

Alexander Pearce: 1822

Pearce was a convict sentenced to transportation for stealing 6 pairs of shoes (Sprod, 1977). His fame rests on three planks. First is his escape from the notorious Macquarie Harbour penal settlement which resulted in the first traverse of the country between the west coast and the settled districts by a European. Next, was the fact that he escaped for a second time Third was his appetite for human flesh. On a number of occasions he was apprehended in possession of human parts (other peoples) and the Pieman River is reputed to have been named in his honour, for what James Calder termed, Pearce's habit of selling "unwholesome meat made into pies" (Calder,1881: 10).

Pearce and seven unlucky convicts escaped on 20th of September, 1822. They struck out towards Hobart and entered what was considered by Europeans to be some of the most inhospitable country in Australia. His fellow escapee, Kennelly, made one of the greatest *faux pas* in history by exclaiming: "I am so weak that I could eat a piece of a man" (Hughes,1987: 220), Pearce evidently thought this to be a fine idea and commenced to devour his companions one at a time. The ever diminishing party eventually reached the point which marks a major division between the quartzitic mountains of the west and the dolerite plateaux of the east. Here Pearce recalls that the country was 'very fine' with abundant kangaroo and emu.

The convicts found themselves on extensive plains of about 30 or 40 miles in extent, where, according to the confession that Pearce gave to the Rev. Knopwood, they sighted a smoke. On approaching near: "they heard the voice of some human beings --- a tribe of black natives" (Sprod, 1977: 35). The convicts rushed the Braylwunyer camp and surprised a group of 40 to 50 people including children. A number of people were injured but the convicts prevailed and were rewarded with possession of: "shelter, campfires and the flesh of Kangaroo, oppossum skins and other reptiles" (Sprod, 1977: 35).

According to the Knopwood confession, Pearce, and his nervous final companion, Greenhill, sighted other smokes over the next few days and attacked two Larmairremener encampments somewhere in the vicinity of the upper Derwent River.

Summary

Extensive buttongrass plains extend in broken patches from near Frenchmans Cap to the Navarre Plains near the King George Range. Family groups of Braylwunyer were seen living on this fringe of the southwest during September. The smokes seen by Pearce and Greenhill were campfires, but from the structure and floristics of the plains today (Jarman *et al.*, 1988), it seems likely that fires lit by Braylwunyer played a large part in their development.

It is interesting to consider the psychological effects that Pearce and his fellow convicts had on the Braylwunyer and Larmairremener. The discovery by Aborigines of dismembered bodies would have seemed an outrageous blasphemy to people who were so careful in the disposed of their dead (Jones,1974,1984, 1988; Roth, 1899; Plomley, 1966, 1983). Interestingly enough, in 1840, the surveyor Calder found several articles of convict clothing which had been carefully interred in a hollow tree. Several neighboring trees had been marked in a mysterious fashion. (Calder,1847: 418). Perhaps the clothes belonged to one of Pearce's victims, interred in a safe place by the Braylwunyer.

After the first 'ambush' on an Aboriginal camp, Pearce and Greenhill kept lookout, because: " although these natives are not cannibals, there has been several instances of people being barbarously murdered by them in several parts of the country" (Sprod, 1977: 35-36). How ironic that the first white people ever to enter the universe of these 'savages' should literally happen to be both murderers and cannibals!

Captain Hardwicke: 1823

Hardwicke travelled from Port Dalrymple to the west coast and made some interesting observations concerning the environment. At Port Sorell, he saw a grassy forest dominated by stringy bark, box and tea-tree brush. In general, the country between there and the Mersey River seemed well suited to agriculture, consisting of an extensive plain of about 600 or 800 acres. To the southwest of the plain was: "an inexhaustible forest of good timber, consisting of lofty gum spars, stringy bark, box, and lightwood" (Hardwicke,1881: 39).

From the Mersey to Rocky Cape, Hardwicke had a poor opinion of the land: "In this extent of coast there is no appearance of its being frequented by natives; and kangaroos are extremely scarce" (Hardwicke, 1881: 39). To the west of Rocky Cape the country took on a more pleasant aspect with heathy plains intersected by thickly wooded forests along the shore. At Circular Head, he estimated that "a very large proportion of land of the first quality, free from timber". He goes on to say that the area was: "much frequented by the natives---. There were several shells of lobsters or crayfish at their fires" (Hardwicke, 1881: 40). Finally he noted that west of Circular Head, the country which consisted of heathy plains and copses of forest, was: "much frequented by natives and kangaroo were in great abundance" (Hardwicke, 1881: 40).

Summary

Hardwicke's commentary makes clear that the heath - forest complexes of the far northwest coast were attractive for Aborigines and by, inference, for settlement by Europeans. His description of Circular Head at being dominated by open country is severely at odds with Hobb's account (see below) who was most impressed by its cover of dense forest.

Plomley sees primary importance in a relationship between Aborigines and vegetation types. He writes that: "The clear demonstration of the interdependence of vegetation and the presence of Aborigines, who were to be found in open country but not in the densest forest. Even those natives who depended upon seafood for their main subsistence still needed a hinterland in which the men could hunt" (Plomley, 1991: 15). He takes Hardwicke's observation that the coast between the Mersey River and Rocky Cape had no sign of Aborigines or kangaroos as confirmation of his thesis. However, as has been mentioned in relation to negative evidence presented by Matthew Flinders and Baudin, this type of argument is inherently weak.

It may simply be that a different, less visible type of occupation took place in coastal forests. Certainly, the ethnohistoric record, so excellently presented by Plomley himself (Plomley, 1966,1983), demonstrates the compatibility of Aboriginal settlement patterns with heavily forested coastlines in the southeast, and tends to negate his proposition. Plomley posits a simplistic relationship between open vegetation (fire affected plant communities) and forest (fire sensitive plant communities) and settlement pattems which, although intuitively attractive, is not supported by either the ethnohistorical or archaeological data.

J. Hobbs: 1824

Like Kelly before him, Hobbs circumnavigated Tasmania. Also like Kelly, Hobb's first encounter with Aborigines concluded with spears being thrown (Hobbs, 1881,19).

The coastal plains near West Point on the west coast was covered with 'timber' consisting off: "very fine stringy-bark, gums, and a few light-wood trees. The soil is barren and little fit for any purpose, with the exception of a few patches nearly a mile inland, of light sandy soil covered with grass" (Hobbs, 1881: 22).

At Circular Head, forests were generally very dense with only a few openings of 20 to 50 acres in extent. In relation to the feasibility of pioneering a route from Circular head to Port Dalrymple, Hobbs considered that: " a waterside (route) is most likely to be the best road, as the natives travel that way and keep it burnt" (Hobbs, 1881: 22).

Whilst giving evidence to the Aboriginal Committee on the 9th of March 1830, Hobbs stated: "On one occasion they (Aborigines) drove the men away by firing the bush and the next day it was found that about two acres of potatoes near the hut had been carried away" (Hobbs: 1830).

Summary

Hobbs seemed to always take the trouble to walk inland at various points in order to assess the land. Although he is probably correct in his conclusion that Aborigines bumt the coastal area, there is actually no evidence to say that inland routes were not as frequently used. The lack of Aborigines and smokes is probably a reflection of declining populations rather than a real absence of people during late summer.

The episode in which Aborigines drove people away from a land holding with fire, presumably in order to obtain food, further demonstrates an understanding by

Aborigines of the use of fire for strategic purposes.

Goodwin and Connelly: 1828

Goodwin and Connelly escaped from Macquarie Harbour on the 14th of March, 1828. Both made it back to the settled districts where Goodwin was employed as surveyors assistant to Charles Darke, while the recividist Connelly continued a life of minor crime. (CSO 1/276/6658). It is commonly thought that Pearce in 1822 and Goodwin and Connelly were the only people to survive an escape from Macquarie Harbour. However others must have succeeded for a paragraph in the Tasmanian and Port Dalrymple Advertiser indicates that a group of 11 prisoners had escaped from the Harbour, one of whom was apprehended at George Town (23rd of March, 1825).

Goodwin was an intelligent and resourceful man who lucidly recorded the details of his journey. Although the exact route is still the subject of some debate (Binks,1980; Flanagan, 1985), it is possible to roughly indicate a number of places where Goodwin commented on the environment or met with Aborigines (the Braylwunyer).

In general the country through which they travelled was thick myrtle rainforest, but on the upper reaches of the Gordon River, in a wide valley (named later by Frankland, 'the Vale of Rasselas') open country was reached in which: "there was excellent feed of all kinds upon it & plenty of kangaroo grass; we saw a number of wattle, stringy bark, gum and Huon pine trees, round the plains" (Goodwin, CSO 1/276/6658).

In this provident vale, the convicts saw: "plenty of kangaroo --- and a great many natives: we ran after a small party of natives, and they left part of an oppossum behind them" (Goodwin, CSO 1/276/6658).

In his official confession, Goodwin admitted to seeing: "a number of natives fires on the hills, and the grass appeared to have been burnt recently and frequently ---. We only fell in with two parties of natives in the whole of the journey, consisting of about ten persons in each, mostly women and children; when we came upon them we had each a long black stick which we pointed at them like muskets, and the natives ran away" Goodwin, CSO 1/276/6658). After 3 or 4 days in Rasselas, the two moved on and intersected the course of the Derwent River.

Summary

This account provides evidence that Aborigines lived for at least part of the year in the southwest (Flanagan, 1982; Thomas, 1984). The fact that both Aboriginal groups consisted of women and children suggests that the men were away on other business and that a roughly normal demographic structure still existed at this time. The timing of the sighting might indicate that visits to the southwest valleys occurred during late summer.

Goodwin's comment that the grass in Rasselas had been recently burnt and had the appearance of being burnt frequently can probably be taken at face value. The fact that he could distinguish different phases of burning points to a fire regime in which patches of vegetation were burnt at different times. It is not clear if Goodwin is referring to grasses in the family Poaceae or to the widespread sedge, buttongrass.

Flanagan (1982,1985) has commented that the familiarity of the Braylwunyer to what appeared to them to be firearms, demonstrates that they had previously come into contact with Europeans. This might indicate that the group had travelled from the settled districts in the east to the western valleys. If this were a traditional pattern of movement, burning of the southwestern inland valleys might have occurred during the entire period from late summer or early autumn.

Jorgen Jorgenson: 1826-1830

The activities of Jorgenson have spawned an impressive collection of books and articles (Clune & Stephenson, 1954; Hogan, 1891; Plomley,1991). The following comments come from a variety of sources, the most significant being a recently reconstructed 'lost' manuscript in which Jorgenson placed on paper the knowledge he had concerning the customs and distributions of the Tasmanian tribes (Plomley,1991).

Jorgenson mentions that Aborigines generally kept small fires and that this practice was adopted in order that they could extinguish the blaze in a few minutes (Plomley 1991: 52). He thought that Aboriginal fires could be easily distinguished from those lit by Europeans. The former: "would ascend in many separate small and faint columns discernable afar off" while the latter: "would rise in one steady and large column discernable afar off" (Plomley, 1991: 56).

Jorgenson mentions that people wer: "very rarely seen without either a fire actually made, or a piece of lighted wood, which they carry with them from place to place". He adds that it was: "firesticks and burning grass which the natives carried with them to light their fires in different places where they might stop "(Plomley, 1991: 56). In an interesting aside he notes that: "I am aware that were acquainted with the mode of procuring fire by friction" but adds the caveat that: "the proper material is not to be obtained in all places" (Plomley, 1991: 56).

Fire was kindled both outside and inside huts (Plomley, 1991: 56 - 58). Jorgenson recorded that in the western language, fire was *patarola* , while in the east it was *lopa*, and in the south, *unee* (Plomley 1991: 60 - 61).

Whilst employed by the Van Diemen's Land Company to survey a practicable route between Hobart and Circular Head in September, 1826, Jorgenson found many indications of Aborigines on the lower Central Plateau, especially in the vicinity of Lake Echo. The vegetation consisted of marshes, extensive plains and open forests in which kangaroos were always abundant (Jorgenson, in Bischoff,1828).

Later, in 1829, Jorgenson was employed under the supervision of Sargeant Anstey of Oatlands, to lead a 'roving party' in pursuit of the Aborigines. He concentrated on the upland areas of the Central Plateau for it was here that he thought existed the great hunting ground for the eastern tribes. On the 29th of December he records that he continually: *"met with native huts, sometimes as many as 30 or so" and continued to:* "look for native fires".

Summary

Jorgenson's observations are not particularly useful in this enterprise. He sheds no new light on either the uses or extent of fire by Aborigines and seems not to have been greatly interested in natural history. The most useful information that he provides is in regard to the attractiveness of the Lake Echo area. The varied plant communities seem to be open formations which may owe their grassy understories to a fire frequency which allowed the growth of grasses without favouring the development of shrubby fire promoting elements.

The roving parties: 1828-1831

The following men were employed in the roving parties to capture Aborigines and conducted their hunts from the Central Plateau to the east coast. Near the Swanport Tier on the east coast, Gilbert Robertson wrote on the 20th of January, 1829, that: "it is evident we must be in their usual route from the number of old fires and huts we saw". One year later, to the east of the Macquarie River, near Campbelltown, Robertson and party: "reached the smoke we had seen last night, but could observe no track - after we passed this smoke and were near Stockers Bottom we saw a fire lighting up about three miles behind us in the very track which we had taken" (CSO 1/322/7578).

Constable Danvers saw campfires and huts at Lake Echo on the 9th of December 1828 while R. Tyrrell saw large numbers of huts and fires on the Basham Plains, also near Lake Echo (CSO 1/320/758).

Other reports from members of the Roving Parties fail to add much to this information.

James Holman: 1831

James Holman's 'observations' are frequently quoted by Bonwick (1870) and Roth

(1899). This is particularly noteworthy because Holman was blind! Nevertheless, Holman's sources must have been exemplary because faith is retained in Holman's information by later authors, in spite of knowledge concerning his infirmity.

He recounts the well known Aboriginal custom of cremation and describes a method of hunting kangaroo in which fire was utilized. He wrote (dictated?): "Having discovered a spot to which they know a number of the animals resort, they make a fire round it, taking care to leave two or three openings by which they may endeavor to escape.; they then station themselves at the places, and as the animals attempting to pass, they spear them. They use similar means when any of these animals are found on a small hill, by making a fire round its base" (Holman, 1835: 405).

Summary

The open country hunting methods using fire act as a counterpoint to the forest methods described by Lloyd. The use of burning techniques over periods of thousands of years would affect vegetation patterns according to the rate of use for any particular area. Very high fire frequencies on infertile substrates would have acted to eliminate trees, with increases in heath or sedge species depending on rainfall. On more fertile soils, grasslands are likely to have resulted. Lower fire frequencies which allowed some tree seedlings to attain maturity would have favoured open understories with ground covers of either ferns or grasses. Places with low fire frequencies might have had denser understories in which the fire sensitivity of taxa increased as frequency decreased.

James Backhouse: 1832

Backhouse was a quaker who, with George Washington Walker visited the colonies to investigate aspects of the penal system (Walker, 1897: 1973). In the course of their studies they visited and commented upon many aspects of life in Australia. The treatment of Aborigines by the colonists formed an integral part of their concern and in this regard their journals and notes provide valuable observations and speculations concerning Aboriginal life.

James Backhouse Walker, collected the papers accumulated by his father (George Washington Walker) and published them in the Papers of the Royal Society of Tasmania (Walker, 1897, 1898). That account of Aboriginal customs and demographics, and the more recently published journals of G. A. Robinson (Plomley,1966), formed the basis for Jones's seminal discourse (1971, 1974) which was the first to attempt a synthetic history of Aboriginal history based on all the major sources.

In 1832, Backhouse toured the colony and recorded his observations in his 'Narrative of a Visit to the Australian Colonies' (Backhouse, 1843). In regard to fire, Backhouse thought that gum trees: "are generally blackened at the base by fire, that has been kindled to clear off the underwood and long grass" (Backhouse, 1843: 25). On Mt. Wellington he observed that: "The trees are blackened to the top, but are beginning to shoot again from their charred stems" (Backhouse, 1843: 34).

With regard to Aboriginal shelters, Backhouse (1843: 78) thought that: "except on the west coast, they had no houses, but in inclement weather took shelter in the thicker parts of the forest in the vallies (sic) or near the sea."

Other than cooking and domestic fires on Flinders Island, Backhouse rarely observed Aboriginal fires. He noted that: "They preserved fire by carrying ignited sticks, or bark, with them, and if these went out, they looked for the smoke of of the fire of some other party, or of one of the fires that they had left, as these often continued to burn for several days" (Backhouse, 1843: 95).

En route to the Hampshire Hills from Circular Head, Backhouse observed that: "This forest is an ascending, undulating ground, and is interrupted by a very few, small, grassy plains. One of these had recently been burnt by a few Aborigines still remaining in this neighborhood " (Backhouse, 1843: 112). He concluded that: "They burn off the old grass, in order that the kangaroo may resort to that which springs up green and tender" (Backhouse, 1843: 112). Later he saw some Aboriginal fires on the far distant coast to the east.

At Jerusalem in the lower Midlands he saw a hills which had been recently burnt, while on the east coast he described forest at Prosser's River, open forest with kangaroo grass at Spring Bay, *Callitris rhomboidea* forest at Little Swanport, forest at Kelvedon, tall forest at St. Patricks Head and open grassy plains at the Break O'Day Plains (Backhouse, 1843: 110,142-146).

On Flinders Island he observed *Xanthorrhoea* spp. which had been charred from burning off the scrub. At Wybalena, Backhouse and Walker: "were occupied in assisting to extinguish a fire---. The fire burnt furiously before a strong wind, but was brought under, by beating it out with green, gum tree boughs. In this work the Aborigines joined and shewed great dexterity" (Backhouse, 1843: 191).

At the Hampshire Hills Backhouse indulged in a little fire lighting: "We set fire to some dead grass and fern, which burnt rapidly, and ignited some of the dead logs with which the ground was encumbered. In this way, the land is often advantageously cleared of unproductive vegetable matter; but it requires many burnings to destroy the logs" (Backhouse, 1843: 116). With J. Milligan, he set fire to an area of ground: "covered with long grass and tall fern" (Backhouse, 1843: 121).

The most spectacular of Backhouses's fires was on Gunn's Plains where: "after burning off the grass ---, a fire was kindled against a log, that proved to be rotten inside, and became ignited; the fire spread, and catching the grass, soon extended into the forest, which was full of brushwood, that it did not appear to have been burnt for many years. The conflagration was exceedingly grand" (Backhouse, 1843: 128).

Summary

This evidence is important because of the credibility generally given to Backhouse's observations. It is important to note the emphasis which he gives to the density of vegetation in the Hampshire Hills.

On the east coast, his observations are interesting in that he recorded a great variety of forest types which in terms of forest dominants appear to be roughly concordant with forests as they appear today. Differences are likely to be apparent in the understorey complement of species. It is significant for example, that open grassy forests with a *Themeda triandra* understorey (kangaroo grass), possibly similar to present day *Eucalyptus viminalis / Allocasuarina stricta - Acacia mearnsii* grassy woodlands (Kirkpatrick *et al.*, 1988), were probably more extensive in the past.

Backhouse's testimony serves as a warning to those who would try to simplify the relationship between Aboriginal settlement patterns and present distributions of plant communities (Jones, 1975; Plomley, 1991). Between the two lies 200 years of change brought about by clearing, grazing and burning activities of Europeans. For example, it is salutary to reflect that on the east coast and in the midlands, very few trees would be greater than 200 years old. Even those that are, might have changed form to cope with different structural characteristics of post-settlement forests. Many open crowned trees in the Fingal valley for instance, have been pollarded in a specific attempt to spread the crowns.

In other words, the structures of todays dry forests do not necessarily provide good analogues for forests extant 200 years ago. Kirkpatrick (1977) and Jarman and Brown (1983) and) argue that modern disturbances to rainforests over the past 150 years might explain apparently anomalous patterns of species occurrences. Jarman and Brown (1983: 84) point out that the effects of exploring, surveying, prospecting, mining, logging and fire may still be manifest in the vegetation because of the longevity of many species.

The evidence presented here (and see below) show that the burning and agricultural activities of Europeans probably contributed as much to the distribution of todays plant communities as did Aboriginal burning. After a consideration of the major exploratory records, Binks (1980) concluded that: "Exploring parties introduced widespread firing as a deliberate policy. The wider the sweep of the fire, the longer it flared and roared in the mountain gullies and darkened the skies for miles around, the greater their satisfaction" (Binks, 1980: 4).

3.5 The Surveyors and land owners

The exploratory adventures of the colonial surveyors have been well documented by Gowland (1976), Binks (1980) and Flanagan (1982, 1985). Details of the appalling conditions suffered by the various parties are not retold here, but it is pertinent to point out that the immense difficulties endured by these men have entered Tasmanian folklore and have led people into believing all that is negative concerning the west coast. Thus, Aborigines could not have lived in the west because the landscape was too rugged or the vegetation too impenetrable. It is to be hoped that a re-evaluation of the explorers reports in conjunction with new discoveries of Holocene sites in the western valleys and mountains (Thomas,1991) should lay to rest that shibboleth.

Henry Hellyer: 1827

Hellyer was employed by the Van Diemen's Land Company to locate land suitable for grazing purposes. To this end Hellyer and a number of other company employees made the first known traverses of the central and northwestern mountains and forests. The first of Hellyer's great trips of exploration was south from Rocky Cape to the area surrounding St. Valentines Peak (Hellyer, 1827, in Bischoff, 1832).

The party pushed through forests to the Dipwood Marsh to the north of the Arthur River, where Hellyer recalled that the place: "appears to be a place much frequented by the native, and has been burnt a few months back" (Bischoff, 1832: 27). They came unexpectedly across a series of 'grassy hills' which were adjacent to large tracts of rainforest. The rainforests were composed of gigantic myrtles (*Nothofagus cunninghamii*), abundant sassafras (*Atherosperma moschatum*) and massive tree ferns (*Dicksonia antarctica*). Except in the thickest of scrub, ferns were everywhere abundant. The grassy hills were extensive and consisted of a central ridge on which grew a few large stringy bark trees (*E. obliqua*). On rocky, less fertile ground closer to the peak, the rainforests were interrupted in places by stringy barks.

From the top of the peak Hellyer estimated that grassy areas of about 1,500 acres existed in a patchwork across the vista. He thought that the area resembled: "a neglected old park" (Bischoff, 1832: 29). An interesting comment is that: "Dead trees lay rotting where they had fallen" (Bischoff, 1832: 29) which may suggest that the portions he viewed at close quarters were in fact fairly recent artefacts, perhaps analogous to the 250 year old grasslands at Paradise Plains in the far northeastern highlands (Ellis, 1985; Ellis and Thomas, 1988).

As they camped on the night of the 15th of February, the grass caught alight from their campfire and quickly spread until rain extinguished it. The next day they continued on to the southwest and: "went over many considerable hills burnt by the natives, found a lot of native huts, and saw several trees from which bark had been taken to cover them" (Bischoff, 1832: 29).

Near to this place, Hellyer came across what he thought to be the most magnificent grassy hill imaginable. It extended for 3 or 4 miles without a single tree. Here he wrote: "the natives had been burning large tracts of grass" (Bischoff, 1832: 29).

He named this place the Surrey Hills and described it as:

"bounded by brooks between each, with belts of beautiful shrubs in every vale, including blue-leaf tea-tree, box, sassafras, blackwood, woodpear, birch, sloe-leaf, musk-holly, celery-top pine, and myrtle. The whole country here is grassy. The grasses in the line of our walk are principally Timothy, fox-tail, and single kangaroo.--- The timber found on these hills is in general of fine growth, very tall and straight: some of it would measure more than 100 feet to the lowest branch, The trees are, in many places, 100 yards apart. They are principally peppermint and stringy bark, --- . It will not in general average ten trees on an acre. There are many plains of several square miles without a single tree. The kangaroo stood gazing at us like fawns, and in some instances came bounding towards us like a flock of sheep. The plains to the north of the peak I called the Hampshire Hills. They appear even more park like than the Surrey Hills, and are handsomely clumped with trees" (Bischoff, 1832: 30).

This vivid description allows a number of comments to be made (see summary below), especially in regard to research which suggests that following the removal of the majority of Aborigines by 1833, the open grasslands reverted back to scrub or rainforest (Bowman and Jackson, 1982; Jackson, 1965; Jones, 1969, 1971, 1973, 1974; Ellis, 1985).

Moving away from the Surrey Hills, the party approached a high forested tier of mountains where they: "found two native huts and marks of many fire-places in the neighbourhood" (Bischoff, 1832: 30). In one of the huts Hellyer discovered some charcoal drawings executed on bark.

Travelling back towards the sea, Hellyer and his companions walked for over a week through tall dark forests, principally dominated by myrtle. Upon retracing their steps to the Dipwood Marsh, they came out on a heathy hill and because: "the day being fine and the heath dry, we set it on fire; and it raged so furiously we were obliged to hurry out of its way, and were in danger of getting burnt" (Bischoff, 1832: 32). The practice of setting fire to the bush by explorers and settlers was alluded to in a previous section and this merely adds a further example.

By now very close to Circular head, the party came across several huts where: "We picked up green boughs by the embers of their fires that had not been gathered two days: we supposed they were not far off, and might have used the boughs for mosquito fans" (Bischoff, 1832: 33).

Summary

The 'firestick farming' theory of Jones (1969) is an elegant and parsimonious explanation for many plant distributions in Australia. Much of the evidence for that theory was derived from Hellyer's description of the Surrey Hills and subsequent comments to the effect that a reduction in fire pressure following the removal of Aborigines resulted rainforest reclaiming the open grassy downs. This influential theory is discussed in Chapter 9.

Hellyer came across recently burned land and Aboriginal huts. Despite his extensive travels he apparently never saw an Aboriginal person face to face. It is clear from the descriptions that coastal woodlands and heaths were separated from elevated inland plains by dense forests of rainforest (Hellyer's green forests) and wet eucalypt forests (Hellyer's Brown forests). In the intervening forests were small patches of grassland.

This pattern suggests at least four general patterns of fire use. On the coastal heaths, extensive cool burns promoted grassy woodlands and heaths, depending on substrate. Infrequent but intensive burns in the great brown forests allowed eucalypts to regenerate at something like 200 to 400 year intervals. Rainforests at the same altitude were substantially untouched by fire except for small patches which had been burnt to create isolated pockets of grassland. At altitudes above 600 m., on good basalt soils, Hellyer suggests that extensive areas of grassland existed in a broadscale mosaic with rainforest and tall stringybark forests (*E. delegatensis*).

Joseph Fossey: 1827

Fossey was a surveyor with the Van Diemen's Land Company. In May, 1827 he travelled part of the route discovered by Hellyer a few months earlier and pushed on to the vicinity of Cradle Mountain where he is thought to have been the first European to approach this spectacular peak.

In the great forests between the Hampshire Hills and the coast he came across: "two small plots of grassland" (Fossey, 1827, in Bischoff, 1832: 40).

Hellyer: 1828

The most impressive of Hellyer's achievements was his expedition to the Mackintosh River in Novermber 1828. His party, consisting of 5 people, set off towards the mountains he had seen to the south of St. Valentines Peak in the previous year.

Once again he intersected one of the smaller plains to the north of the Surrey Hills where the party: "crossed the tract of open country and entered a small open plain lately burnt by the natives" (Hellyer: 9/12/28).

After pressing through scrub and buttongrass plains, the expedition crossed the Macintosh. From a hill nearby they saw: "extensive plains to the left which had been burnt" (Hellyer: 12/11/28). By following the shallow valley of what is now called the Sophia River, they arrived at some plains which were: "heath and a fine sort of grasstree (not growing in tussocks) which the natives have burnt. They would, I thought, hardly come to burn a small patch, and I constantly expected to find a portion of good country not far off" (Hellyer: 12/11/28). This small patch may have been caused by lightning but if not, is further evidence that people did indeed visit the western mountains.

Hellyer intersected a second and more extensive plain, and from the summit of a nearby hill: "observed that the plain which I have since named Cranbourne Chase extended for about 8 miles in length nearly in a N. and S. direction and about 2 miles in width. --- The chase has a cultivated and diversified appearance and from its having being lately burnt in several extensive tracts, looking fresh and green in those places, and in others so completely covered with blooming heath that it resembled vast fields of clover divided by shrubs serpenting every brook which intersected it" (Hellyer: 13/11/28).

The chase was a buttongrass moor expanse containing a fair proportion of flowering heaths, probably belonging to the Epacridaceae. Hellyer's description of the distribution of burnt areas demonstrates unequivocally that in this instance, patch burning was carried out. Later the party returned to the chase where Hellyer further described the area as: "heath and grasstree partly burnt and partly waterlogged" (Hellyer: 14/11/28).

The parties dogs: "captured 3 remarkably fine kangaroo on the burnt ground close by, and the men declared on dissecting them that they had never seen any so fat before, which circumstance leads me to think there is something peculiar to this spot which causes the kangaroo to become so fat, and that the natives burn it off as they are aware of its qualities" (Hellyer: 14/11/28). The kangaroos show that even in a buttongrass environment, it was possible for Aborigines to hunt and obtain large game. The presence of an adjacent 'forest of tall peppermints' gives the necessary varied conditions which provide suitable habitats for marsupials (Green, 1973).

Hellyer's percipience extended to him theorizing that: "It is possible that the natives by only burning one set of plains are enabled to keep the kangaroos more concentrated for their use, and I can in no way account for their burning only in this place, unless it is to serve them as a hunting place on migrating from the coast to the interior, a question which a view from Mt. Heemskirk might have advanced" (Hellyer, 14/11/28).

On the 17th of November the party was heading northeast towards Cradle Valley. The low country leading up to the Cradle Plateau caused Hellyer to note that: "The heathy country appears to be desirable for the natives as it affords them kangaroo, wombat and oppossum and it appeared to have been burnt some time previous of which the many dead stumps standing in the gully bear ample testimony" (Hellyer: 17/11/28).

These observations confirm the presence of Aborigines in the western Tasmanian valleys. The burnt tree stumps in a gully either hint at a previously extensive wildfire that burnt usually fire protected situations, or a controlled fire which was restricted to the gully.

Summary

These extracts from Hellyer's report do not give any indication of the tough, almost deadly conditions with which the party had to cope. The major importance of this trip is demonstration that Aborigines burnt buttongrass plains in the very midst of the western mountains. They give credibility to Jacksons (1965, 1968, 1973) argument that the existence of buttongrass plains is linked to burning caused by Aborigines.

The area of vegetation burnt at any one time is difficult to estimate, but from Hellyer's description there must have existed a considerable variation within the total area of Cranbourne Chase. From a personal knowledge of the Sophia River Valley, it is likely that Cranbourne Chase had a maximum area of 15 km^2. The 'diversified appearance' is reasonably interpreted as a series of buttongrass plains, scrub thickets and rainforest all contained within 15 km^2.

Hellyer specifically points out that the plains were burnt in small areas and that this accounted for the variety in vegetation. It is estimated from the pattern of vegetation which existed in the Sophia River valley prior to 1985 that even aged button grass expanses were about 1 km^2 in area. This may approximate the area burnt in a single controlled fire. He further points out that some area of the plains was swampy underfoot. This condition in concert with the local reticulated stream pattern may have allowed great control to have been exercised over the spread of fire. Unfortunately, the entire area has been flooded by the construction of a major dam across the Mackintosh River.

John Helder Wedge: 1824 1828

As a government surveyor, Wedge was employed in surveys from the west to east coasts. He examined land granted to the VDL Co in 1828 and participated in Frankland's landmark 1835 survey to explore the country beyond the settled districts in central Tasmania. His diaries (Crawford *et al.*, 1962) provide valuable supplementary information to be examined with his official reports to the Surveyor General.

On his expedition to the northwest coast he examined an area which extended from the far northwest tip of the island south to near Temma and inland through the Arthur River catchment to Circular Head.

While travelling through the sandy coastal country near Circular Head he crossed plains of from: "three to four thousand acres" (Wedge, 1828: 35) in extent. In adjacent forest he thought it worthy of remark: "that whilst travelling through the forest I set fire to the underwood on the margin of the plains, and that it burnt to a considerable extent, and in a great measure cleared the land" (Wedge, 1828: 35).

In the northwestern corner he chiefly travelled through open heathy forests on sandy soils. Swamp forests were intersected in which progress was considerably impeded by thickets of sharp flag grass (*Gahnia grandis*). North of Mt. Cameron he passed through: "low forest of stringy bark trees and pencil cedar (*Phyllocladus aspleniifolius*), skirting the swampy forest". Here he found himself: "surrounded by undulating low rises covered with the *Eucalyptus* and pencil cedar, and a thick underwood of dogwood (*Pomaderris apetala*). Some of the tea-tree (*Leptospermum scoparium*) was of considerable girth" (Wedge, 1828: 36).

The prime woolgrowing land of the VDL Co was in this quarter and although substantial treeless areas are to be seen today, when Wedge passed by, the land was clothed in an open grassy *Eucalyptus obliqua* woodland with an understorey of *Banksia marginata*.

In the higher country leading towards the Surrey Hills, Wedge came across a series of 'beautiful open plains' each of some 1,500 acres in extent (Wedge, 1828: 38). Between the plains were extensive wet forests. These plains probably led towards the elevated country near St. Valentines Peak.These plains seem to be among the largest recorded in forests discovered by explorers in the north.

Wedge estimated that there was approximately 40,000 acres of land immediately suitable for grazing. This must not be taken to imply grassland, for the majority of this land was woodland or grassy forest. A further 100,000 acres consisted of unsuitable heaths or wetlands. He estimated that about 700,000 acres of forest existed, a large figure that plainly irritated the London based wool barons who owned the VDL Co. (Meston, 1954).

Summary

Wedge's journey contain no references to Aborigines or fire, other than blazes set by himself. The estimate of grassy vs non grassy vegetation is of interest and suggests that if the result of 10,000 years of post-glacial burning resulted in only 5% of the area being grassy, then 1) Aboriginal fire was ultimately unsuccessful as a clearance tool against natural post-glacial climatic and vegetation trends. This is the general view put forward by Macphail (1979, 1980), Bowdler (1983). 2) grassiness was not necessarily the only attribute selected by Aborigines as desirable in the vegetation 3) the energy and spatial requirements of the people who lived in the area were fulfilled by the 5% fraction, plus the resources obtained from forest and coast.

W. S. Sharland: 1832

This expedition was charged with the responsibility to find a practical route to Macquarie Harbour from the settled districts. Sharland and 10 men made their first nights camp on Bashan Plains near Bothwell on the 29th of February, 1832.

The expedition plodded its way through open grassy forests and groves of cider gum (*E. gunnii*) to the west of Lake Echo. Two native huts were seen at the junction of the Nive and Little Nive Rivers. The country was a mosaic of marshes and open forest in which more huts were sighted.

On the 8th of March Lake St. Clair was sighted for the first time by Europeans. The grass (buttongrass?) on marshes at the southern end of the lake seemed: "to have been burnt during the early part of summer" (Sharland, 1832 in 1861: 5). Two more native huts were seen close by.

As the party neared Frenchmans Cap, dense scrub slowed their progress. Thankfully, Sharland managed to come across a burnt area which afforded them a passage through the undergrowth (Sharland,1861: 5).

By following a marsh, Sharland was able to make up some time and the party soon arrived a:t "a bare hill where a fire had been made by the blacks and I am inclined to suppose that the track I had followed is that which they pursue in passing through this part of the country" (Sharland, 1861: 5-6). More huts were seen as the group made its way past Mt. Mullens.

On the 11th of February, in the valley of the Loddon River, the expedition came across a landscape which is strikingly reminiscent of that observed by Hellyer at Cranbourne Chase at the Sophia River. Sharland wrote that:

"After much fatigue in the getting through, we suddenly, on reaching the top of the hill, opened into ground recently burnt, with a most beautiful valley extending SW, beneath us. The whole of this ground had been burnt, apparently immediately before the late snow, and , I conclude, by the natives. The valley had all the appearance, at a distance, of undergoing all the various processes of agriculture, -some parts (the most recently burnt) looking like freshly ploughed fields; and again, other parts possessing the most beautiful verdure from the sprouting of the young grasses & rushes" (Sharland, 1861: 6).

This description provides good evidence for the use of fire in the southwest valleys. No sightings were made of Aborigines, although from the numbers of huts that were observed, Sharland implies that the valleys were well used. The extraordinary description of the burnt Lodden valley having the appearance of 'all the various processes of agriculture' provides a vision which encapsulates the essence of Jones's 'firestick farming' hypothesis, while at the same time, emphasising the eurocentric world view which was carried by all explorers and settlers.

Like Hellyer's Cranbourne Chase, the buttongrass plains of the Loddon were burnt in patches. Sharland estimated that some were burnt 'before the late snow', which, assuming that the late snows occurred sometime after October 1831, suggests that the burn was less than 3 months old.

From this it is probable that people may have utilized the valleys leading up to Frenchmans Cap anytime between spring and mid-summer. Burning of these places would therefore have been undertaken in the summer months.

A gruesome find by Sharland on the banks of the Lodden River was of human remains which Sharland speculated belonged to an escapee from Macquarie Harbour. It is possible that the body represented one of Pearce and Greenhill's dining sites (see above, Alexander Pearce).

From near to Barron Pass on the ridges leading up to the summit of Frenchmans Cap, Sharland noted that: "I never observed the grass tree (probably *Richea pandanifolia* but possibly *Gymnoschoenus sphaerocephalus*) attain the height which it does upon a hill immediately under the Cap; its head completely towered above the neighbouring shrubs. I observed pines in this part (*Athrotaxis selaginoides*), the first I had seen, but of small size, not being more than 15 or 20 feet high" (Sharland, 1861: 7). These observations suggest a low incidence of fires in an exposed and wet location.

On the 16th of March, the return journey brought the expedition back to the Derwent River where they passed several groups of Aboriginal huts. Near to one, a kangaroo carcass was observed: "carefully placed in the hollow of a tree, and stones place round her" (Sharland, 1861: 9).

Summary

Sharland's expedition was a landmark journey which traversed some of the roughest ground in the state. His report makes it clear that Aborigines had occupied all of the country between Bothwell and Frenchman's Cap. The burning of buttongrass plains is presumed from this evidence to have occurred in summer. This reasonably assumes that seasonal visits were made to the Frenchman's Cap area during the height of summer. If the evidence of Goodwin (1828) and Darke (1833, see below) is taken into account, burning of the valleys may have occurred at any time between October and April. The burning of the buttongrass plains in patches seems very similar to the description given by Hellyer for Cranbourns Chase.

John Charles Darke: 1833

Employed in the fledgling Land Survey Office, Darke had already participated in the survey of numerous parts of the state as well play a major role in the capture of a number of dangerous escapees (Darke's Journals, LSD,1/19.1/72).

In south central Tasmania, the Peak of Teneriffe (Wylde's Craig) was a familiar landmark that straddled the divide between the settled districts and the unknown expanses of the west and southwest. Darke was dispatched in March 1833 to explore the country beyond the peak. In his company was the one available European who had first hand knowledge of that region, the well known escapee called James Goodwin.

On the 26th of March, the party was travelling through grassy eucalypt forests yet just one day later they were forcing their way across ridges and vallies choked with dense forest which appeared to Darke to never having being visited by fire (Darke's Journals, LSD,1/19.1/72). After attaining the summit of the peak, Darke became the first European to describe the distant view of Lake Pedder.

On the 1st of April, Darke's bedraggled and hungry party reached the course of the Gordon River in the Vale of Rasselas. Here he commented that: "the ground has been much burned off by the natives whose huts we observed. Kangaroos are plentiful" (Darke's Journals, LSD,1/19.1/72). This observation is highly significant for it confirms Goodwin's observation of people in Rasselas made in March,1828. Even more significant is that it is possible to speculate that people regularly utilized and burned parts of the Vale of Rasselas from late summer to early Autumn.

Somewhere to the north of Rasselas, probably near the upper Denison Range, the party: "passed through a forest of Huon Pines" (Darke's Journals, LSD,1/19.1/72).

On a second trip to the Vale a few months later in May - June, 1833, Darke travelled to the southern end of the marshes and located: "several trees newly hacked and on searching we found a native hut, nearly new with a rug in it. This confirmed me in my own opinion that these plains are frequented by natives in the summer, and who, most probably, take up their quarters at Port Davey during the winter" (Darke's Journals, LSD,1/19.1/72).

Darke's comment that the native hut was nearly new suggests that it had only recently been vacated, and was therefore probably less than a week old. In that case people might have used the vale for an extended period from March to June. Darke thought that there was no reason why people did not traverse the rest of the country between Lake Pedder and the southwest coast. If the dream of the Wilderness Society to drain the now artificially dammed Lake Pedder ever comes to fruition, it would be exceedingly interesting to conduct archaeological surveys along the old shoreline in order to ascertain the densities and types of artefact scatters to be found along this lowland southwestern lakeshore.

The next day, as the party ascended the south side of the Peak of Teneriffe they: "passed over nearly all the way over burnt ground" (Darke's Journals, LSD 1/19.1/72).

Summary

This journals of these expeditions provide valuable data in regard to the occupation of the southwest. It is highly significant that occupied campsites and burnt patches were observed from late summer to late Autumn. When combined with the evidence of Goodwin(1828) and Sharland (1832) it is possible to say that Aborigines utilized a widespread selection of southwestern valleys for up to six months of the year.

The burning of the south side of the Peak of Teneriffe is inexplicable in terms of correlations with sightings of smokes or campsites. It is not possible to say if the fire(s) was accidentally or deliberately lit. An estimate of the time since burning is not possible with any precision. However,the easy passage offered to Darke through the burnt area suggests that the fire had occurred within 10 years of 1833.

Frankland: 1835

This expedition had in its membership the well known surveyors and explorers, Frankland, Wedge, Calder, Seymour and Alexander McKay as well as about 14 other people, including two Aborigines, several convicts and a group of soldiers (Binks,1980: 132). On the 9th of February, the party left Marlborough at the edge of the settled districts and moved in the direction of the lake sighted by Sharland in 1832.

The next day brought them in sight of the mountains of the Central Highlands, pre-eminent from this direction being the high and 'remarkable' Mt. Olympus. The party skirted the western shore of Lake St. Clair and moved into the Cuvier Valley. Today, the landscape has remained substantially unchanged since Frankland's time. Frankland wrote that: "The opposite bank of the river was steep but thinly wooded and here and there small marshes interspersed. These clear patches occurred more frequently as we advanced, and after proceeding about a mile we emerged into a long open valley quite free from timber, save for a few ornamental clumps of small gum trees" (Frankland: 12/2/1835). A modern bushwalker would see essentially the same pattern of vegetation on that route today.

After descending from Mt. Olympus the party had to camp: "by the reeking embers of a fire which some of the party had unintentionally given rise to, and which put us to great inconvenience" (Frankland: 12/2/35).

The party split into two expeditions , one, under the assistant surveyor Seymour, was to venture north into the high country in an attempt to locate open grazing country. The other, led by J. H. Wedge pushed southeast from the Peak of Tenerrife towards the Huon River and eventually back to Hobart.

Seymour followed the Nive River up to its source in the lake country and discovered a series of extensive grassy plains, well suited for sheep grazing. Wedge, on the other hand, made hard going of travelling down the Gordon River before entering the thick forests which characterise the southeastern river systems.

Summary

In spite of its large size and the presence of so many competent surveyors and bushmen, the reports from this expedition are disappointing. They contain little of interest in regard to sightings of Aborigines or vegetation patterns. Needless to say, this expedition also contributed to the palimpsest of human activity in the area by allowing fires to escape in the Cuvier Valley below Mt. Olympus.

James Erskine Calder: 1840-1841

Calder was the classic public servant who worked his way from assistant surveyor to Surveyor General. His bushcraft and social skills made him a trusted government employee and a frequent contributor to public debate.

Calder accompanied the Sir John and Lady Jane Franklin on their overland journey to Macquarie Harbour (Burns, 1842 in Mackaness, 1955). He guided them to points of interest which he and Alexander McKay had noticed on their survey of 1840. By Calder's time, there was no widespread Aboriginal occupation of Tasmania, and therefore many of his comments regarding Aborigines are second hand. To be fair though, few people had Calder's opportunity to talk to those who had first hand experience , especially Alexander McKay, who, after G. A. Robinson, was probably more familiar with the Aborigines than any other European.

On the 13th of December 1840, about 10 miles west of Lake St. Clair, Calder came across a native encampment which appeared to be only recently vacated. Pieces of partially decayed kangaroo flesh still remained in a well built, bee-hive shaped hut and Calder picked up a native spear which he carried back to Marlborough (Calder, 1849, in CSO 8/30/489).

Calder described the country to the west of the Lake as open forest with frequent marshes characterised by: "a plant something similar to the head of a grass tree---. It bears its seeds on a long straw like stalk". From obvious experience he mentioned that the buttongrass was: "in the highest degree inflammable" producing a: "fierce tremendous conflagration" (Calder, 28/12/40).

On the 25/1/1841, the party found clothing and other remains of escapees from Macquarie Harbour. The items had been carefully placed in a hollow tree. These may have been the same remains viewed by Sharland in 1832 (Calder, 1849: 418).

More significantly, Calder came across Aboriginal huts, one of which contained charcoal drawings of scenes containing men, kangaroos, dogs and other images. This discovery is remarkably similar to that located by Hellyer in the far northwest.

An interesting event occurred on Christmas eve, 1840, when Calder and was sheltering from a particularly violent thunderstorm in a large rockshelter to the southeast of Frenchman's Cap. The party actually witnessed a lightning strike set fire to the surrounding dry vegetation. Fortunately, a: "copious shower of rain extinguished the fire" (Calder, 1849: 421). This place is today called Lightning Plain.

Summary

The reports of Calder provides good evidence for the presence of Aborigines in the southwest but fail to add substantially to earlier accounts. He admits that it is possible that the signs of Aborigines seen by himself and McKay may relate to an isolated family who gave themselves up to authorities on the north coast in 1842 (In Meston, 1954).

The fire at Lightning Plain is a good example of how lightning is generally thought to be an ineffective ignition source in western Tasmania (Jackson and Bowman, 1982). Like those who had gone before, Calder was not adverse to setting alight to vegetation at various points along his route. This occurred especially on buttongrass plains.

The Franklins: 1842

Sir John and Lady Jane Franklin travelled to Macquarie Harbour in 1842 with the help of J.E. Calder who had previously completed most of the journey in 1840. The expedition is remarkable for a number of reasons, none of which unfortunately relate to Aborigines or fire, other than a number of fires allowed to escape by the party itself.

The report by Burns (1842 in Mackaness, 1955) emphasizes the density of forests in the Franklin Valley.

Charles Gould: 1859

Gould's evidence is interesting for two reasons. The first is that as a trained geologist Gould was observant and thorough. The second is that his observations relate to a period 20 years after the last of the tribal people had been taken to Flinders Island.

In the mountains to the west of Lake St. Clair is some of the roughest and least well known of any 'wilderness' area in the state. Gould and a large party of men conducted a geological survey through these ranges during January and February of 1860. In the Collingwood Valley near to the present day Lyell Highway, Gould was: "surprised to observe that it had recently been burnt out" (Gould, 1860: 5). This apparently large fire had almost certainly been ignited by Europeans and again serves to emphasise the massive changes which occurred in vegetation systems after settlement.

At the base of the remote Eldon Bluff, Gould noted that: "Kangaroos and wombats abound; and upon this account, as well as in consequence of the shelter afforded by the situation, the Aborigines, when in this portion of the western country, probably selected it as as a favourable spot for their encampments, since I found traces in many places of the country having been burnt by them years ago, and in one the remains of a kind of hut" (Gould, 1860: 7).

Summary

This was the last of the great expeditions to the western country. The fact that Gould found what he thought to be native huts (although he admits that they might have been constructed by convicts, though this seems unlikely) in places burnt long before, emphasizes the relativity involved in cross-cultural comparisons. Places which Gould and his predecessors thought to be incredibly rugged and remote,were in fact part of an Aboriginal economic system, merely other nodes on the seasonal round, places to visit and to maintain.

If Gould in the Eldons, Hellyer on the King and Sophia Rivers, Sharland on the Lodden, Darke in the Vale of Rasselas and Pearce on the Navarre Plains all found signs of Aboriginal occupation, then who is to say that those places have always been empty, wild or remote?

3.6 Conclusions

The foregoing accounts provide a wealth of detail in regard to the landscape of Tasmania between 1642 and 1840. In Tasmania, fire ecologists argue that because the proportion of burnt vegetation caused by lightning *per annum* amounts to less than 0.01%, the distribution of fires over the last 20,000 years cannot be regarded as random (Calder, 1849; Jackson and Bowman, 1982). The only other regular ignition sources must have stemmed from the activities of people.

The major difficulty with the study of fire ecology stems from a lack of knowledge concerning the long term dynamics of fire in almost all major plant communities. Yet the knowledge that people have occupied Australia for at least 40,000 years has great implications for fire ecologists. Additionally, the possibility that people have been resident in Australia for up to 120,000 years (Singh *et al*,1985) engenders a degree of nervousness in all Quaternary palaeo-ecologists, especially those whose interests are primarily climatological, for other than on certain offshore islands, how far back in time do researchers need to delve in order to be absolutely sure of finding a completely natural, ecosystem?

The ethnohistoric evidence presented suggests that burning of the bush by Aborigines occurred in most parts of the island. That evidence, in conjunction with an appreciation of contemporary plant ecology suggests that different regimes were employed wherever different environmental zones existed. All of this is assumed by plant ecologists, usually with little more than a cursory examination of archaeological, palynological and ethnohistorical sources. In this sense it is considered useful to have a compendium of annotated evidence which demonstrates the statewide extent and effects of Aboriginal burning activities.

Rather more difficult is the question of elucidating details of fire regimes such as fire frequency and intensity. It is considered that the presence of Europeans forced such profound changes in traditional systems that many records cannot be used to illustrate traditional burning techniques. Furthermore, it is suggested that many fires were deliberately set by Aborigines as a response to the alien European presence, either for signalling or defensive purposes. The use of fire by Aborigines for hunting provides the traditional method which could have been easily adapted for more dangerous foes. In this respect the observations of large fires by Peron and Kelly bring to mind the vexed question as to whether the camera acts as independent observer, catalyst or accessory to the crime. In the latter two cases, the observations are likely to suffer from the same sort of uncertainty as the fate of Schrodinger's cat! What has been interpreted as natural behaviour regarding fire, is likely to have been altered by the simple act of observation.

Furthermore the ethnohistorical accounts demonstrate that at the time of culture contact, there were indeed, Aborigines occupying the interior of the southwest. The southwest was not the wilderness so beloved by environmentalists and archaeologists (Gowland, 1976; Binks, 1980; Jones, 1984, 1988).

Jones (1969) had brilliantly utilized ecological data in order to supplement the meagre historical records and in so doing created a strong argument which demonstrated the 'general' effects of fire on the landscape. However, specific fire regimes could not be reconstructed at that time because of a lack of data.

The evidence from the northeast (Chapter 2) suggested that a regional altitudinal gradient correlated with increasingly particular use of fire. On the coast, widespread firing at intervals, probably between about 4 and 20 years, probably characterized most fire regimes. In fertile inland locations, especially in places with moderate precipitation, fires were more restricted in extent except for rare extreme fires which probably devastated large areas of forest. At higher altitudes, where precipitation levels increased as temperatures decreased, fires were much more restricted, although the frequency of fires on small patches of grassland may have approached the upper values for coastal areas.

This pattern probably also applied in the northwest where roughly similar physiographies and vegetation zones exist, although in a somewhat different relationship. Small buttongrass plains are likely to have been burnt at regular intervals leading to the creation of generally even age stands, with copses of eucalypts and scrub wherever drainage conditions permitted. Extensive tracts of rainforest might not have been burnt at all. Mixed forests dominated by *Eucalyptus obliqua* were burnt very infrequently.

In the southwest, extensive tracts of buttongrass plains were maintained by burning to create a complex of uneven aged stands. The high mountain ranges which stand between the coast and inland plains were probably not subjected to intensive burning, although the evidence of Gould suggests that some of these areas were burnt and utilized.

Chapter 4

Aboriginal sites in Tasmania: settlement patterns based on the use of forest

4.1 Introduction

The objective of this chapter is to discuss some possible relationships between forests and Aboriginal settlement patterns in Tasmania. This task was accomplished by conducting surveys for Aboriginal sites in the north of the state and by reviewing the archaeological evidence for the Aboriginal use of forests provided by previous research in other parts of the state. Particular attention is paid to site distributions in northeastern and northwestern forests.

The chapter examines certain notions developed from the ethnohistoric sources in the previous chapter in order to ascertain if that data is consistent with the physical evidence provided by Aboriginal sites. Although the ethnohistorical data from inland locations is fragmentary, there is a strong suggestion that settlement patterns varied according to region, based on language differences and social and economic traditions (Jones, 1971a, 1971b 1974; Plomley, 1966). Of the nine or so recognized Tasmanian tribes, the Northeastern Tribe seemed to have functioned with a greater degree of social isolation than many of the other tribes . In contrast, the Northern Tribe seemed to have close relationships with the West Coast,.Big River, Port Dalrymple and Stoney Creek Tribes (Walker, 1898; Jones, 1971a, 1971b, 1974).

It is of interest to see if these two socially different groups produced similar archaeological traces. This is suspected because the territory of both tribes included frontage onto Bass Strait and encompassed extensive areas of wet forest and subalpine plateaux. A significant difference is that reduced precipitation and poor soils led to the development of large areas of dry sclerophyll forest in the northeast,.

It is not necessary to take an environmentally deterministic stance in order to assert that social similarities reflect environmental similarities. The proposition is made in the belief that people always had choices in regard to settlement location and economic targets. If it is found for example, that Aborigines in the northeast and the northwest had similar settlement patterns, this would not necessarily mean that people were forced into utilizing certain places by natural forces. It could for example indicate that people chose to use similar areas in a like manner. Alternatively, similarities in site distributions between places might point to a common cultural heritage or a history of intertribal exchange.

The ethnohistoric data suggests that the North Tribe burned highland forests in a manner which led to the creation of patches of grassland in tracts of rainforest. These patches generally occured in fertile locations with high precipitation. In places with infertile soils, buttongrass plains took the place of grasslands. This contrasts with the lowlands, where wet sclerophyll forests and patches of rainforest indicated the operation of a fire regime characterized by infrequent, intense fires. Nevertheless, fires were restricted enough to permit the survival of extensive tracts of rainforest. Locations with poorer soils carried dry sclerophyll forests, often with scrubby or heathy understories.

In the northeast, areas of grassy woodland, heathy forest and heathland were maintained by burning strategies which reinforced the development of dry sclerophyll vegetation between coastal heaths and inland wet forests. Isolated pockets of rainforest managed to survive within the dry sclerophyll zone by occupying fire protected gullies and shaded south facing slopes.

Any explanation for the plant community distributions must take into account fire regimes. It is thought that variations in the rate of visits to any one place might determine the rate of ignitions and this might be reflected in the archaeological site density figures. This notion does not take into account why people visited places, and assumes that a society which apparently could not create fire, would intentionally maintain a high rate of ignitions.

On the basis of the ethnohistoric data presented in Chapters 2 and 3, the northeastern coastal plains should have high site densities while the hinterland forests and montane plateaux should have very low densities. In the northwest of the state, densities could be expected to be similar to the northeast for coastal areas, but higher for inland areas where much more data exists to show that people regularly visited those places. The southeast of the state should have high site densities on the coast and low densities inland, while the southwest should have high densities on the coast and extremely low densities inland. The Central Plateau and other alpine areas should have low site densities.

Of course the quality of the ethnohistoric data is not especially good, but considering how often it has been used to justify ecological theory or management practices, it is important to test its reliability in the face of hard archaeological data.

4.1.1 Forests and people

A pervasive theme in Tasmanian archaeological studies has been the influence of forests in regard to Aboriginal occupation patterns, with many researchers viewing wet forests as barriers to settlement and communication (see below). However, a close reading of the journals of G.A. Robinson (Plomley, 1966) and other sources, reveals that a majority of references to Aboriginal campsites and paths refer to forested areas (see Chapter 2). Thus, a situation has developed in which forests have been regarded on the one hand as barriers and on the other as corridors.

From early in the European history of Tasmania, observers viewed wet forests as divisive environmental formations. Walker (1834 in 1973: 268) noted that "The West Coast is shut off from the centre and east --- by a wide region of mountain and forest, extending throughout the whole length of the island". From the European perspective with its horses, carts and other impedimentia this was undoubtably true, but was this necessarily so for Aborigines?

The reaction of the European psyche to the Tasmanian landscape has resulted in two basic respones. The first is a 'threat syndrome' in which forests are viewed as places imbued with an almost sentient malignancy, while the second is a 'conquest syndrome' in which the challenge of crossing or even surviving in the Tasmanian landscape defines the relationship between people and the environment.

Flanagan (1985) points out that many Tasmanian Europeans in the 19th century had to invent myths in order to justify their inability to come to terms with a countryside radically different from the tamed lands of their birthplaces. He argues that the influence of the Romantic movement dictated the language of landscape description employed by early explorers and surveyors. Every sober description of fire or forest reported in chapter 2 of this thesis has a counterpart which employs the language of Romanticism. Adjectives such as hideous, great, immense, forbidding, sterile, gloomy, vile and waste are liberally scattered through the records (Flanagan, 1985:66). The widespread nature of this type of commentary has contributed to prevailing attitudes, not only to southwest Tasmania, which was Flanagan's main concern, but to forests everywhere.

To the convicts and early settlers, the forests contained nothing but the threat of death and the certainty of backbreaking work. They provided cover for bushrangers and escaped convicts, and perhaps more significantly, were home to Aborigines. It is important to note that the 19th century use of the term 'woods' refers to forests and not to the structurally open class of vegetation termed 'woodland'. It is also interesting to note that the colonial newspapers often referred to Aborigines as 'people in the woods' (Hobart Town Gazette, 19/10/1816) or 'wanderers of the woods' (The Tasmanian & Port Dalrymple Advertiser, 12/1/1825). Evidently the settlers thought that Aborigines were at home in forests.

In the 20th century, forests were regarded as emblems which symbolized Tasmanian history. The folklore of Tasmania celebrated the physical efforts of track cutters (Binks, 1984), forestry workers (Jennings, 1983) and bushwalkers (Gee & Fenton, 1978) with each group acting in its own way to alter the natural integrity of forests. An amalgam of these attitudes still exist, for large sections of Tasmanian society maintain a view of forests as threats or challenges. Tasmanians have inherited a sense of pride based on the tallness of the trees, the hardness of their timber, the difficulty and danger of felling the forest giants or the problems of navigation in featureless forests.

Little or no attention has been given by researchers as to how these attitudes might have influenced the development of ecological or archaeological theory (*sensu* Feyerabend, 1975). What of the possibility that the concept of wilderness did not exist in Tasmania until its invention by Europeans? What if Aborigines did not live in fear or awe of forests?

There is ethnographic evidence that Aborigines believed in the existence of evil spirits (Plomley, 1966), but there is no evidence to suggest that Aborigines shunned forests as a result. Is it too much to suggest that the ubiquity of the threat and challenge syndromes in contemporary society may have contributed to the development of archaeological settlement hypotheses in which forests are presented as barriers. Might it not be more productive to view forests as unifying entities, equally as significant to Tasmanian Aborigines as were maritime resources, marsupials and ochre?

The notion that rainforests constituted an impediment to settlement runs deeply through a great deal of the most significant Tasmanian literature (eg. Bowdler, 1983;

Cosgrove, 1984; Jones, 1977, 1984; Kiernan *et al.*, 1983; Lourandos, 1968). These researchers view rainforest areas as impediments to settlement. In an early paper, Jones (1966: 1) correlated ethnohistorical data with vegetation distributions to conclude that "areas not occupied by the Aborigines coincide closely with the distribution of the temperate rainforest." He went on to suggest that Aboriginal burning may have acted to"reduce the adverse effect of the rainforest and to create, in a limited way, a more favourable environment" (Jones, 1966:2). Later, he regarded the people who 8,000 years ago at Rocky Cape as having been: "For several thousand years, pressed against their new coastline of quartzite cliffs by the tangle of wet scrub inland" (Jones,1977:194).

This position is however, much more sophisticated than the impression conveyed by any quote in isolation. For example, Jones posits that changes in diet and stone tool manufacture at Rocky Cape:

"reflected the response of prehistoric Tasmanian society to the opportunities offered them by the adjustment of the environment to non-glacial conditions. Thus 'natural' ecological factors such as climate and the effects of salt spray on the new coastline, would have combined with fire pressure of the Aborigines themselves , to open up the country into a mosaic of coastal heaths, small grassy plains and the succession from wet sclerophyll scrub to *Nothofagus* rainforest" (Jones, 1977:194-195). This significant proposition is taken up in chapters 6 -8 in regard to the recent evolution of Holocene vegetation systems in the northeast.

In the southwest, rainforest has also been cast as a villain, this time responsible for the eviction of Aborigines from their limestone caves (Kiernan *et al.*, 1982; Jones,1984; Cosgrove *et al.*, 1990)). Rainforest in the southwest has been consistently viewed as an obstacle:

"The greatest impediment to travel, however, was not so much the mountains, since there are rivers cutting through them in huge gorges, or the climate, though it is cold and wet, with sleet and snow sometimes even in summer and the whole number of sunshine hours being the lowest in the whole of Australia, but the vegetation. Choking the valleys and slopes of the hills is dense closed-canopy rainforest that constitutes a formidable barrier to any human movement." (Jones,1984).

Similarly, Bowdler(1983:62) views the post-glacial expansion of rainforest as a force preventing settlement by noting that:

"rainforest effectively pushed people out of some areas (such as the southwest) and prevented the effective occupation or reoccupation of other areas such as Hunter Island and the west coast during its period of maximum extent (7,000 - 4000 BP)."

Lourandos (1968) had initially accepted Jones's hypothesis but later moved to challenge this position by presenting data from a sandstone rockshelter (Warragarra) in the upper Mersey Valley, located "deep in the rainforest belt" (Lourandos 1983: 45). He suggests that this site "clearly indicates that settlement did take place of parts of this vegetation zone perhaps throughout the Holocene" (Lourandos 1983: 45). He pointed out the need for fundamental ecological research to clarifiy a number of issues, including the importance of establishing a definition for Tasmanian rainforest. He further realised that local palynological studies could provide the data which might link occupation patterns with vegetation change.

In a study devoted to the explication of Aboriginal site patterns in Tasmania, Cosgrove (1990) points out that the amount of ethnohistoric data for the use of forests by Aborigines is meagre. He suggests that callidendrous rainforest (*sensu*, Jarman *et al.*, 1984) might have been deliberately protected from burning so as to retain its open park like understorey. This attribute would be attractive to people for the purpose of travelling and for maintaining contact with neighbouring groups.

In regard to the north of the state, Cosgrove believes that Aboriginal settlement patterns were based on a combination of coastal and inland economic resources. He contrasted this pattern with more strictly coastal strategies in the west, the seasonal use of forests in the east, and a central and northern pattern which focussed "on resources of the forest for perhaps a substantial part of the year" (Cosgrove, 1990: 34).

The rest of this chapter investigates archaeological settlement pattems in inland locations in northeastern and northwestern Tasmania. The northeast of the state has had remarkably few archaeological investigations considering the extent and variety of landforms which exist east to west between the Tamar River and Cape Portland and north to south from Waterhouse Point and Ben Lomond (Cosgrove, 1984, Kee, 1987). From the available ethnohistoric data and because a large central proportion of this area was covered by rainforest at the time of European contact, Jones (1971a, 1971b, 1974) assumed that the wet forests of the northeast were, for the most part, not settled by Aborigines.

4.2 Evidence for the use of northeastem forests by Aborigines

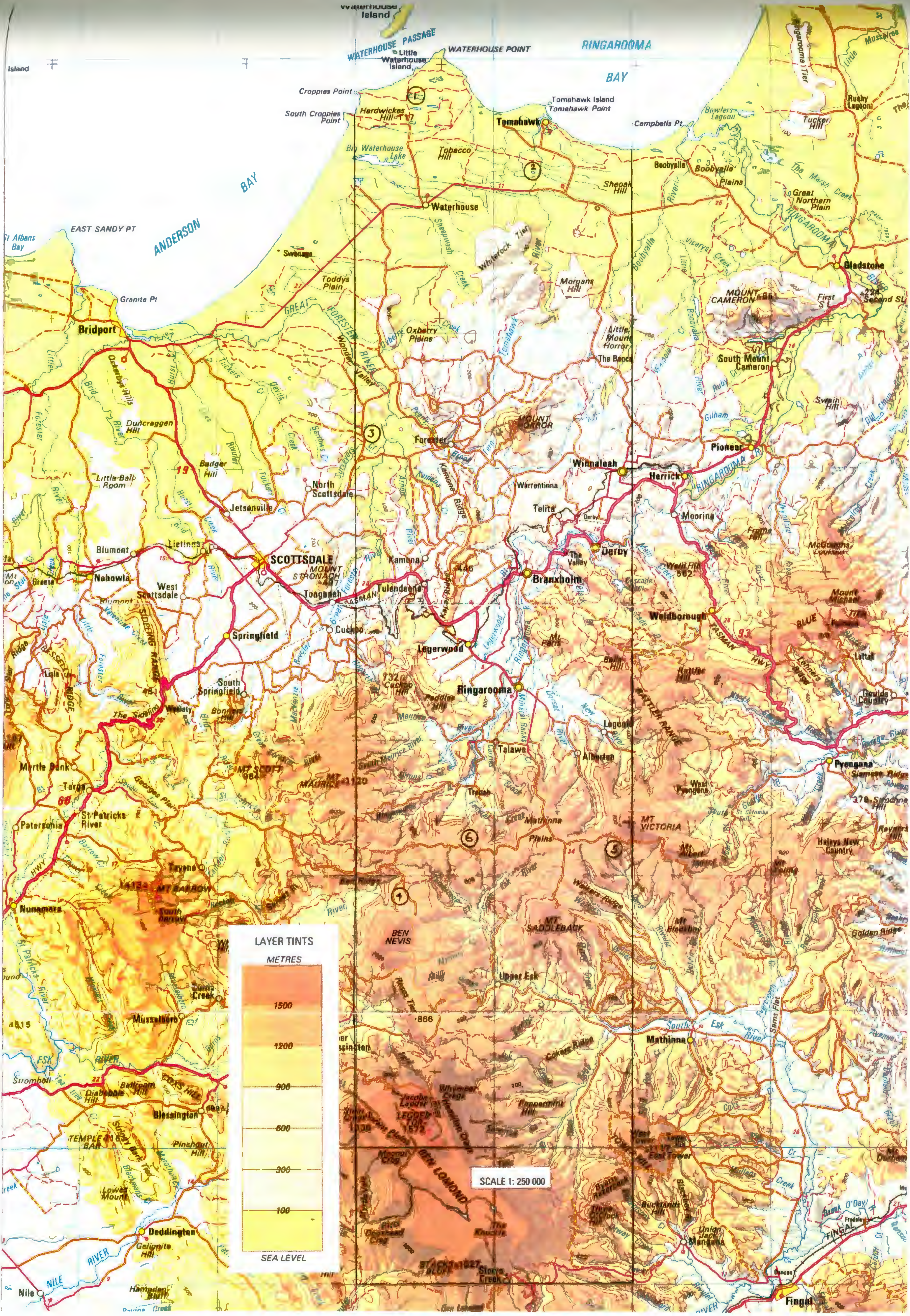
A broad transect 90 km in length, 20 km in width and 1800 km^2 in area was defined which ran from the coast at Waterhouse Point to the southern edge of the Ben Lomond plateau (Figure 4.1) to incorporates some of the steepest environmental gradients in Tasmania. The most obvious controlling variable is altitude which ranges from sea level to 1,570 m. Other related gradients include temperature, precipitation and soil fertility. Represented in this complex are examples of the major vegetation types found in the state *viz* coastal vegetation, heathland, dry sclerophyll forest, wet sclerophyll forests, rainforest, treeless alpine heath and scrub, sedgeland and limited areas of grassland.

The transect consists of approximately 100 km^2 of heathland between 0 m and 50 m in altitude (coastal plain); 300 km^2 of forested land between 50 m and 100 m (undulating hills); 370 km^2 of forested land between 100 m and 300 m (steep hills); 120 km^2 of montane forests and plains between 700 m and 1,000 m (montane plateaux) and 120 km^2 of treeless alpine country (alpine). Descriptions of the physical characteristics of the above units are provided with the results in Section 4.4.

The remaining 840 km^2 of land, comprised extensive agricultural holdings and was not surveyed because access proved difficult. The Scottsdale farming community was

Figure 4.1. The primary study area, northeastern Tasmania. Reproduced with permission from the Tasmanian Department of Planning and Environment.

1 - Waterhouse Marsh
2 - Leedway Lagoon
3 - Forester Marsh
4 - Big Heathy Swamp
5 - Una Plain
6 - Paradise Plains



Waterhouse Island
WATERHOUSE PASSAGE
Little Waterhouse Island
WATERHOUSE POINT
RINGAROOMA
BAY
Island
Croppies Point
South Croppies Point
Hardwickes Hill
Tomahawk Island
Tomahawk Point
Tomahawk
Campbells Pt
Big Waterhouse Lake
Tobacco Hill
Boobyalla
Boobyalla Plains
Bowlers Lagoon
Tucker Hill
Rushy Lagoon
The Marsh Creek
Great Northern Plain
Sheoak Hill
Waterhouse
ANDERSON
BAY
EAST SANDY PT
St Albans Bay
Swimcart
Todds Plain
Granite Pt
GREAT
FORESTER
RIVER
Whiterock Tier
Morgans Hill
MOUNT CAMERON
Gladstone
First
Second
Bridport
Oxberry Plains
Little Mount Horror
The Bends
South Mount Cameron
Duncraggen Hill
MOUNT HORROR
Swan Hill
Forester
Gilham
Pioneer
Badger Hill
Winnaleah
Herrick
RINGAROOMA
Warrentinna
Little Ball Room
North Scottsdale
Jetsonville
Telita
Moorina
Derby
Blumont
Lietinna
SCOTTSDALE
MOUNT STRONACH
Kamona
The Valley
Nabowla
Branxholm
Weld Hill
West Scottsdale
Tonganah
TASMAN
Tulendeena
Weldborough
BLUE
Springfield
Cuckoo
Legerwood
Mt Paris
TASMAN
HWY
Cuckoo Hill
South Springfield
Ringarooma
Gould's Country
Myrtle Bank
MT SCOTT
MT MAURICE
Talawa
Alberton
Pyengana
Targa
West Pyengana
Patersonia
St Patricks River
Mathinna Plains
MT VICTORIA
Halleys New Country
Tayene
MT BARROW
Nunamara
South Barrow
Ben Ridge
BEN NEVIS
MT SADDLEBACK
Golden Ridge
LAYER TINTS
METRES
1500
1200
900
600
300
100
SEA LEVEL
Upper Esk
Musselboro
South
Esk
River
Mathinna
ESK
RIVER
Stromboli
Ballroom Hill
Blessington
Jacobs Ladder
LEGGES TOR
Peppermint Hill
TEMPLE
Pinchgut Hill
BEN LOMOND
SCALE 1: 250 000
Lower Mount
Deddington
Gelignite Hill
The Knuckle
STACKS BLUFF
Storys Creek
Mangana
Fingal
FINGAL
NILE
RIVER
Nile
Hampden Bluff

uniformly opposed to surveying for Aboriginal sites. The local constabulary gave adviceto the effect that it would be dangerous to ask permission from certain gun toting landowners! With this restriction firmly in mind, the agricultural land was eliminated from the analysis.

4.3 Methods

One square kilometre quadrats within the landscape units were examined by surveying all vehicular and walking tracks contained within their boundaries, and by running approximately parallel transects across each block at 100 m intervals. Direction was provided by compass while distance was measured by pedometer.

All quadrats were subjectively selected by choosing 1 km^2 grid squares on the Tasmanian Department of Lands 1: 25,000 map series so that each contained a variety of medium scale topographical features within larger units recognized by landscape studies (Pinkard, 1980). In the case of rainforest and wet forest areas, the final selection was made on site, using groundsurface visibility as the primary criterion.

In the highland forest areas, quadrats were imposed over mosaics of plain and forest in an attempt to maximize archaeological visibility. The location of quadrats was predetermined to a large degree by the the limited extent of open montane country. Wherever the archaeological visibility was enhanced by the existence of vehicular tracks, the opportunity was taken to inspect such places (*sensu* Cosgrove, 1990). On the treeless summit plateau of Ben Lomond, quadrats were selected at points which lay above access routes which led through encircling dolerite cliffs up to 300m high.

Surveys by Cosgrove (1984) and Kee (1987) had located a number of sites to the east of the study area, including the 8,000 year old Rushy Lagoon site near Cape Portland, but neither of these surveys included montane, rainforest or alpine environments. Prior to the present survey, a total of five artefact scatters had been located in the Waterhouse area, two in the vicinity of Mt. Horror and none in the high country (Kee, 1987). These sites are not included in subsequent site density calculations.

Relative proportions of artefacts were calculated based on the number of artefacts, excluding unmodified manuports and artefacts less than 10 mm in length, at each site; or in special cases, on the cumulative total of all artefacts from a defined subset of the total number of sites located by a survey. Site densities were calculated as the number of sites per one square kilometre.

Details of site contents and artefact attributes were recorded onto standard Tasmanian Parks Wildlife and Heritage recorded sheets. A site was defined as any artefact or cluster of artefacts which was separated from its nearest neighbour by at least 50 m. Artefacts were defined according to the categories used by Lourandos (1977), Thomas (1983), Brown (1986), Thomas (1987) and Thomas & West (1990)

In an effortt to obtain a large sample of artefacts from a highland site, an excavation was conducted in a rockshelter (MV2) near Mt. Victoria at 800 m altitude. It was also hoped to obtain a basal date which could be correlated with dates from the basal sediments of a nearby *Gymnoschoenus sphaerocephalus* bog.

Standard excavation techniques were utilized, (*sensu* Jones, 1971a; Bowdler, 1984). Spits were removed in arbitary 3 cm levels with the contents dry sieved and weighed. Radio-carbon dates were obtained from charcoal samples recovered from the lowermost spit. Other than the reporting of radio-carbon dates and a technological analysis of artefacts, the results of these excavations are not further discussed and will be published elsewhere.

4.4 Results and analysis

The results are presented in sequence according to the land units defined in section 4.3.1

4.4.1 Coastal Plain (0 - 50 m)

Four quadrats each of 1 km^2 were selected at Waterhouse Point as sufficient to characterise its archaeology. For the most part, the area consists of heathland and sheep grazing properties. The most characteristic feature of the area is an extensive dunefield consisting of Interglacial marine sands, late Last Glacial terrestrial dunes and lunettes and Holocene cover sands (Bowden, 1984). Cosgrove (1985) had observed the presence of artefacts eroding out of putative Pleistocene age longitudinal dunes to the east of the study area and it appeared likely that a sample of inland Pleistocene open sites would be discovered.

The unit is defined as the area of land bounded by the coast and the Bridport to Gladstone road. This is not as artificial as it seems for the road almost follows the boundary between soils formed on Quaternary marine sands and those formed on granite and dolerite (Figure. 4.2). The total area contained within the transect is 100 km^2. More than 50 km of coastline was also surveyed but that data is not presented in this thesis.

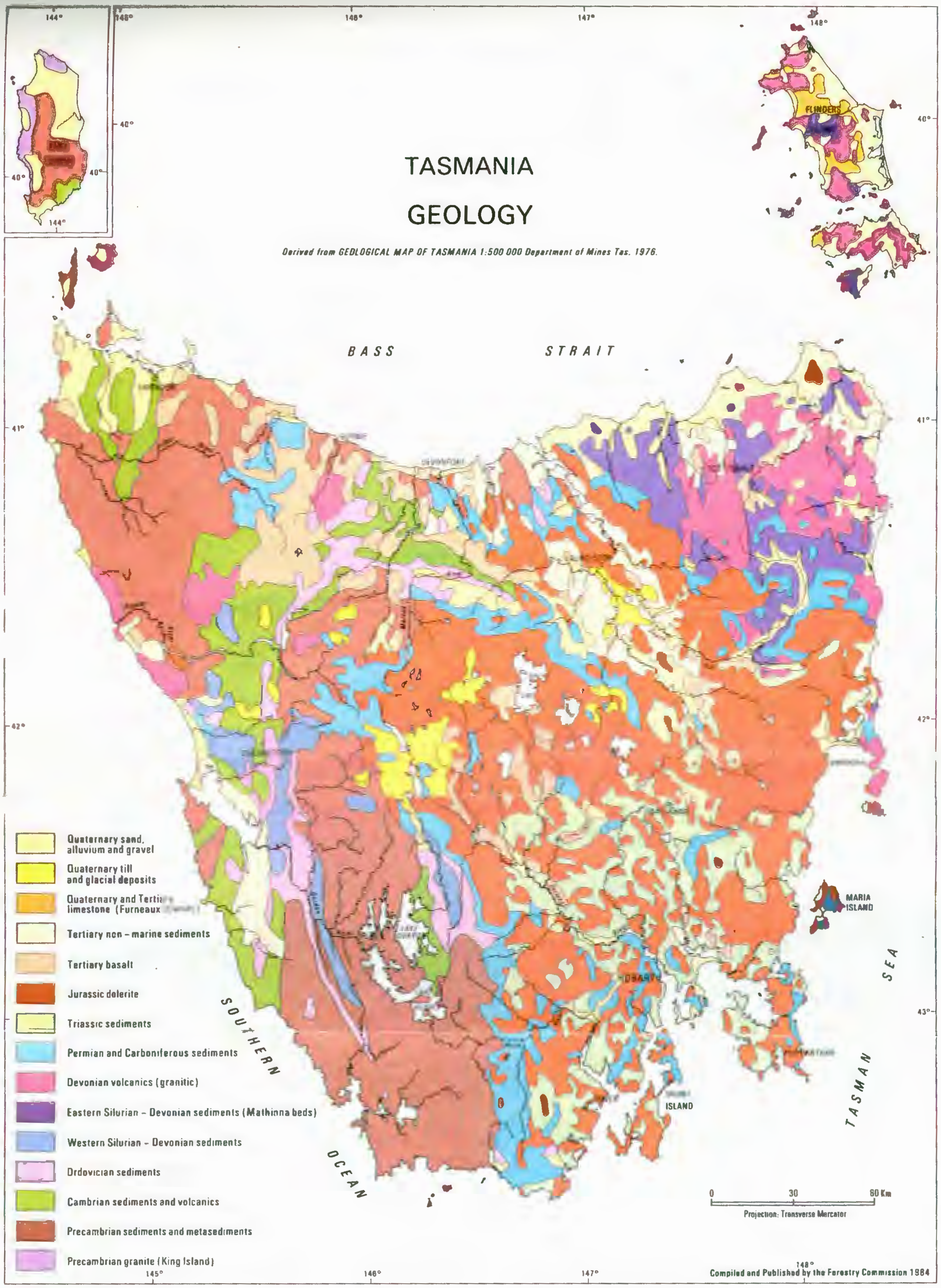
A total of 47 artefact scatters were located in 4 quadrats comprising 4% of the area of the land unit. Visibility was patchy and estimated to be 30% of the ground surface for most of the area of all quadrats. The total area of ground actually sighted in the 4 km^2 therefore amounts to 1.2 km^2. Assuming that sites are distributed equally across the landscape, this gives 39.2 sites per km^2 or about 3,900 sites in the 100 km^2 of the Waterhouse area. The nearly equal distribution of sites across the 4 quadrats suggests that this may be a reliable figure. The average number of artefacts per site in the surface sample is 2.2.

No midden material was found more than 200 m from the sea. This is a very different situation to the west coast for example where midden sites are commonly encountered up to 1 km inland.

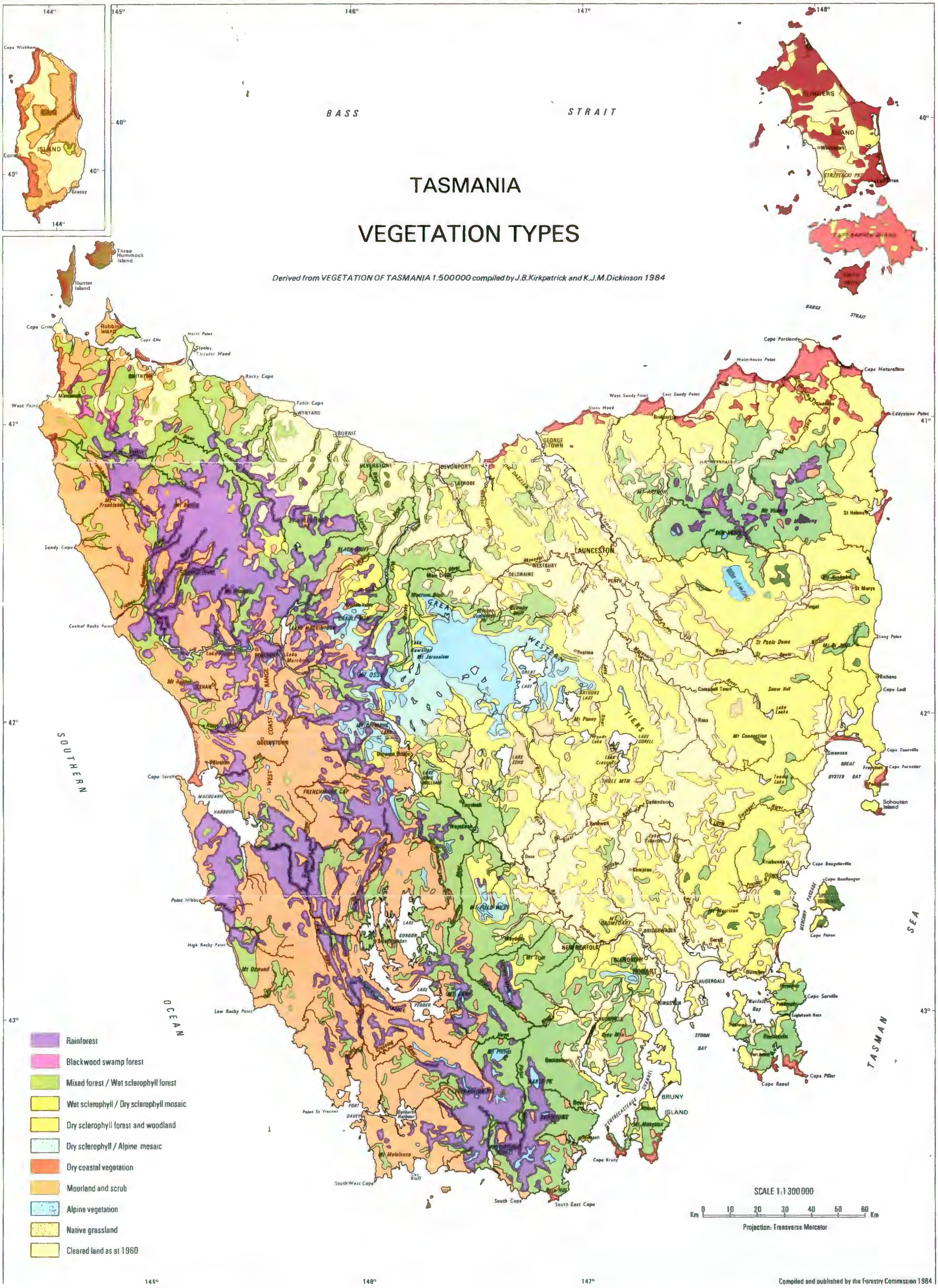
The largest and most significant scatter (WHM1) was not located in the formal quadrats, but on the northern margin of the large reed marsh 1 km southwest of One Tree Hill. At this place, 734 artefacts were analysed from a total estimated to be in excess of 2,000.

igure 4.2. The geology of Tasmania (reproduced with permission of the asmanian Forestry Commission).

Figure 4.3. Vegetation of Tasmania (reproduced with permission of the Tasmanian Forestry Commission).



TASMANIA
GEOLOGY
Derived from GEOLOGICAL MAP OF TASMANIA 1:500 000 Department of Mines Tas. 1976.
BASS STRAIT
FLINDERS
MARIA ISLAND
TASMAN SEA
SOUTHERN OCEAN
ISLAND
Quaternary sand, alluvium and gravel
Quaternary till and glacial deposits
Quaternary and Tertiary limestone (Furneaux Group)
Tertiary non - marine sediments
Tertiary basalt
Jurassic dolerite
Triassic sediments
Permian and Carboniferous sediments
Devonian volcanics (granitic)
Eastern Silurian - Devonian sediments (Mathinna beds)
Western Silurian - Devonian sediments
Ordovician sediments
Cambrian sediments and volcanics
Precambrian sediments and metasediments
Precambrian granite (King Island)
0
30
60 Km
Projection: Transverse Mercator
Compiled and Published by the Forestry Commission 1984
144°
145°
146°
147°
148°
40°
41°
42°
43°


TASMANIA
VEGETATION TYPES
Derived from VEGETATION OF TASMANIA 1:500000 compiled by J.B.Kirkpatrick and K.J.M.Dickinson 1984
BASS STRAIT
SOUTHERN OCEAN
TASMAN SEA
Rainforest
Blackwood swamp forest
Mixed forest / Wet sclerophyll forest
Wet sclerophyll / Dry sclerophyll mosaic
Dry sclerophyll forest and woodland
Dry sclerophyll / Alpine mosaic
Dry coastal vegetation
Moorland and scrub
Alpine vegetation
Native grassland
Cleared land as at 1960
SCALE 1:1 300 000
Km 0 10 20 30 40 50 60 Km
Projection: Transverse Mercator
Compiled and published by the Forestry Commission 1984

The site extends over a distance of 1km from the western to the eastern end of the marsh (Plates 1).

Another large deflated site (WHM2) exists on a creek which runs into Croppies Bay. A further 2 large artefact scatters were found in the large deflated areas to the south west of Big Waterhouse Lake (Plate. 15). All of these sites are perched on hardpans which appear to be relict B horizons of podsol soils stripped of their A horizons. In all cases the sites are associated with poor drainage. Unfortunately, the efforts of the Tasmanian State Goverment to stabilize large areas of mobile dunes has led to the situation where many Aboriginal sites, including some of the above, have been crushed by bulldozers.

There is a suggestion that regularities exist in relation to the spatial patterning of sites. All known large accumulations of artefacts are located near creek lines or lagoons, and none contain shell material. The vegetated sand sheets contain 31 small sites per kilometre, apparently scattered at random across the sand plain.

In contrast to the surface artefacts found at the remaining 47 sites, the artefacts which constitute WHM1 are actively eroding out of the upper horizons of a soil profile which is continuously exposed for approximately 1 km along a deflated vehicle track. The track follows a long ridge marking the northern bank of the marsh. Inspections of the uneroded margins of the track did not reveal any extensive spread of artefacts on the adjacent ground surface. A similar circumstance has been previously observed elsewhere in the northeast by Cosgrove (Cosgrove, 1985).

The surface site has markedly greater percentages of simple flakes and retouched flakes compared to cores, fragments and flaked pieces. In contrast, WHM1 has higher percentages of fragments, flaked pieces and cores. Additionally, it should be noted that only 5 lithic types were observed on the surface sites compared to at least 17 at WHM1.

Flakes	Retouched flakes	Cores	Flaked pieces	Fragments
41 (40.2%)	5 (14.7%)	3 (2.9%)	26 (25.5%)	10 (9.8%)
195 (26.6%)	47 (6.4%)	54 (7.4%)	272 (37.1%)	166 (22.6%)

Table 4.1. The frequency of artefact classes from WHM1 (lower) and WH surface sites (upper).

Dating of WHM1

Dates were obtained from the A horizon of WH1 adjacent to in-situ artefacts. A carbon date was obtained from clean hard black charcoal taken from 60 cm depth in the bleached A2 horizon of the aforementioned dune. The inverted saucer like section of

Plate 1. Waterhouse Marsh on the coastal plain of northeastern Tasmania. In the foreground, a low heath dominated by *Banksia marginata* and *Allocasuarina monilifera* grows on highly siliceous sands. Three pollen traps were set in a transect from the left hand margin to the centre of the marsh. Sediment core WH/3 was retrieved from the centre of the marsh.

Plate 2. Waterhouse Marsh two days after an intense fire in November 1987. The patchy nature of the burn is evident from the number of surviving plants. During the fire, the surface of the marsh was burnt, resulting in massive regeneration by aquatic vegetation.

Plate 3. The alpine plateau of Ben Lomond. In the distance to the north are Ben Nevis and Mt. Victoria.

Plate 4. Forester Marsh in the undulating hill country to the south of Waterhouse Point. The remaining large trees are survivors from an earlier cycle of logging. A dense stand of *Lepidosperma longitudinale* dominates the marsh. Pollen traps were set in the forest, in the centre of the marsh and in the foreground heath. A sediment core (FM 1) was retrieved from the centre of the marsh.

Plate 5. Cradle Mountain and Lake Dove. The Overland Track ascends past the summit of Marion's Lookout in the right middle distance.

Plate 6. The flooded course of the Mersey River at Lake Rowallan. Aboriginal sites are located along the eroded banks of the impoundment. The sunlit mountains in the background are in the Cradle Mt. - Lake St. Clair National Park.

Plate 7. The subalpine grasslands of Paradise Plains in the northeastern highlands. Ten pollen traps were set across the plains from eucalypt forest behind the viewer to rainforest in the distance. A *Sphagnum* bog is located out of sight in the central depression.

Plate 8. Pollen trap BH1 at Big Heathy Swamp in the northeastern highlands. The 1,350 m high summit of Ben Nevis looms above to the south. *Restio australis* and *Empodisma minus* dominate the bog surface. A small patch of *Sphagnum* can be seen near the lower right hand margin. A sediment core (BH 1) was retrieved from the trap site.

the charcoal deposit initially suggested that it represented a small Aboriginal fireplace. (Plate 13). Sediment characteristics from the A and B horizons are provided in Fig. 6.20.

The charcoal returned a date of 4,840 +/- 80 BP (Beta - 17291) and seemed to be reliable in terms of the quality and amount of sample. In order to check the accuracy of the C^{14} date a sample of quartz sand grains (90 - 125 microns) from 5 cm higher in the profile than the charcoal deposit was dated using the thermoluminescence technique (TL). The sample returned a date of 6,400 +/- 700 years (W1192). After re-calibration this gave an age of 6,350 +/- 700 BP. At one standard deviation, the charcoal and sand dates disagree by 730 years whereas at two standard deviations the dates overlap.

If, as seems possible, the charcoal sample was even slightly contaminated by younger carbon, then the real difference between the two samples becomes even less. The TL date is regarded as reliable estimate of the time of sediment burial (J. Price, University of Wollongong, pers comm). The carbon date is regarded as providing a minimum age for the same depth in the profile.

4.4.2 Inland undulating hills (50 - 100 m)

The 270 km^2 of this unit includes extensive rough grazing lands to the west of Mt. Horror (Plate 4; Figure 4.1). The 4 quadrats in this unit constitute 1.5% of the total area of the major transect. The local vegetation consists of an open forest of *E. viminalis* with a scrubby understorey of *Acacia verticillata, Allocasuarina monilifera, Allocasuarina littoralis* and *Lomandra longifolia*. The open nature of the forest and relatively low litter loads gave reasonable ground surface visibility estimated at 20%. Approximately 0.8 km^2 of bare ground surface was sighted in the 4 km^2, resulting in 5 sites per km^2 with each site averaging 3 artefacts per site.

4.4.3 Inland steep hills (100 - 300 m)

Three quadrats were surveyed at the headwaters of the Tomahawk River and one at the base of the Whiterock Tier (Figure 4.1). The unit is very diverse with a large range of geological and landform types, and vegetation varying from dry sclerophyll forest to rainforest in an area of 370 km^2. A small amount of additional data from this unit is available from a survey by Gaughwin (1991).

Within each quadrat, ground surface visibility varied between 5% and 20% depending on the level of disturbance by forestry activities and on this basis a figure of 12.5% was used to calculate site densities in the 0.5 km^2 of ground surface sighted by the survey. Three sites were located in this sample giving an average of 6 sites per km^2 with each site containing on average, 1.7 artefacts.

4.4.4 Montane plateaux (700 m - 1,000 m)

Initially, one quadrat was surveyed on the Maurice plateau, however, no sites were located and so rather than continue sampling in a rainforest with very poor visibility, 4 additional quadrats were located on the open plain and forest mosaics near Mathinna Plains, Paradise Plains, Big Heathy Swamp and Dans Rivulet near Mt. Victoria (Figure 4.1).

The plateau covers an area of 120 km^2 and is composed of extensive areas of rainforest, mixed forest, wet sclerophyll forest and smaller areas of sedgeland and grassland. Five quadrats comprised 4.2% of the area of the unit had groundsurface visibility which varied immensely from less than 5% in some pockets of rainforest to 20% on some areas of degraded grassland. The situation was akin to that found in the preceding unit and on that basis it seemed reasonable to accept an average visibility figure of 12.5%. This resulted in 0.6 km^2 of groundsurface being inspected. A number of rockshelters and open artefact scatters were located.

4.4.4.1 Open sites on the plateaux

A total of 23 sites was located resulting in 38.3 sites per km^2. This figure is slightly misleading because 8 of the sites are rockshelters which are obviously not distributed equally across the landscape. Adjusting the figure to 15 open sites results in a site density of 25 open sites per km^2 at an average of 1.9 artefacts per site. The suface of the rockshelter site MV2 consisted of 43 artefacts comprising 4 lithic types *viz* quartzite, quartz, silcrete and black chert.

Five sites were located on Mathinna Plains (Plate 17), four on Paradise Plains (Plate 7), two at Big Heathy Swamp (Plate 8) and four near the rockshelters at Dans Rivulet (Plates 18 & 19). Each site contained less than 5 artefacts made from quartz, quartzite or silcrete. It seems likely that many more sites exist where visibility was impeded.

4.4.4.2 Rockshelter sites at Mt. Victoria

Seventeen sandstone rockshelter sites were located at the head of Dans Rivulet below the prominent dolerite peaks of Mt. Victoria and Mt. Albert. Seven of the shelters contained a total of 10 artefacts on their surfaces, nine contained no visible artefacts while the remaining shelter (MV2) contained 43 artefacts (Plates 18, 19).

Dating of MV2

A date of 1490 +/- 70 BP (Beta - 32573) was obtained from good quality black charcoal fragments approximately 5 mm diameter at a depth of 12 cm to 15 cm at the base of the cultural deposits. The charcoal may have been affected by contamination from younger carbon and was therefore subjected to a pretreatment series of acid/alkali baths. However, the dry nature of the deposit may have mitigated against contamination by leaching of humic acids. The basal age of the cultural deposits fall between 1,560 and 1,420 years BP at one standard deviation. No artefacts were found below 15 cm.

4.4.5 Alpine plateaux (1,000 m+)

This unit comprises 120 km^2 of treeless alpine vegetation and blockfields. The open nature of the vegetation did not provide good archaeological visibility because much of the area is covered with massive blockfields or tight swards of alpine herbs and shrubs (Plate 3).

Four quadrats were surveyed in the 120 km^2 of the Ben Lomond plateau where visibility of bare ground was estimated to be 15%. This resulted in 0.6 km^2 of ground surface being examined. A single site was located on the shores of Lake Youl, which resulted in an average of 1.7 sites per km^2.

4.5 Discussion

The use of altitudinal gradients as the basis for a regional site surveys allows underlying environmental factors which may have influenced settlement decisions to be uncovered. It is evident that a pattern of variation exists in the northeast in which low site densities are found in lowland forests and on alpine plateaux. Forests are generally undulating to moderately steep, varying between dry sclerophyll and rainforest. The alpine plateaux are difficult of access and subject to extreme weather conditions.

Higher site densities are recorded for treeless coastal heath communities and for mosaics of open communities and forest at moderately high altitudes.

The discovery of sites in rainforest in the northeastern highlands is of great interest for it expands the known areas of occupation. Further to this, the 1,500 year BP basal date from MV2 shows that the sandstone rockshelters were occupied at the same time as similar rockshelters in the northwest (Cosgrove, 1990). It is possible on this basis to tentatively verify the models of Jones (1977), Bowdler (1984) and Cosgrove (1990) who posited a late Holocene expansion by Aborigines into previously unused or little used areas. Lourandos (1983a, 1983b) has put forward the notion that an intensification of effort by Aborigines in regard to expanding their range was responsible for an increase in site usage and the establishment of new settlements in environmentally marginal areas .

This scheme does not accord well with data from the southwest and west which shows that people have been occupying environmentally extreme places for at least 30,000 BP (Allen, 1990; Cosgrove, 1990). The intensification model may still have relevance for Holocene populations but cannot hold for the Pleistocene, where some sites were occupied at 20,000 years BP before being vacated at about 12,000 years BP. Other sites show continuous occupation between 30,000 and 2,000 years BP (Cosgrove, 1990). The nature of the evidence is such that the richness of the Pleistocene deposits far exceeds that of any Holocene sites discovered so far.

The long term perspective offered by Cosgrove acts as an intellectual magnifying glass focused on the southwest; if that focus is shifted to other places what will the image reveal? In the north east, it is entirely possible, indeed probable, that low altitude sandstone rockshelters will provide sequences comparable to those in central Tasmania. Even more interesting may be the valley fill deposits of the Esk, St Pauls and Break O'Day Rivers. Terraces in these valleys contain open scatters of artefacts and it remains for future work to investigate and date these difficult deposits.

With the data available, it is possible to examine a number of hypotheses concerning Aboriginal occupation of the northeast and to suggest links between population and resource centers, or travel routes and vegetation patterns.

Cherty hornfels is known to be a ubiquitous component of stone tool assemblages from the Midlands and east coast regions (Sutherland, 1972; Lourandos, 1968; Brown, 1986) and its absence from highlands sites might indicate a lack of contact between the people of the Fingal valley (the Plangermairreener) and the people who occupied the shelters at Mt. Victoria (the Pyemmairrenerpairrener?). On the other hand, the presence of silicified breccia and silcrete at Mt. Victoria and the other high altitude northeastern sites points to associations with the Leenerrerter from the north coast.

Altitude	Northeast	Statewide (source)
0 - 50 m	39	18.6 (Brown, 1986)
50 m - 100 m	5.0	9.3 (Brown, 1986)
100 m - 300 m	6.0	5.5 (Brown, 1986)
300 m to 700 m	2.0	35.0 (see below)
700 m to 1,000 m	25	3.0 (Thomas, 1987)
1,000 m +	1.7	1.5 (Cosgrove, 1984)

Table 4.2. Site densities (sites per km^2) calculated for the northeast and other places in Tasmania. (data taken from Brown, 1986; Cosgrove, 1984; Thomas, 1987).

The distribution of sites in the northeast seems to be strongly controlled by an altitudinal gradient in a way that suggests a preference for locating sites on coastal heathlands and montane plateaux. The steepness of the landsurface appears to be the critical factor in the overall distribution of sites. Few sites are to be found in areas with steep hillslopes, whereas, large numbers of sites are found wherever extensive level areas are found below about 1,000 m. This finding supports a similar suggestion made by Brown (1986) for sites in southeastern Tasmania.

4.6 Evidence for the use of forests in other parts of Tasmania

The central northwestern area between Bass Strait and Cradle Mountain can be regarded as a western twin to the northeastern region. The most significant point of comparison is that both places are bounded by Bass Strait to the north and alpine plateaux to the south. This provides a marked degree of environmental similarity which was formerly heightened by the presence of extensive tracts of wet forest which once lay between coastal dry sclerophyll and alpine plant communities (see Hellyer in Chapter 3).

The excavation of a number of rockshelters by Lourandos (1983) and Cosgrove (1990) has demonstrated the occupation of subalpine and montane regions of the northwest by at least 10,000 BP. Few data existed in regard to the spatial distribution of open sites across the landscape. Jones (1974) had pointed out that the uplands of the northwest in the vicinity of Surrey Hills, near Cradle Mountain formed a significant focus for Aboriginal occupation, while at the same time maintaining that the northeastern high country was uninhabited. This hypothesis forms the basis for a number of comparative surveys which aimed to determine if the settlement patterns of the northeast were unique, or part of a wider northern Tasmanian tradition.

The surveys were initiated in the expectation that differences in site densities and site locations could provide information in regard to the settlement of alpine treeless plateaux, sub-alpine plains and adjacent forested valleys. This was considered to be essential in the light of similarities in the timing of occupation between Mt. Victoria area and the Great Western Tiers rockshelters (Cosgrove, 1990).

4.7 Settlement patterns in the Cradle Mt - Lake St Clair National Park

The Cradle Mt. - Lake St. Clair National Park in north central Tasmania provides an ideal opportunity to assess settlement patterns in a varied alpine and sub-alpine landscape (Plate 5). The Park contains the highest mountains in the state, as well as a high proportion of treeless alpine country and a large extent of subalpine woodlands and grasslands. Jones (1974) and Cosgrove (1984) had previously entertained the notion that the the Overland Track followed the route of a former Aboriginal path which connected putative grasslands on the Surrey Hills with the Derwent Valley to the south.

4.8 Methods

A systematic survey of the Overland Track in the National Park was conducted during October, 1987 (Figures 4.4 & 4.5). All of the track (4 m in width) and eroded areas up to 100 m either side of the track margins were inspected, as well as nearby places, such as rockshelters, which offered reasonable access and visibility. One person inspected the footpath and adjacent erosion scars, while a second person walked in a zig zag fashion, crossing the track at roughly 100 m intervals or where topography allowed. Whenever an artefact was located, both people intensively surveyed an area of approximately 100 m x 100 m, centering on that artefact. All alternative tracks, side tracks and eroded areas near to huts were surveyed. A total length of 116 km was surveyed.

In order to account for any major deviations Aboriginal people may have made from the present route of the path, a number of controlled block (*sensu* Cosgrove 1984, Brown 1986) surveys were undertaken at selected locations. In each of the Lake Windermere, Pelion Plains, Pinestone Valley and Narcissus Plains areas, 1 km^2 quadrats consisting of 5 parallel 1 km long transects were surveyed. It was considered that the precipitous nature of the surrounding country precluded the existence of any substantially different routes.

The best ground surface visibility (often misleadingly termed archaeological visibility) was achieved on the more exposed sections of the Track, such as near Lake Windermere, where erosion caused by periglacial processes and recent trampling enhanced the

Figure 4.4 The location of clusters of Aboriginal sites in the Cradle Mt. - Lake St. Clair National Park (Pelion Plains area). Reproduced with permission of the Tasmanian Department of Planning and Environment.

Scale 1: 50,000.

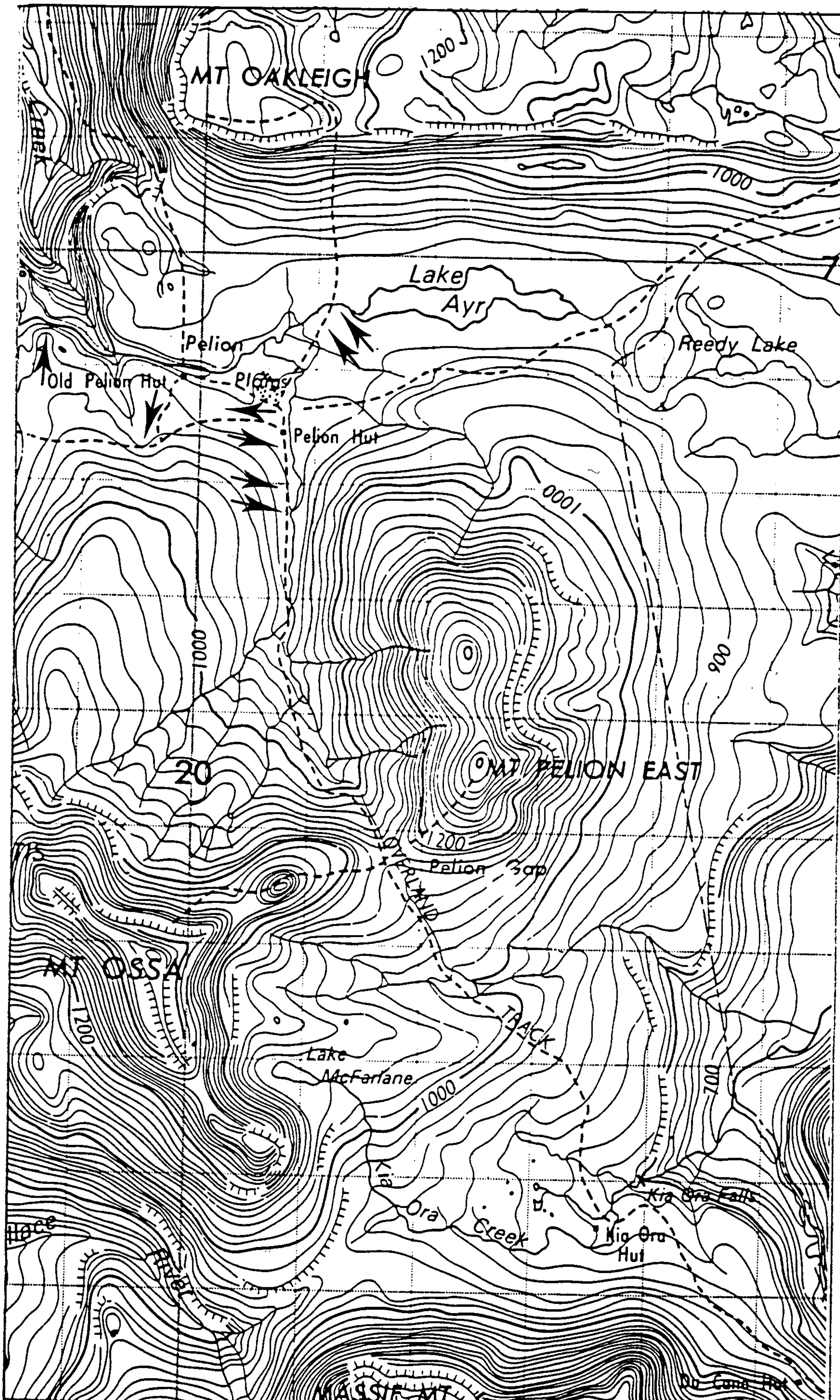
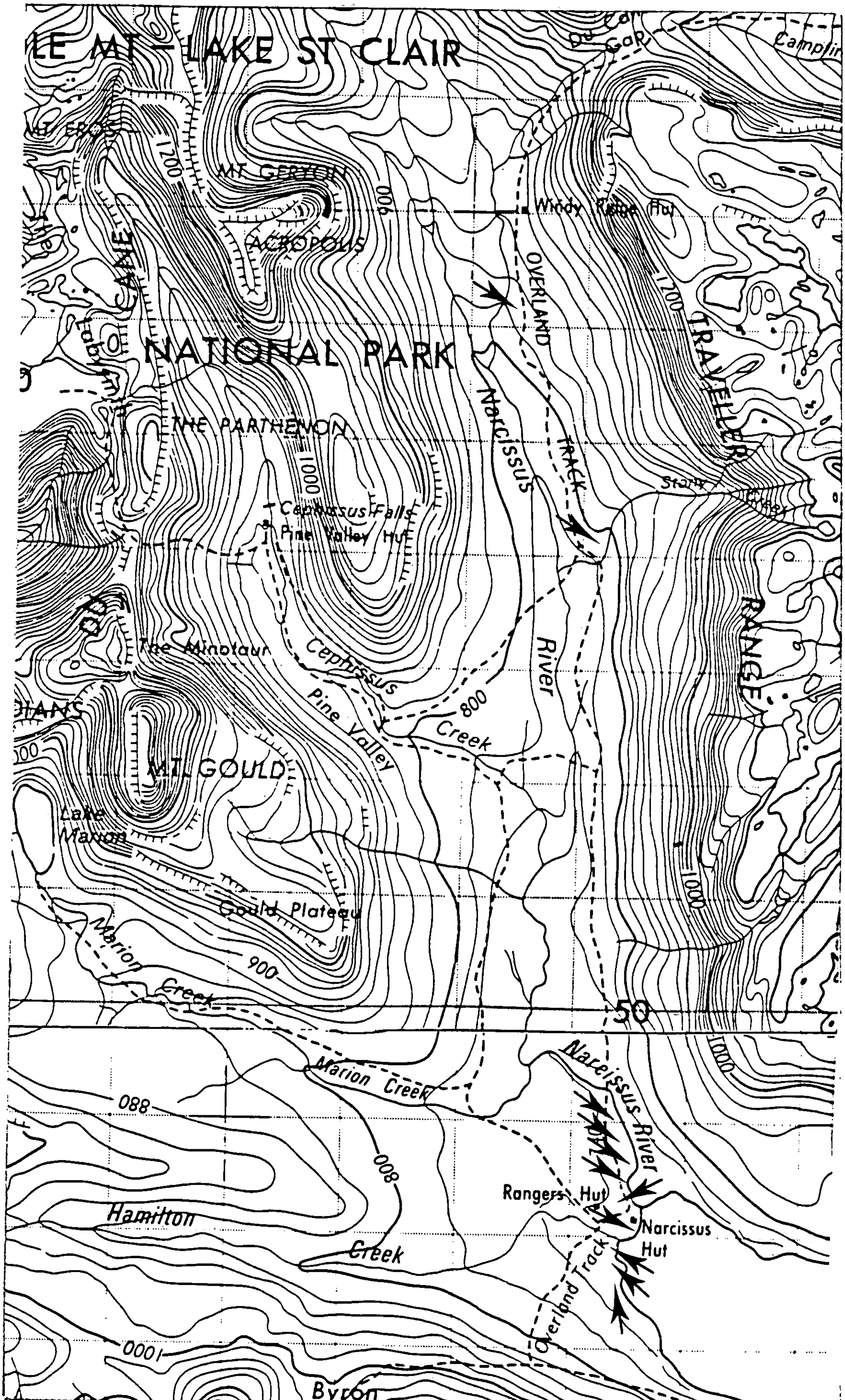

MT OAKLEIGH
1200
1000
Lake
Ayr
Reedy Lake
Pelion
Plains
Old Pelion Hut
Pelion Hut
1000
900
1000
20
MT PELION EAST
1200
Pelion Gap
MT OSSA
1200
TRACK
Lake
McFarlane
1000
700
Kia Ora Falls
Kia
Ora
Creek
Kia Ora
Hut
River
MASSIF MT
Du Cane Hut

Figure 4.5 The location of clusters of Aboriginal sites in the Cradle Mt. - Lake St. Clair National Park (Narcissus Plains area). Reproduced with permission of the Tasmanian Departmant of Planning and Environment.

Scale 1: 50,000.



LE MT - LAKE ST CLAIR
Du Cane Gap
Camplin
MT EROS
1200
MT GERYON
900
Windy Ridge Hut
ACROPOLIS
OVERLAND
1200
TRAVELLER
CANE
NATIONAL PARK
Narcissus
TRACK
THE PARTHENON
1000
Cephissus Falls
Pine Valley Hut
RANGE
River
The Minotaur
Cephissus
800
Pine Valley
Creek
MT GOULD
Lake Marion
1000
Gould Plateau
Marion
900
Creek
50
Narcissus River
Marion Creek
088
008
1000
Rangers Hut
Narcissus Hut
Hamilton
Creek
Overland Track
0001
Byron

probability of detecting sites. The least visibility occurred on buttongrass plains at Cradle valley and Pelion Plains. However, some sites were recorded on low hillocks where visibility was relatively good.

4.9 Results and analysis

A total of 25 sites were located at an average of 0.25 sites per km^2 (Table 4.3). All sites were located in forests or woodland. The results show that no close similarities exist between site densities found on the Overland Track and those calculated for valleys and lake shores on the Central Plateau (Cosgrove, 1984; Thomas, 1983, 1984). Site densities on or near to the Overland Track are lower than for areas of similar altitude on the Central Plateau, with the exception of the rugged Traveller Range (Cosgrove, 1984).

The track was divided into sections based on distances between hut sites. Such divisions correspond to an average days walk of 6 to 10 hours. If dissected in this way the figures reveal variations which relate to altitudinal differences between sections (Table 3).

Section (km)	Altitude (m)	Site Density (sites.km)
Cradle Mt (27)	1,200	0.03
Pinestone (15)	1,050	0
Windermere (20)	1,050	0.1
Pelion Plains (22)	800	0.5
Narcissus (16)	800	0.6
St. Clair (16)	800	0.1

Table 4.3. Site densities per linear km of sections of the Overland Track (distances refer to the total length of track surveyed in each section).

Higher site densities in the Pelion and Narcissus regions suggest that sites are more commonly found at lower altitude valley heads. Anomolously low values in the Lake St. Clair section are probably due to large scale disturbances which have accompanied industrial and tourist developments at the southern end of the lake. These include massive disturbances to the lake shore itself due to the construction of a dam. It is expected that in the absence of major disturbances, site densities at the southern end of Lake St. Clair would exceed 0.6 per km^2.

The results indicate that the Lake Windermere and Pinestone Valley areas, with reasonable visibility, returned far lower densities than at Pelion and Narcissus Plains which have much poorer visibility. The paradox is simply resolved by positing an inverse relationship in the mountainous regions between altitude and site densities.

The maximum number of artefacts found at any site was 4. In a survey of the alpine and subalpine parts of the Central Plateau (Cosgrove 1984) it was found that nearly 86% of sites contained less than 11 artefacts. On the shores of the Great Lake, Thomas (1983) found that 79.2% of sites contained less than 11 artefacts. Both of those studies located a number of larger sites each consisting of more than 100 artefacts of varying types and lithologies which suggested that a number of places on the plateau were frequently utilized by Aborigines. The lack of large sites on or near to the Overland Track seems to indicate that camping on a regular or even seasonal basis did not occur along that route.

Throughout the length of the track there is an abundance of lithic types suitable for stone-working. Nearly 60% of the artefacts recorded by the survey are made from quartz and it seems certain that the raw material was procured from the extensive sandstone and conglomerate beds found throughout the area. Just over 17% of artefacts are made from quartzite which is also commonly found in the park.

An analysis of the artefacts shows nothing remarkable in terms of style or technology. No heavily worked flakes, hammerstones, grinding stones or ochre fragments were located. In addition, no lithic working areas or extensive artefact scatters were recorded. The lack of heavy items such as grinding stones and anvils and the small size of both sites and artefacts indicates a lack of intrasite complexity. This suggests that use of the area, as determined by lithic and technological parameters, was of low intensity with no evidence for large or complex sites.

4.10 Settlement patterns in the Mersey River valley

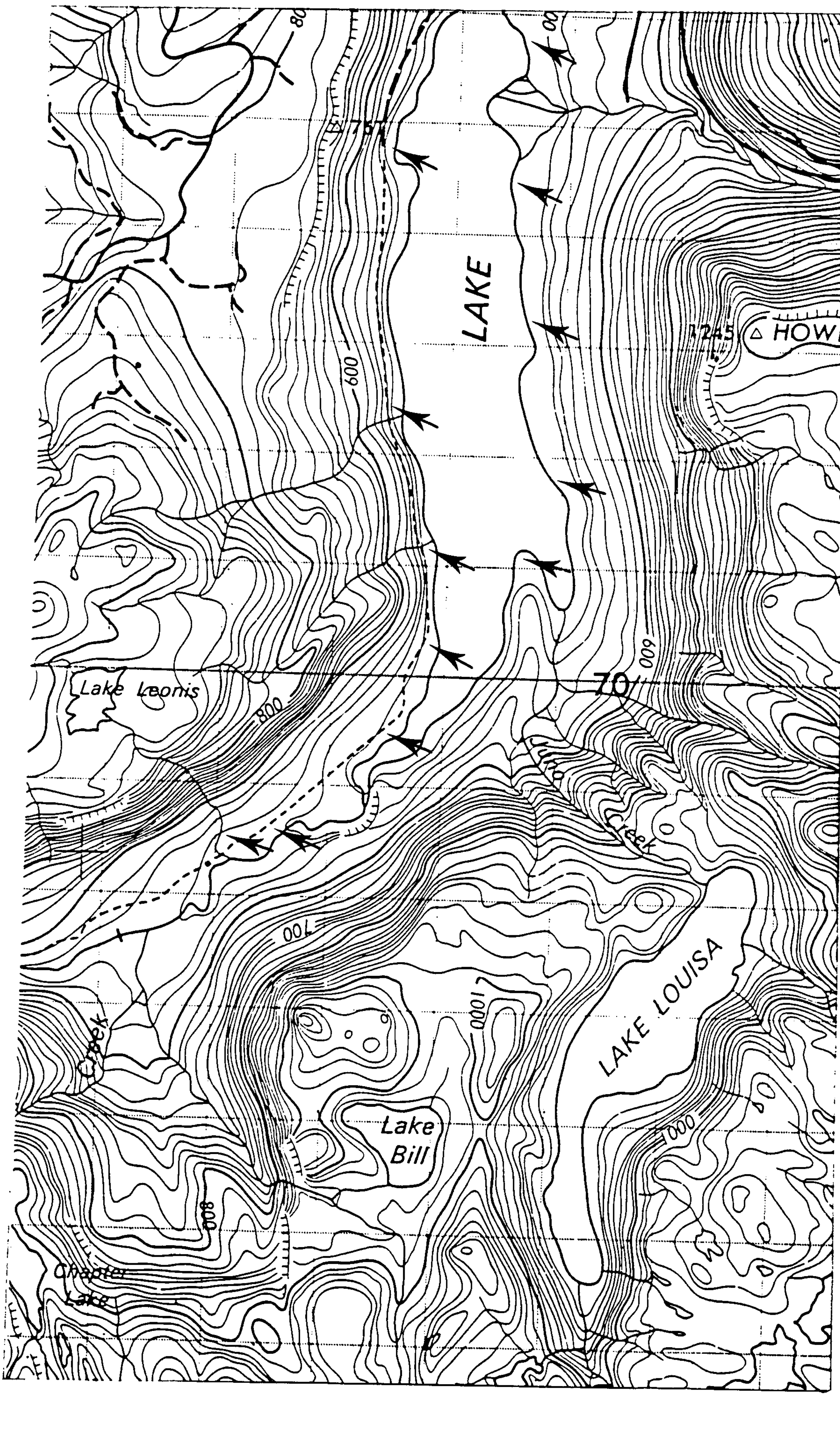
The upper Mersey River valley is, together with the Cradle Mountain area and the West Coast, one of those 'traditional' places which all Tasmanians regard as special, or as embodying an essential Tasmanian character. In terms of landscape this is undoubtably true, but new evidence indicates that all of these places have had a much more ancient and significant traditional pattern of use by Aborigines.

The Mersey Valley in the vicinity of Lake Rowallan (Plate 6) is a mosaic of rainforest and wet eucalypt forest (Figure 4.6) situated an an altitude of 500 m. Lourandos (1983) excavated the important sandstone rockshelter site of Warragarra and proved that occupation of the area commenced about 10,000 years BP.

During the late Last Glacial the valley floor was mantled by extensive till deposits. A maximum age for Aboriginal sites in the study area is estimated to be about 13,500 years BP (Hannan & Colhoun, 1986). Lourandos has hypothesised that older sites are almost certain to be found north of the limit reached by the ice of the 'Rowallan Glaciation' (Lourandos, 1983; Hannan and Colhoun, 1986).

Figure 4.6 The location of clusters of Aboriginal sites in the Mersey River valley at Lake Rowallan. Reproduced with permission of the Tasmanian Departmant of Planning and Environment.

Scale 1: 50,000.


LAKE
1245
HOWE
600
Lake Leonis
800
70
Creek
700
Creek
LAKE LOUISA
1000
Lake Bill
1000
800
Chapter Lake

4.11 Methods

Two people traversed the exposed shoreline of Lake Rowallan during the drought year of 1990. Simple physical principles dictated that the survey be concentrated on the southern end of the lake,where the greatest area of normally innundated land is exposed. The two resultant parallel transects were spaced 50 m apart on average. On steep banks the transects gave total coverage of the shoreline. In other places the transects were sometimes up to 100 m apart . In these cases both people adopted a random walk approach which ensured a more comprehensive cover.

The proportions of different lithic types and the proportions of technological categories within each lithic type were recorded. In general, all artefacts were recorded except at large sites which appeared to contain greater than 100 artefacts. In those cases a minimum of 20 artefacts were recorded.

4.12 Results and analysis

A total of 49 sites were located on 7 kms of lake shore and 4 km of vehicular tracks (Figure 4.6). Allowing for two surveyors independently traversing the shoreline on separate courses, the shoreline transect gives a site density of 35 sites per km^2. This figure compares with the 21.4 sites per km^2 calculated from Kee's (1990) data for the adjacent Forth valley.

The sites varied in size from single artefacts to scatters of several thousand artefacts. A sample of 576 artefacts was examined and categorized according to lithic and functional characteristics. Simple flakes (392) with no sign of retouch or any sort of secondary working account for 68% of the assemblage. Retouched flakes (66) form 11.5% of the assemblage with cores (70) accounting for a further 12.1%. Flaked pieces (27) and fragments (18) form 4.7% and 3.1% respectively. Minor components include hammerstones (2) 0.3% and a dolerite grinding slab (1) containing traces of orange ochre (0.2%).

4.13 Discussion

The Cradle Mountain - Lake St. Clair sites cannot be understood in isolation from sites at lower altitude, for the people who used the sites must have accessed the sub-alpine plains from lower altitude sites. The high country sites are therefore likely to form part of an economic and social web which utilized forested river valleys or ridges as essential components of the seasonal round.

The data suggests that people did not intensively or regularly visit the higher ridges and plateaux of the central Tasmanian mountains. From the high points of the Overland Track it is everywhere apparent that lower altitude valleys offer access to the high country. Furthermore, during periods of foul weather, the valleys of the Derwent, Mersey and Forth rivers offer respite from the often freezing conditions on the high ridges. The presence of over thirty Aboriginal sites located just south of the study area at 700 m in the Derwent Valley (Kiernan, 1985), and the concentration of sites at the Pelion and

Narcissus plains suggested that river valleys might have higher site densities than the grasslands and alpine shrublands of the mountains.This hypothesis was tested by conducting the survey of the upper Mersey River which has its source in the Cradle Mt - Lake St. Clair National Park.

The survey of the Mersey River valley revealed a large number of sites in an area which has received scant attention by archaeologists, despite the attractions of good access and a well known 10,000 year old site at Lees Paddocks (Lourandos, 1983a). The discovery of extraordinarily large open sites in the valley prompts the formulation of a hypothesis which asserts that other major river valleys of Tasmania will prove to be rich in sites, notwithstanding the present density of vegetation cover.

The evidence collected so far shows that all of the sites in the Mersey valley were located in rainforest or tall wet mixed rainforest (*sensu*, Gilbert, 1959). Luckily, none of these forests were felled consequent with the flooding of the valley, and it is still possible to identify the composition of the overstorey forest dominants (Plate 6). By counting the rings on seven recently sawn *Eucalyptus* stumps, it was possible to arrive at a tentative age for one area of *Eucalyptus* forest . The stumps all contained between 270 and 300 rings which probably indicates that the entire patch regenerated as an even aged forest following fire.

For the most part the valley consisted of patches of tall wet forest interdigitated with areas of *Nothofagus cunninghamii* rainforest. Understoreys were composed of *Polystichum proliferum, Dicksonia antarctica* and occasional thickets of shrubs up to 4 m high. The clear implication is that the pre-European vegetation consisted of a mosaic, similar in many respects to that which exists today.

Johnston (1982) has suggested that the open nature of patches of grassland in the valley can be attributed to the effects of Aboriginal burning. This is a reasonable assumption, but until ecological and palaecological data comes to hand the case is not clear. An interesting result is that all sites are located in places that once supported tall mixed forests or rainforests. Pollen analysis (Hill *et al.*, 1988) shows that the regional vegetation of the Mersey Valley has retained the same proportions of types throughout the Holocene.

Lourandos (1983) has pointed out that the Warragarra evidence links northern Tasmanian with the southwestern Tasmanian sequences, so that the northern river valley sites form a Holocene counterpoint to the well known southwestern Pleistocene sites.

The exciting discovery by Cosgrove (1990) of a number of 30,000 year old sequences from the southern Central Plateau demonstrates that people managed to successfully cope with conditions that changed vegetation from cool and wet subalpine associations to sparse herb and shrub dominated communities at about 20,000 years BP, to wet eucalypt forests between 13,000 and 6,000 years BP and finally to the montane eucalyptus forests and woodlands seen today. On this basis, the occupation of the northern and southern parts of the central highlands must have depended on the resources offered by forests for the whole of the Holocene.

4.14 Forests and Aboriginal sites in Tasmania

In one sense, the archaeological equivelant of the barren alpine blockfields of Ben Lomond are the long uninterupted sandy beaches found along Anderson's Bay. In both places site densities are low. Between these two extremes are site distribution patterns, which although different, have a number of similarities. In the northeast, coastal plains have very high site densities consisting mainly of small artefact scatters. Site densities drop dramatically as distance from the coast increases until a point is reached when montane plateaux are intersected at about 800 m. These places have increased site densities, though never as high as those on the coast. Alpine areas above 1,300 m have extremely low site densities.

In the northwest, coastal site densities are not known and are currently the subject of research by the Tasmanian Department of Parks, Wildlife and Heritage. Densities are high in the forested montane river valleys at about 600 m before falling dramatically above 1,000 m.

The archaeological evidence is in agreement with the ethnohistoric data from the northwest but in conflict with that from the northeast. In the northwest, people evidently utilized the full environmental variation from coast to highlands. This situation is not so clear in the northeast where sampling problems meant that extensive areas of agricultural land were not surveyed. This country is known to have supported dense wet sclerophyll forest prior to 1860 (Jennings, 1983).

That there is not perfect agreement between the two types of evidence is not surprising considering the inherent difficulties associated with both historical records and field surveys. Nevertheless, it is possible to sense links between the two.

An initial hypothesis derived from the ethnohistoric sources and previous speculations by Jones (1969) is that high site densities are related to a greater number of potential ignition sources and thus a higher frequency of fires. The hypothesis seems to hold for the northeastern coastal heathlands and montane plateaux where high site densities are associated with a mosaic of fire prone and fire sensitive vegetation.

In the northwest, site densities are very high in the Mersey River valley which suggests that forested river valleys were utilized in preference to steeper slopes. In the northeast there are no river valleys comparable in size to the Mersey of Forth valleys and it is speculated that occupation sites in the country which leads up to the eastern plateaux will not be concentrated in valleys as it appears to be in the west.

In between these two extremes of coast and plateaux are the great low to mid altitude forests of northern Tasmania which, according to the ethnohistorical evidence, had very few patches of open vegetation and were chiefly composed of large tracts of wet eucalypt forest, alternating with equally large tracts of rainforest. There is no evidence to suggest that people regularly burnt these forests as part of an annual cycle. The absence of regular burning suggests an entirely different type of occupation pattern to that on either the coast or plateaux.

The existence of many sites in the forested Mersey River valley is not incompatible with the ethnographic evidence of Hellyer and Robinson, both of whom recorded the presence of Aboriginal huts and campsites in the forests of the northwest. That no such evidence exists for the northeast may well be a bias in sampling, for Robinson did record that people formerly lived in the deep forests near to the present day town of Scottsdale (Plomley, 1966:378). This is the very area where site surveying could not proceed because of political considerations.

It is entirely possible therefore that high site densities will be found in many forested areas. This conclusion needs to be further tested and if proved correct would falsify the hypothesis that high site densities are associated with high rates of ignitions.

4.14.1 The Central Plateau

On the subalpine and alpine areas of the Central Plateau, surveys by Thomas (1983) and Cosgrove (1984) have established a pattern of occupation which is characterised by sites containing less than 10 artefacts. Sites are usually found in protected locations, often in the ecotone between forest and plain or forest and lagoon margin. Thomas (1983) demonstrated that people preferred to camp in forested areas surrounding Great Lake and Cosgrove (1984) suggested that this might be a reflection of real preferences for site locations. A large proportion of the western margin of Great Lake is fringed by treeless alpine heath and grassland which contains almost no known sites. In contrast, over 200 sites are located on the lake margins where forests grow very close to the waters edge.

A number of rockshelters located between 700 m and 900 m on the steep escarpment of the Great Western Tiers have been excavated and dated in the course of a cultural resources management project by Cosgrove (1990). The data show that the shelters were first occupied between about 1,200 and 2,800 years BP. Cosgrove argues that the occupation of these steep forested places fits in with the notion of an expansion by people into previously under utilized areas sometime about 3,000 years BP (Cosgrove, 19990:102). The shelters are located in a zone of tall forest and do not represent the initial occupation of forested locations for the slopes and hill country to the north of the shelters is likely to have been full forest at least since the start of the Holocene.

The evidence from the Central Plateau demonstrates that sites are closely associated with the presence of forest. In places with a stable long term vegetation history, such as the plains to the west of Great Lake (Thomas, 1984), occupation patterns probably had the same relationship to forests as is suggested for the contemporary archaeological record. Aboriginal settlement patterns may therefore have continued relatively unchanged for the entire Holocene. The assumption that the occupation of the high Central Plateau only began some 3,000 years ago (Lourandos, 1983; Cosgrove, 1990) is likely to be a severe underestimate.

4.14.2 Eastern Tasmania

This region was heavily forested at the time of European settlement and according to the accounts of early mariners was the focus of a well developed marine based economy (chapters 2 & 3; Brown, 1986; Lourandos, 1968, 1972, 1977). The evidence further suggests that people were well aquainted with life in forests. The writings of Labillardiere, Peron, Collins and others clearly indicates that villages or settlements were located within forests. The archaeological evidence from inland locations is extremely sketchy, but preliminary indications indicate that medium to low site densities are found in most regions, except where lithic quarries or rockshelter sites exist (Brown, 1986).

There are few alpine areas in easternTasmania proper, although the lack of archaeological evidence from Mt. Wellington near Hobart points to a very low rate of visits above the snowline. This might be expected in an environment located so close to rich sources of marine and forest resources.

4.14.3 Western Tasmania

This area provides the least reliable distributional data and yet is the most exciting of all the areas considered. The association of present day rainforests with Aboriginal sites is a celebrated feature of the southwestern archaeological research reports (Kiernan *et al.*, 1982; Jones, 1984; Cosgrove *et al.*, 1990). An irony is that no evidence exists to show that rainforests existed in the area during the time period represented by the sites, ie about 30,000 years BP to 12,000 years BP (Jones, 1984; Kiernan *et al.*, 1982; Cosgrove *et al*., 1990). This simple relationship provides the background which all settlement models for the southwest must take into account.

The key to understanding trends at the end of the Pleistocene is to examine what happened during the Holocene. Although some brief mention is made of the possibility of occasional short term visits by people to the margins of the southwest during the Holocene (Kiernan *et al.*, 1982, Jones, 1974, 1984), remarkably little attention has been given to the possibility that people did not abandon the west at about 11,000 BP, but merely broadened the focus of their attention to encompass alternative resources which resulted in modified settlement patterns.

In order to develop a testable hypothesis concerning settlement patterns in the west it is essential to gather together data which demonstrates the use of the southwest during the Holocene (this has been done in relation to ethnohistorical evidence in Chapter 2).

The discovery of sites, some of which may be of Holocene age and which are associated with present forested environments include a date of 300+/-150 (ANU 2787) from an open site at the mouth of the Denison River (Brown *et al.*, 1989) and 330+/- 105 BP (WK2089) from the King River valley (Tas. Dept. of Parks and Wildlife, 1991). The King River sites have been the subject of a recent investion by Macfarlane and Coates (1990) who agree with the growing conviction by a number of archaeologists that at least some of the open sites might be Holocene in age (Macfarlane and Coates, 1990; Thomas, 1990).

At least 53 other open sites are known from inland southern Tasmania, including sites near to the heavily forested Picton River (Brown, 1985; Brown *et al.*, 1989; Allen, 1989), and Lake Gordon in the west (Prince, 1985; Cosgrove, 1985). Other possible Holocene sites include those located near the White Spur Dam Impoundment (Cosgrove and Hughes, 1983), Lake Mackintosh (Allen, 1990), the upper levels of the

Flying Fox site on the Franklin River (Brown *et al.*, 1989) and on the ridges above the Franklin River (Downie, 1983).

A large number of artefact scatters (Corbett,1980) located on hill slopes above the East Queen River near Queenstown are assumed to be of Pleistocene origin, primarily because the author subscribes to the view that people never utilized inland areas of the West Coast during the forested Holocene phase. This kind of assumption is commonly encountered in reconstructions of Aboriginal history and relies heavily on the assumption that Aborigines did not inhabit areas of rainforest in th west.

In the northwest, over forty sites have been located in rainforest (Cosgrove 1988, Thomas & Van Eckart 1989b) and recent surveys indicate the presence of many more sites in similar forests (A. McConnell, Tas. Forestry Commission, pers comm.). Thomas & Van Eckart (1989b) have suggested that the widespread incorporation of the favoured rocktype "spongolite" into the toolkits of the northwestern tribes may have been because burning of rainforest and underlying peats by Aborigines had exposed bedrock deposits of that rock at about 2,500 years BP.

In western Tasmania, the number of dated archaeological sequences allows detailed explanations to be attempted. All such attempts have thus far used a palaeoecological approach and in this sense the general question of Aboriginal / forest relationships is theoretically crucial to the development of hypotheses concerning cultural and ecological change.

The apparent cessation of occupation in the southwestern caves at about 12,000 BP has been attributed to an expansion of forests during the early Holocene which forced people out of wet and shaded valleys (Jones, 1984; Kiernan *et al.*, 1982; Cosgrove *et al.*, 1990). This hypothesis is not as firm as it once seemed, for the number of potential Holocene sites recorded from the southwest continues to mount. Certainly the ethnohistorical data presented in Chapter 2 points to a similar conclusion.

Just as suggestive is that the extent of fire promoted *Gymnoschoenus sphaerocephalus* heathlands which suggests that the occupation of inland southwestern Tasmania has a long antiquity, probably measurable in thousands of years and perhaps even extending over the full span of the Holocene (MacFarlane and Coates, 1990; Thomas, 1990).

4.14.4 Northwestern Tasmania

The Surrey Hills area in the northwest has been assumed to be heavily influenced by Aboriginal burning of the vegetation. Jones (1969, 1975) has promoted a hypothesis that frequent burning of rainforest by Aborigines resulted in the creation of a grassland disclimax. The removal of Aborigines from the area by about 1842, apparently lowered fire pressure and allowed the development of rainforest where once grasslands had flourished. This theme is pursued in Chapter 9.

The reasons for burning are thought to be predominantly economic (Horton, 1986; Jones, 1969). Especially significant is the use of fire to attract game to regenerating grassland. For an area as extensive as the Surrey Hills, this implies that in the absence of firing, the quantity of game was insufficient for Aboriginal needs.

The North Tribe may have had a population of between 200 and 300 people (Jones, 1971b,1974:326).Jones (1974) and Plomley (1966) are firm in their opinion that a band sized group, the Noeteeler, claimed the Surrey Hills as their core territory. Jones for example notes that the people "from the Surrey Hills and Emu bay districts paid regular visits to the west coast" (Jones,1974:345). The clear implication is that at least one band and possibly a whole tribe, derived a substantial portion of their yearly dietary intake from resources captured or gathered on the Surrey Hills. If this was the case then substantional collections of artefacts should exist, on the lower, protected parts of the hills.

A recent survey by Pickering (1991) located 123 sites on the Surrey Hills in the northwestern uplands. Site densities are not available, but the average number of artefacts per site is only 2.8. Pickering (1991:22) suggests that: "Occupation at these sites was probably brief yet regular resulting in larger concentrations of artefacts over time. Larger sites therefore represent repeated brief, low discard, occupations of an environmental foci rather than single longer term high discard occupations". What he seems to be suggesting is that large congregations of people rarely gathered on the Surrey Hills. This is a significant finding, for the area has been assumed from ethnohistoric evidence to be a focus for intensive, regular occupation.

From this evidence it is possible to postulate a former pattern of occupation in the northwest characterized by a low density occupation of wet sclerophyll forests at low altitudes and an extensive use of high altitude locations but with low overall rates of occupancy. People evidently used the Surry Hills area, but not in a manner which resulted in dense concentrations of artefacts. The ethnohistoric data (Chapters 3 and 9) suggests that the grasslands described by Hellyer (1828) were in fact woodlands, while the presence of numbers of decayed logs on the supposed grasslands suggests that at least some of the area may have been created within the past few centuries (Hill & Reed, 1986). This does not preclude a much older phase of initial occupation, but it does suggest that parallels exist between the type of settlement at the Surrey Hills and that thought to have occurred in smaller but similar areas in the northeastern highlands (see chapter 8; Ellis and Thomas, 1988).

4.15 Conclusions

In the northwest, ethnohistoric observations point to a strongly formed coastal settlement pattern which gave way to a transient wet forest occupancy. At altitudes above 600 m, montane forests existed as portions of mosaics in which grassy formations were attractive to Aborigines for hunting purposes. This pattern is born out by the available archaeological evidence.

In contrast, an occupation pattern for the northeast, based on the distribution of Aboriginal sites, can be discerned, which runs counter to expectations derived from ethnohistorical data. That data suggests a steady decrease in site frequencies from coast to highlands. Instead, there is a pronounced decline in site densities between the coastal plains and the montane plateaux. The validity of this suggestion in relation to long term settlement trends is dependent on the excavation of archaeological sequences and the availability of local vegetation histories, and to this effect the following chapters partially address the problem by considering pollen based vegetation histories from sites located along an altitudinal gradient fromWaterhouse Point at sea level, to the highest point in the northeast at Ben Lomond.

On the Central Plateau, site distributions conflict with ethnohistoric sources. This is to a large extent the result of a lack of early observations owing to the remoteness of the area and its unsuitability for agricultural purposes. The settlement of the area was thought to be well understood following Cosgrove's (1984) survey for sites and Lourandos' (1983) report of a basal date of near 10,000 years BP from the Warragarra Shelter in the Mersey Valley. Subsequent research by Cosgrove (1990) shows that the lower parts of the plateau have been occupied for at least 30,000 years. On this evidence, and in consideration of the pollen evidence, it is evident that Aboriginal settlement patterns in inland locations of the north were focused on the use of forested areas for at least 10,000 years.

In contrast to conventional wisdom, the evidence presented above, points to a well developed occupancy of the southwest during the Holocene. Buttograss plains are not a simple vegetation unit but a complex of community types, each with their own particular floral and faunal composition (Jarman *et al.*, 1988a). They represent a far more diverse and rich resource than has been recognized by most archaeologists. The maintainence of buttongrass plains by Aboriginal burning is well documented in the ethnohistorical records and it is anticipated that many sites assoiated with this activity will be found on the plains themselves, as well as in adjoining forests.

In general, archaeological settlement patterns tend to be more complex and difficult to interpret than the ethnohistoric sources. The ethnohistorical and archaeological data agree that site densities should be high on coasts, regardless of vegetation type. Lowland forests seem not to have been exploited to any great degree, although future research may well throw light on this poorly understood zone. Montane forests and forested river valleys have relatively high site densities in the northwest and northeast.

The elevated Central Plateau has low site densities, but the sites are well distributed across the landscape, while alpine areas in the northeast have exceedingly low site densities. This is explained by the use of the Central Plateau as an access route between north and south, whereas places like Ben Lomond and Ben Nevis constituted formidable barriers to communication. In the east, site densities seem to conform to the early model proposed by Lourandos (1972).

In the majority of cases, complex Holocene inland sites are associated with forests, including rainforest and wet sclerophyll forest as well as dry sclerophyll forest. Exceptions to thiswillbe limited areas of open woodland in the central midlands, restricted expanses of coastal heathlands and occasional sites in places which were associated with the occurrence of special resources.

Chapter 5

Modern Pollen

5.1 introduction

A significant sub-branch of palynology is the documentation of the production, dispersal and depositional characteristics of pollen. In a very real sense, the study of Quaternary fossil and sub-fossil pollen depends on a knowledge of the contemporary ecological and physiological relationships of the modern flora. This is especially the case in Holocene studies where it can usually be assumed that speciation leading to taxonomic divergence has been minimal.

Macphail (1979, 1980) has convincingly argued that the present day forests of Tasmania are the only forests we will ever know in detail. He correctly points out that palynologists study past pollen assemblages and not past floras.

The specialized knowledge acquired by the person interested in contemporary pollen dynamics usually includes considerations of pollen morphology and pollen transport mechanisms. Armed with corrections based on such knowledge, palynologists can qualitatively or quantitatively transform raw pollen data into quasi-floral data. Only at this point it is possible to utilize known ecological relationships in an attempt to reconstruct past environments.

It is always been assumed that quantitative relationships exist between the abundance of a pollen taxon and the abundance of that plant taxon in the local vegetation. By studying the pollen productivity and dispersal characteristics of contemporary vegetation communities it has proved possible for palynologists in Europe and North America to characterise the pollen spectra of particular communities (Birks & Gordon, 1985; Bonny, 1980; Bradshaw, 1988; Bradshaw & Webb, 1985; Janssen, 1984; Meadows, 1984; Jacobson & Bradshaw, 1981; Prentice, 1986; Stevenson, 1985; Tinsley & Smith, 1974).

The relationships between initial pollen source and final pollen deposition are complex, varying according to local physiographic, ecological, genetic and climatic factors (Birks & Gordon, 1985; Jacobson & Bradshaw, 1981), but careful consideration of the pollen source area, the pollen site itself and the spatial arrangement of communities allows the problem to be addressed.

The pollen flora of northern Europe is fairly well understood, thus providing a firm base upon which to assess pollen influx and dispersal characteristics. In addition, the general ecology of European plant communities is such that environmental zonations are generally well displayed. This admirable situation stands in contrast to Australia where the taxonomy and ecology of both pollen and plants is yet poorly understood.

A major impediment to progress in Australian pollen studies is the ubiquity of a small number of widespread taxa. For example, *Eucalyptus* is found from sea coasts to alpine summits, yet the pollen is only reliably identified to the generic level. Likewise, *Acacia, Allocasuarina, Poaceae, Epacridaceae* and *Asteraceae* are widespread and also undifferentiated beyond the generic or family levels.

Few details concerning the modern pollen rain in Tasmania are available (Colhoun & van de Geer, 1986; Harle, 1989; Macphail, 1976; Macphail & Jackson, 1978; Margraf & Busby, 1986;). On mainland Australia, Kershaw (1973) identified the fact that in tropical rainforests, pollen influx is exceedingly low, possibly because of the dominance by insect pollinated plants. Kershaw also introduced multivariate ordination techniques to Quaternary pollen studies in Australia. More recently, Raine (1980) investigated the use of various trapping devices at Blue Lake in the Kosciusko National Park, including Tauber traps (Tauber, 1965, 1967). Dodson (1983) and Dodson and Meyers, (1986) have been responsible for considerable advances in the recognition of plant communities from modern pollen spectra collected from surface samples in rainforest, sub-alpine woodlands and wet sclerophyll forests. Kodela (1990) has provided a sophisticated analysis of modern pollen spectra, by utilizing discriminant function analysis and other multivariate classificatory procedures performed on pollen data from the southern tablelands of New South Wales.

This chapter describes the results obtained after analysing pollen collected from 20 standard Tauber pollen traps set across various plant communities in northeastern Tasmania. The object of the exercise was to provide qualitative modern analogs for the interpretation of fossil pollen spectra derived from mire deposits. No details are presented concerning quantitative relationships between pollen abundances and plant cover. This relationship was considered to be beyond the scope of the thesis, although preliminary results suggested that future research would be fruitful.

5.2 Methods

5.2.1 Field methods

Nine Tauber pollen traps were set in transects from surrounding vegetation to swamp center with the intention of characterizing the modern pollen rain of a marsh in a coastal heathland, a small marsh in a dry sclerophyll forest and a bog in sub-alpine forest. A further 10 traps were placed along a 1 km transect across a woodland / sub-alpine grassland / rainforest transition. Traps were placed in the centres of vegetation communities in an effort to characterise those communities by the ambient pollen rain.

Individual traps were constructed from polythene bottles with wooden aero-collars as described by Macphail (1976) and Tauber (1967). The aperture into the trap bottles had an area of 20 cm^2.

Each assembly was initially fixed at ground level, but after six traps had been attacked by animals in the first week, the traps were repositioned onto 1 m high wooden stakes and fastened with rubber circlets. The percentage cover of all vascular plants was recorded in a 400 m^2 area (subdivided into four 10 m x 10 m quadrats) surrounding each trap Plant nonclemature follows Buchanan *et al.*, (1990).

In the field, traps were set with 2 cm depth of glycerol spiked with fungicidal powder before being collected and recharged every 3 months. Wire mesh (5 mm) covered the mouth of each trap in an effort to minimize contamination by insects. Traps were collected over two full summer and winter cycles. A third year of collecting was abandoned after the summer of 1987 spawned an impressively large population of recreational shooters with sights set on pollen traps. Twenty percent of traps were lost to vandals in that year.

It was found that no significant amounts of extraneous organic material accumulated in traps, and therefore, samples were treated and concentrated in the manner described by Moore & Webb (1981). Acid treatments, with the exception of acetolysis, were omitted. Owing to the amount of work generated by this approach, samples were combined to give half year records. Each preparation of concentrated pollen therefore contained 6 months pollen influx per 20 cm^2. All pollen sums are greater than 500.

5.2.2 Analytical methods

Two Way Indicator Species Analysis (TWINSPAN)

All trap data and most core data (see Chapters 6 - 8) was analysed using the polythetic divisive classification program TWINSPAN (Hill, 1979a). The technique has been widely used in ecological investigations and is considered to be suitable for pollen studies (Jarman *et al.*,1988a; Kirkpatrick, 1983; Minchin, 1987; Stevenson, 1985). TWINSPAN constructs a series of dichotomies which first divide the samples, and then the species into groups at hierarchical levels. TWINSPAN initially ordinates the data by reciprocal averaging with the resulting first axis broken at its midpoint in order to polarize the samples into positive and negative groups. The divisive procedure is repeated until a pre-determined number of dichotomies is reached. The result is a sorted matrix of samples (traps) *versus* species (pollen taxa) which is ordered by arranging like samples and like species together. This is achieved by identifying differential or indicator species which best discriminate between positive or negative groups. Indicator species are composed of entities termed pseudospecies, which are allocated quantitative values based on a break down of the actual value. Thus, a real species for example, with an abundance of 17 %, is composed of *pseudospecies 1* with a value between 0 and 2%, *pseudospecies 2* - 2 to 5%, *pseudospecies 3* - 5 to 10% and *pseudospecies 4* - 10% to 20%. The calculation of pseudospecies is of great help in deciding the significance of any particular occurrence. Pseudospecies cut levels are shown in Table 5.1.

Pseudospecies	Cut levels	Weights
Pseudospecies 1	1	0% - 2%
Pseudospecies 2	1	2% - 5%
Pseudospecies 3	2	5% - 10%
Pseudospecies 4	3	10% - 20%
Pseudospecies 5	3	> 20

Table 5.1. TWINSPAN pseudospecies, cut-off levels and pseudospecies weightings

Two modes of analysis were initially utilized. The first analytical mode employed was a standard TWINSPAN analysis (Hill, 1979a) and gives equal weighting to all species and pseudospecies with no weight given to variable abundance measures. This amounts to standardizing the between taxon variance and approximates a standardized Euclidian distance measure of dissimilarity (Prentice,1980,1986). The second mode upweights more abundant taxa so that the distances between data in terms of rare, moderate and very abundant approximates a simple Euclidian distance measure of dissimilarity.

A comparison of both diagrams revealed an essentially similar pattern which affirms the robust nature of the technique. However, a number of significant differences were also revealed. The method of weighted analysis places together samples which are interpretable in terms of major or dominant pollen representatives. This analysis splits the samples into a series of dichotomies which agree with field observations and known environmental relationships. The dominant taxa in this analysis are reasonably well understood in terms of Tasmanian autecological and synecological relationships.

In contrast, a standardized analysis is driven by occurrences of less abundant taxa. This type of analysis is equally influenced by regional wet forest taxa as by local minor taxa. The standard equal weighted TWINSPAN analysis gives less attention to diagnostically important taxa, in this case, *Allocasuarina*, *Eucalyptus* and Poaceae. This analysis tends to highlight local herb and shrub elements as well as poorly represented regional taxa. The hope that subtle ecological relationships may be revealed, must be balanced against a danger that stochastic occurrences and ecologically unimportant taxa may dominate the classification.

A decision was made to utilize only the results of the weighted analysis. The standard unweighted analysis would probably prove to be useful in situations where the level of ecological resolution was equally distributed among all taxa. The use of a weighted analysis, allows interpretations to be based on known relationships between community dominants and major understory taxa. The final groupings, known as TWINSPAN groups are displayed as a dendrogram in Figure 5.1.

Detrended Correspondence Analysis (DCA)

This ordination was performed by the program DECORANA (Hill, 1979b). This offers a multidimensional view of the data which complements the two dimensional classification offered by TWINSPAN. An important attribute of DCA, and other multidimensional scaling techniques, is that realistic graphical appraisals of inter and intra-group relationships are obtained (Figure 5.2)

DCA has not been widely used with pollen data, but encouraging results have been forthcoming from Spain (Stevenson, 1984) and England (Prentice, 1986). The technique has a number of attributes suitable for palynological data, pre-eminent among these being its ability to cope with large heterogeneous data sets (Grimm, 1989; Kovach, 1989; Prentice, 1986).

5.3 The study area: trap sites

Waterhouse Marsh

Waterhouse Marsh is a freshwater coastal lagoon, (altitude 30 m) in an area characterised by terrestrial longitudinal dune systems and podsolized soils (Plates 1 & 2). In well drained locations, the dunes support low heaths rich in *Allocasuarina monilifera,* grasses, graminoids and members of the Fabaceae and Epacridaceae. In poorly drained situations, the dry heaths grade into tall wet heaths dominated by representatives of the Myrtaceae and Epacridaceae.

WH1. Set in an exposed location on a dune crest clothed in very short dry heath dominated by dwarfed *Allocasuarina monilifera.* The site is 200 m from the center of the swamp center and 10 m higher than the present water level. This location gives full access to all wind directions.

WH2. In a thicket of wet heath up to 1.5 m in height, 20 m from the swamp edge. Adjacent communities are dry heaths such as that surrounding WH1. The site is sheltered from winds from the north and south which pass over dry heaths and aquatic vegetation respectively before reaching the trap .

WH3. Situated in the center of Waterhouse Swamp. The trap is at least 100 m from any dry land vegetation. Surrounding the trap on all sides is a dense community of *Baumea arthrophylla* with occasional patches of *Triglochin procera*.

Forester Marsh

Forester Marsh is a small lagoon,100 m in diameter, located in a dry sclerophyll forest at an altitude of 100 m (Plate 4). The lagoon contains up to 1 m depth of water in winter and during wet periods. In extended droughts, the bog surface remains wet, without any visible free water. Fire is common in the surrounding bush and is easily carried onto the marsh surface by the numerous dead leaves of the semi-aquatic dominant, *Lepidosperma longitudinale*.

FM1. Set 100 m from the edge of the swamp, the trap is located in an open forest of *Eucalyptus amygdalina* and *E. viminalis* with an understorey of woody shrubs and *Allocasuarina monilifera*. The site is exposed to all prevailing winds. The understorey is quite open with many 2 m high individuals of *Allocasuarina monilifera*.

FM2. Set in a thicket of wet heath dominated by *Epacris lanuginosa* and *Melaleuca squarossa*, the trap is 5 m from the swamp edge in a poorly drained position. The overhead canopy of *Eucalyptus* is sparse, owing to past logging activities. The trap is in a relatively open location but is protected from strong winds by a dense wall of shrubs.

FM3. Located in the center of the marsh.The trap is positioned in 1 m depth of water and is surrounded on all sides by an exceedingly dense stand of *Lepidosperma longitudinale*.

Big Heathy Swamp

This mire is a sub-alpine restionaceous bog, on the interfluve between the North and South Esk rivers at an altitude of 800 m. Rising over the southern edge of the mire is the alpine plateau of Ben Nevis (1,368 m). A watercourse which separates Ben Nevis from Big Heathy Swamp ensures that no mineral input can enter the mire. The bog is somewhat elongated and has a maximum width of 300 m with an area of 0.75 km^2. The local geology comprises heavily weathered granite basement rocks and gravel sediments of the Mathinna Beds (Burrett and Martin, 1989)).

The bog surface is continually wet and is characterised in places by a number of pool complexes up to 0.3 m deep which are fringed by tall graminoids, chiefly *Restio australis*. Elsewhere, the vegetation is generally very low, rarely exceeding 0.25 m in height and comprises a mat heath of *Empodisma minus, Astelia alpina,* and *Epacris gunnii* with occasional isolated clumps of *Melaleuca squamea* and *Callistemon viridiflorus* (Plate 8).

Surrounding the bog are seral forest communities which change from a tall wet *Eucalyptus dalrympleana / E. delegatensis* forest with Myrtaceous tall shrub second storey over a grassy and fern rich ground layer, to an open woodland of *E. rodwayi* on the poorly drained margins of the bog.

BH1. A treeless site some 200 m from the nearest eucalypt. The site is characterised by a 20 cm high sedgeland dominated by *Astelia alpina, Restio australis* and *Empodisma minus*. The bog is constantly wet underfoot, although in very dry summer months the top few centimeters of organic matter can dry out sufficiently to carry a light fire. The site is exposed to all wind directions.

BH2. This trap is located in a *Eucalyptus rodwayi* woodland growing on mounds of dry soil which seem to rise sufficiently above the water table to provide better drainage conditions. Consequently, the site has a higher proportion of herbs and woody shrubs than BH1. Although characterised by its slightly improved drainage, the site is nevertheless still surrounded on all sites by bog vegetation. The site is exposed to northerly, westerly and southerly winds.

BH3. Located in a *E. rodwayi* forest some 200 m from BH2. The site is situated on mineral soil some 100 m from the margin of the bog. The forest has a dense 4 m high wall of understorey shrubs from the families Myrtaceae (*Leptospermum lanigerum*) and Fabaceae (*Oxylobium ellipticum*). The trap was protected from all but the strongest of winds.

Paradise Plains

Paradise Plains is a sub-alpine grassland at an altitude of 1,000 m (Ellis,1985,1986; Ellis & Thomas, 1988). The area consist of grasslands and herbfields which are surrounded on all sides by rainforest and wet sclerophyll forest (Plate 7). The plains are dotted with copses of invading pioneer shrubs and clumps of remnant rainforest. Ellis (1985, 1986) considers that the plains are the remnant of a larger grassland expanse created by Aboriginal burning of rainforest sometime before 1800.

PP1. A large forest copse consisting of *E. delegatensis* greater than 60 m in height, with a grassy understorey and a few scattered shrubs of *Coprosma nitida* and *Persoonia gunnii*. The copse is situated on an elevated knoll and forms a prominent feature of the area. On one side of the copse is a gully filled with rainforest while the other side is a *Acacia* woodland. The knoll catches winds from all directions.

PP2. Very open *Acacia dealbata* woodland with an exceptionally dense groundlayer of *Poa labilliardieri*. The site is protected from northwesterly and northeasterly winds.

PP3. The trap was set in a forest of mature *Leptospermum scoparium* with an open understorey consisting of *Phyllocladus aspleniifolius*, *Persoonia gunnii* and various ferns. The forest floor is covered with a profusion of mosses and lichens which exclude most other small vascular plants. The dense canopy of tea-tree effectively protects the open understorey from winds from any direction.

PP4. An open community of *Leptospermum lanigerum* shrubs some 3 m in height. The trap was 20 m from a dense wall of *Leptospermum* which fringes the *L. scoparium* forest of PP3. The site is exposed to westerly and southerly winds.

PP5. The site is a *Sphagnum* bog on the banks of a small creek. The area is treeless and some 50 m lower in altitude than PP1. A dense thicket of *Richea gunnii* heath grows in and around pillows of *Sphagnum* spp. with patches of herbfield. Although the site is exposed to all wind directions, the location allows much of the wind to pass overhead.

PP6. A very exposed site set on a gentle ridge. The site is a herb rich grassland dominated by *Poa* spp., with a mat heath of *Pernettya tasmanica* and numerous small herbs. The exposed nature of this site renders it vulnerable to strong winds from all directions.

PP7. A similar site to PP6 except that it is in close vicinity (50 m) to a number of isolated clumps of rainforest surrounded by belts of *Leptospermum lanigerum*. The site is exposed to all wind directions.

PP8. This trap was located underneath the canopy of a small clump of *Nothofagus cunninghamii* which consists of 3 large open crowned trees. The trunks and branches of these open form rainforest trees are festooned with the strap like fronds of the kangaroo fern, *Microsorum diversifolium*. The clump has a dense grass understorey and is exposed to all wind directions.

PP9. The site is situated between the isolated rainforest clump of PP8 and a prominent wall of rainforest which marks a sharp transition from grassland to rainforest. Exposed to all wind directions except easterlies .

PP10. The trap was set in callidendrous rainforest (Jarman *et al.*, 1986) about 100 m in from the grassland/forest transition. The forest is dominated by *Nothofagus cunninghamii* and *Atherosperma moschatum* with a very sparse understorey of pteridophytes. The location of the trap was protected from wind.

5.4 Results and analyses

5.4.1 TWINSPAN analysis

The Twinspan classification (Fig. 5.1) efficiently discriminates between the lowland sites of Waterhouse Marsh (WH) and Forester Marsh (FM) and all others. The most extreme samples are included in TWINSPAN groups A and F. These consist of coastal heathland (group A) and rainforest (group F) respectively. The dry sclerophyll forest traps at Forester (group B) are most closely related to the dry sclerophyll heaths of group A whereas all the traps from Big Heathy Swamp and Paradise Plains show broad similarities. These patterns reflects altitudinal differences and floristic similarities between sites.

The species which best indicate the first dichotomy or split of the analysis is *Melaleuca squamea* 0 - 2% which is very common in the northeastern highlands but not so abundant on the lowland plains. Species which were placed in the lowland group (negative split) are *Allocasuarina* 20%+, *Eucalyptus* 20%+, *Ricinocarpus pinifolius* 10 - 20%, *Melaleuca squarrosa* 20%+ and *Banksia marginata* 10 - 20%. At this level all other traps (positive split) are characterized by *Nothofagus cunninghamii* 20%+, *Dicksonia antarctica* 5 - 10%, *Tasmannia lanceolata* 2 - 5% and *Microsorum diversifolium* 2 -5%.

A second split in the negative group divides the Waterhouse traps (group A: WH1, WH2, WH3) from the Forester traps (group B: FM1, FM2, FM3), on the presence of the indicator species, *Leptospermum lanigerum* 0 -2%. It is important to note that indicator species are pseudospecies with the least value which clearly separate one group from another. The analysis shows that the Waterhouse traps are characterised by the presence of *Allocasuarina* 20%+, *Melaleuca squarrosa* 10 -20%, *Leptospermum lanigerum* 10 -20% and *Banksia marginata* 2 - 5%.

Forester traps (group B) are distinguished by *Eucalyptus* 20%+, *Leptospermum scoparium* 20%+, *Hibbertia* 20%+, *Pomaderris apetala* 10 -20%+ and a number of shrubs such as *Goodenia lanata, Ricinocarpus pinifolius* and *Acacia verticillata*. Rainforest species are also represented, although at relatively low levels. The split accurately reflects differences between Waterhouse Point with its *Allocasuarina / Banksia* heaths and Forester Marsh with its *Eucalyptus* forest and heathy understorey characterised by high populations of low woody shrubs. The rainforest representation at Forester is a function of the relative nearness of wet sclerophyll forests and rainforests on the slopes of Mt. Horror.

Traps from Big Heathy Swamp are not clearly divided from those on Paradise Plains. BH1 is in an open location (Plate 8) which accepts a high proportion of grass pollen from grassy forests on the western margin of the swamp. In contrast, BH2 and BH3 are

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situated on the eastern edge of the swamp, with BH2 located 10 m from an extensive *Leptospermum* thicket and BH3 in a *Eucalyptus rodwayi* forest with a dense understorey of *Oxylobium ellipticum.*

Group C (B2, B3) splits from groups D and E with *Melaleuca squamea* 2 -5% as the indicator species. Preferential species for group C include *Eucalyptus* 10 -20%, *Melaleuca squamea* 10 -20%, *Leptospermum scoparium* 10 -20%, Fabaceae 5 -10% and *Pittosporum bicolor* 2% - 5%. These species are characteristic of scrubby understories in wet *Eucalyptus* forests.

Group D (BH1, PP2, PP5, PP6, PP7, PP8) consists of traps located in grassy plant communities on Paradise Plains and Big Heathy Swamp. The group has no indicator but is characterised by the preferential species, *Nothofagus cunninghamii* 20%+, *Pomaderris apetala* 10 -20% and *Dicksonia antarctica* 5 - 10%. The fact that most of these samples came from open grassland is not sufficient to distinguish them floristically from other traps in group E because *Poa* grasses occur at all of the locations. The major differences between sites are structural and therefore at least some of the pollen representation may be attributed to community structure. In this case, regionally dispersed taxa such as *Nothofagus* and *Pomaderris* might find their passage to earth unimpeded by a dense forest canopy (Kershaw and Hyland, 1975)

Group E (PP1, PP3, PP4) has the indicator species, *Leptospermum scoparium* 5 - 10%. Preferentials species include *Leptospermum* 20%+, *Leptospermum lanigerum* 5 - 10%, *Tasmannia lanceolata* 2 - 5% and *Dicksonia antarctica* 10 - 20%. This assemblage of plants is typical of patches of old growth *Leptospermum scoparium* forest with rainforest understories (Ellis, 1985) and is similar in some respects to group C

Group F (PP9, PP10) is a unique group based on the presence of *Tasmannia lanceolata* 5 -10%. *Tasmannia* is a common understorey element in northeastern rainforests and is commonly found at the transition between rainforests and grassland. This is precisely the relationship that PP10 (rainforest) has with PP9 (forest edge). *Atherosperma moschatum* 20%+, *Tasmannia* 20%+, *Microsorium diversifolium* 5 - 10% and *Stylidium graminifolium* are the preferential species. On this basis, high percentages of *Atherosperma* would seem to be excellent indicators of the local growth of pure rainforest, far better than even *Nothofagus*, for *Nothofagus* is at least as well represented in a number of traps some distance into the grassland (group D).

5.4.2 DCA analysis

The DCA ordination produced results which are consistent with the TWINSPAN analysis, however, the graphical presentation of the first two axes of the ordination does not discriminate between all groups. Because plant communities are not isolated entities but continuoms of variation, the lack of resolution in the DCA probably reflects ecological reality in a more realistic fashion than the TWINSPAN analysis. (Stevenson, 1985; Whitaker, 1987).

The first axis (eigenvalue 0.331) allowed TWINSPAN groups A and B to be separated from all others without identifying differences between the majority of traps from Paradise Plains and Big Heathy Swamp (Figure 5.2). The gradient defined by the axis has the treeless Waterhouse Point traps (A) at one extremity and the rainforest trap from Paradise Plains (F) at the other. The ordination successfully demonstrates differences between places with regional arboreal pollen input and those with closed forest canopies. However, the actual distance between the sites is complicated by rises in altitude and precipitation and a decline in temperature. Considering that rainforest can grow at low altitudes in the east, the gradient is likely to represent precipitation diffences between the coastal fringe and the northeastern highlands.

On the same axis, *Atherosperma, Tasmannia, Pimelea, Stylidium, Microsorum, Nothofagus* and *Dicksonia* have high scores while *Melaleuca squarrosa, Allocasuarina, Sprengelia* and *Amperea* have low scores. These groups do not define, but are characteristic of high altitude rainforest and coastal heath communities respectively.

Dodson and Myers (1986) have pointed out that the ubiquity of *Eucalyptus* pollen in both wet and dry forests could result in misidentifications being made concerning source vegetation types. On the basis of the DCA scores it would be possible in Tasmania to confuse marsh sites surrounded by wet eucalypt forest with grassy / shrubby understories with sites situated in mosaics of rainforest and grassland. This is because open highland sites accept regional pollen from regional source areas which are composed of mixtures of the widely dispersed and / or widespread species, *Eucalyptus, Nothofagus* and *Poaceae.*

The second axis (eigenvalue 0.126) does not place geographically close samples together (Fig. 5.2). Broad groups are composed of traps which are located in places with similar complements of understorey herbs and shrubs.

Traps BH2, BH3, P3 and FM2 have high sample scores and are sited in locations which are surrounded by *Leptospermum* or *Melaleuca* thickets with Fabaceae species also common. Traps PP2, PP5, PP7, PP8 and BH1 have low scores and are located in open grassy situations except for BH1 which is adjacent to a very grassy eucalypt forest. High species ordination scores are attained by *Leptospermum* , *Melaleuca, Pittosporum, Fabaceae, Hibbertia* and *Pimelea,* while Lilaceae, Gentianaceae, *Astelia, Phebalium* and Ranunculaceae have low scores. Poaceae has a relatively low score as does *Acacia, Boronia, Nothofagus* and proteaceae. The axis is interpreted as

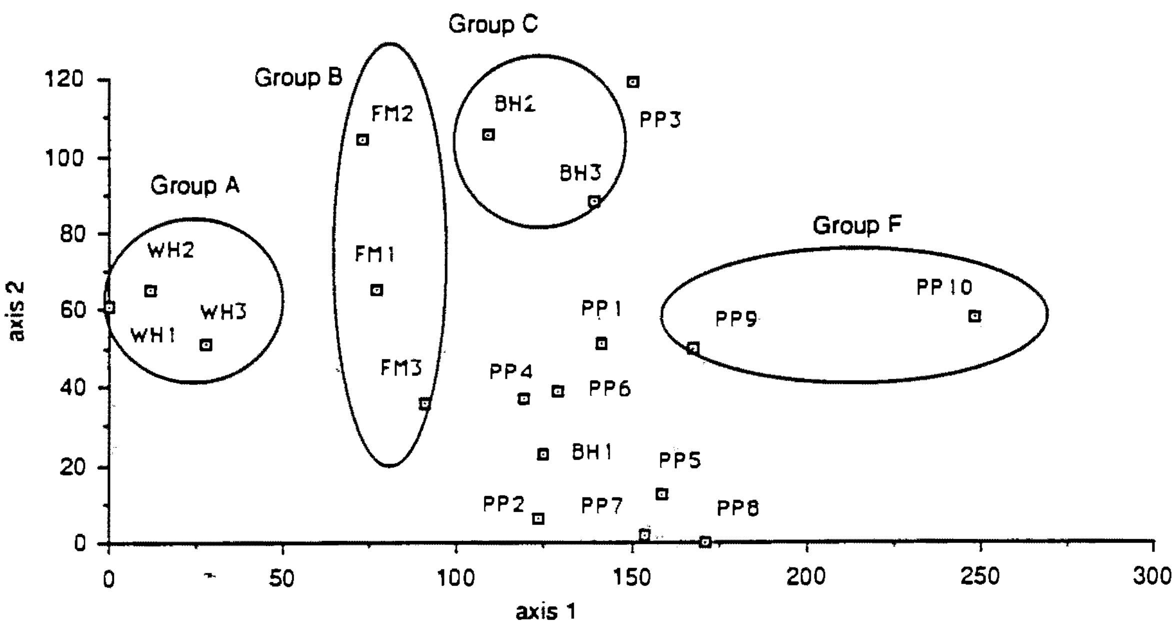


Figure 5.2. Pollen traps. DCA axis 1 versus axis 2. TWINSPAN groups A (coastal heath), B (dry sclerophyll forest), C (montane wet sclerophyll forest) and F (rainforest) are indicated. Groups D (subalpine grassland) and E (subalpine grassy forest are less clearly distinguished.

being a gradient which controls density of understories, and as such, is probably a complex of precipitation, fertility and fire effects.

The remaining traps (FM1, FM2, WH1, WH2, WH3, PP1, PP4, PP6, PP9 and PP10) fall in between the two extremes mentioned above. Species associated with the traps include a diverse pollen flora comprising *Eucalyptus, Banksia, Allocasuarina, Ricinocarpus, Dodonaea, Atherosperma, Dicksonia,* Asteraceae and Chenopodiaceae, as well as many others. These traps are apparently characterized by mixed pollen assemblages with both regional and local elements as well as trees, shubs and herbs.

5.4.3 Pollen analysis

Nothofagus cunninghamii

At Waterhouse Point *Nothofagus* has very low values which accurately reflect the fact that the nearest source is nearly 50 km to the south (Figure 4.3). The percentage curve (Figure 5.3) has higher values in traps WH1 and WH3 than in WH2. This is explained by the position of WH2 in a dense community of *Melaleuca squarrosa, Sprengelia incarnata* and *Epacris lanuginosa.* The site is at the bottom of a steep sandy bank and is sheltered from all wind directions. Wind seems to blow over the site with very little downdraft. This may have the effect of reducing regional pollen rain at the trap site. The more exposed position of the traps at WH1 and WH2 is expected. to increase regional component at those traps.

At Forester Marsh (Figure 5.4), *Nothofagus* has lower values than those recorded at Waterhouse. Percentages are below 2% despite the fact that reasonable stands of *Nothofagus* grow on the slopes of Mt. Horror, less than 10 km to the east. From this, and from the even lower values at Waterhouse, it can be concluded that the regional background value for *Nothofagus* in the northeast is a maximum of 2%. A slight increase in values from trap FM3 indicates a heightened sensing ability of even very small open water surfaces compared to places under canopies or which are surrounded by locally dense shrubs.

Big Heathy Swamp at 900 m altitude is surrounded by wet forest within a region in which *Nothofagus* rainforests are extensive. Little variation occurs in the representation of either percentage or influx values across the transect, and thus, *Nothofagus* values are explained by a large source area from which pollen can penetrate the relatively open eucalypt forest canopy (Figure 5.5). The percentage values are less than 12%, while influx is less than 30 grains.cm^2.yr^{-1}. By subtracting the regional percentage value of 2%, it can be seen than the extensive rainforests in the northeast account for only 10% of the total pollen rain, even when allowing for a substantial component of pollen

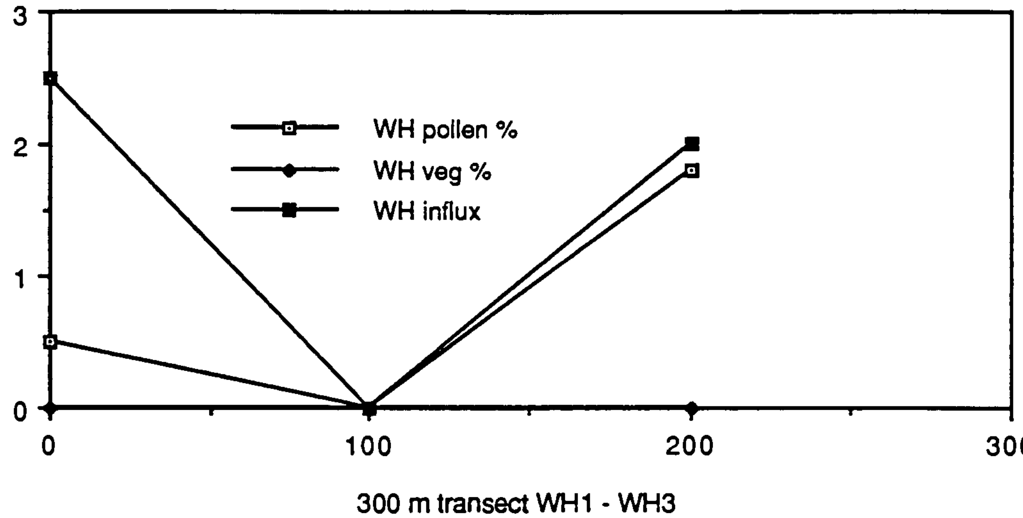


Figure 5.3. The response of *Nothofagus cunninghamii* pollen across a 200 m transect (x axis) at Waterhouse Marsh. Influx in grains.$cm^{-2}.year^{-1}$.

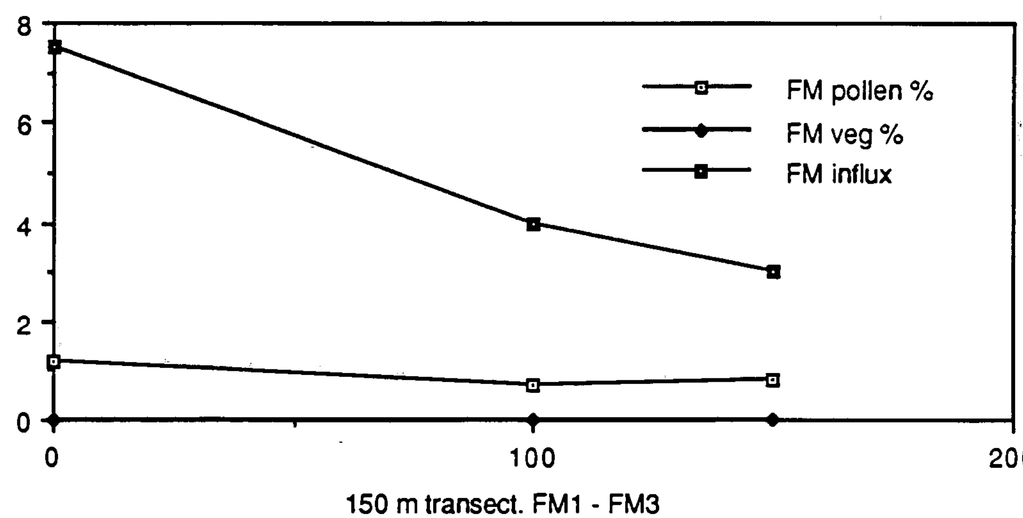


Figure 5.4. The response of *Nothofagus cunninghamii* pollen across a 150 m transect (x axis) at Forester Marsh. Influx in grains.$cm^{-2}.year^{-1}$.

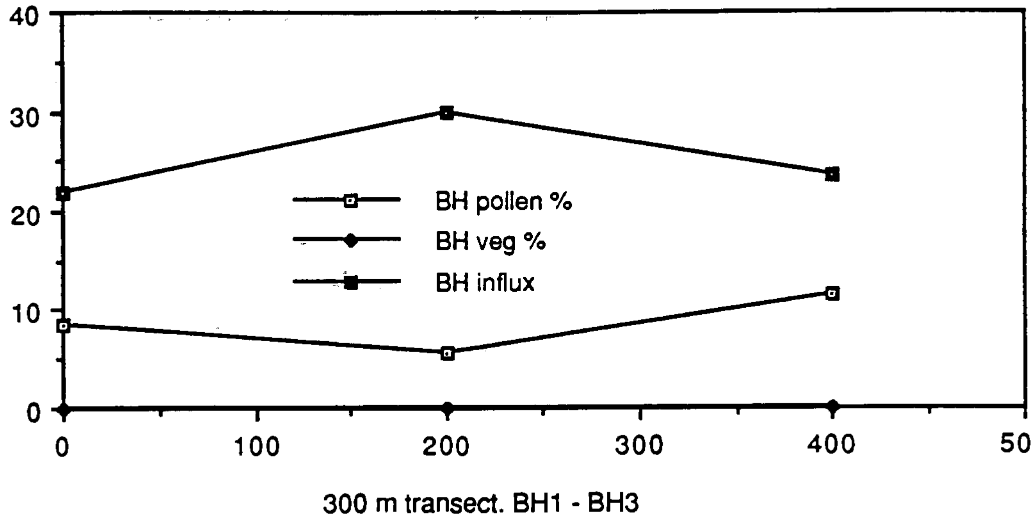


Figure 5.5. The response of *Nothofagus cunninghamii* pollen across a 300 m transect (x axis) at Big Heathy Swamp. Influx in grains.cm^{-2}.year^{-1}.

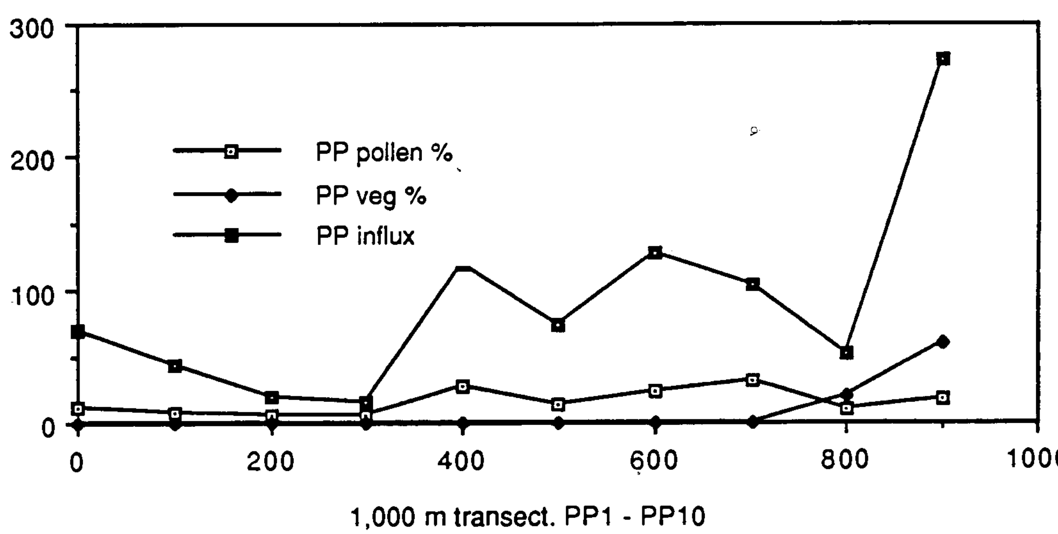


Figure 5.6. The response of *Nothofagus cunninghamii* pollen across a 1,000 m transect (x axis) at Paradise Plains. Influx in grains.cm^{-2}.year^{-1}.

blown up from forests at lower altitudes (Macphail, 1979).

Paradise Plains is surrounded on all sides by rainforests and *Nothofagus* values are considerably higher than from other traps. The mean percentage value is 15.5% with a range of 5.3% - 32.6%. Influx varies from 16 grains.cm^2.yr^{-1} to 272 grains.cm^2.yr^1 (Figure 5.6) The curves for percentage and influx display similar trends and is explained by nearness to source, topographical position and vegetation cover.

The major trend is for values to increase from PP1 to PP10, but fluctuations run counter at a number of traps. From PP1 values decline until they reach a minimum at PP3 and PP4, in and on the edge of a forest of *Leptospermum scoparium*. The decline is explained by a wind protected downhill slope and the presence of the tea tree forest which acts to intercept air born pollen as well as artificially deflate percentage values. From PP5 to PP8, in a very open locations, values rise sharply to maximums at PP7 and PP8 where the presence of a number of open crowned *Nothofagus* trees which probably release large quantities of pollen due to their form and vigour. At PP9, values suffer a decline before rising within rainforest at PP10.

The decline at PP9 is interesting considering the nearness of the trap to the forest edge (70 m). It is possible that westerly air streams deflect upwards as winds move towards the wall of forest, thus pushing pollen upwards and out of reach of the trap. Alternatively, pollen may act in a manner described by Tauber (1977) and Janssen (1973) so that the trunk space derived component does not move much in a horizontal direction while canopy derived pollen is moved laterally before being deposited.

Another curious phenomenon is the depressed *Nothofagus* values in PP10, despite its location in a true rainforest. Reference to the Figure 5.5 shows that extremely high percentages of *A. moschatum* pollen were found in PP10. Such values would tend to depress the importance of *N. cunninghamii*. That this is so, can be judged from Figure 5.6 in which absolute rates of deposition of *Nothofagus* are considerably higher at PP10 than either PP7, PP8 or PP9.

Eucalyptus

The ubiquity of this taxa in Australian pollen diagrams owes more to its enormous regional source area than to its powers of dispersal. Low percentages in all 3 traps reflect the regional background value, which in this case has a mean of 5.5%. The mean for influx values is 16.6 grains.cm^2.yr^{-1}. Slightly higher values in WH1 and WH3 are a function of greater airflow past these two traps than at WH2 (Figure 5.7).

At Forester Marsh, percentages vary between 15 and 27% with FM1 recording the highest values (Figure 5.8). As at Waterhouse, local dominance of shrubs tends to

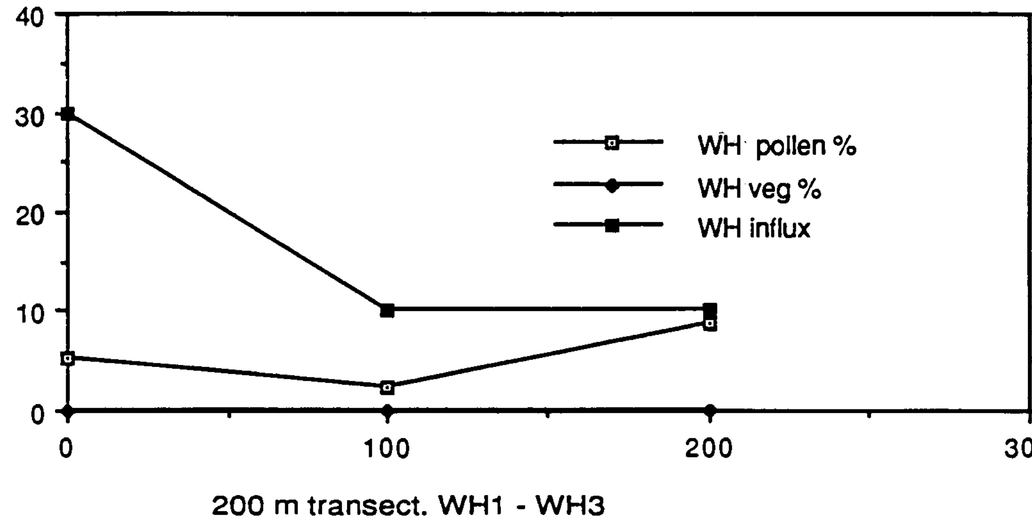


Figure 5.7. The response of *Eucalyptus* pollen across a 200 m transect (x axis) at Waterhouse Marsh. Influx in grains.cm^{-2}.year^{-1}.

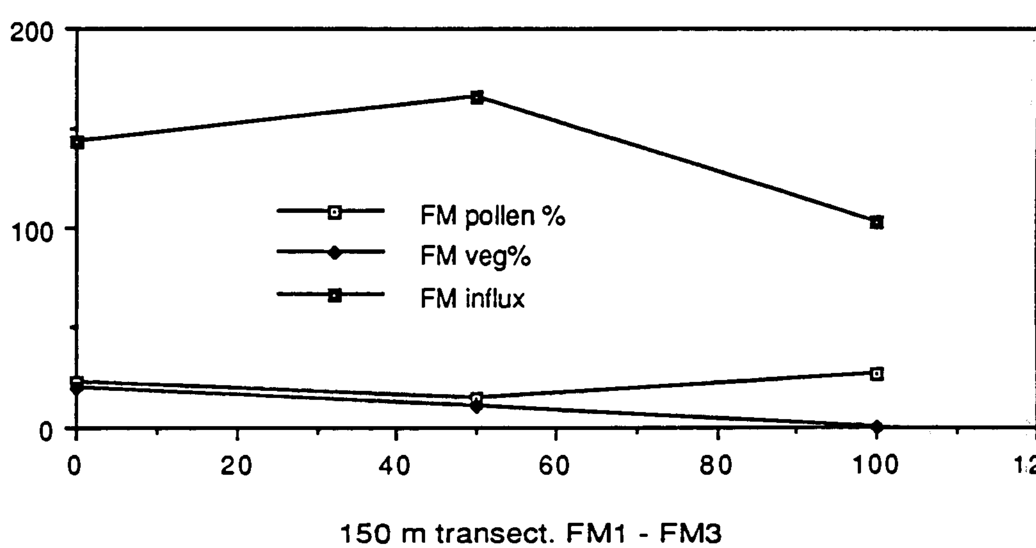


Figure 5.8. The response of *Eucalyptus* pollen across a 150 m transect (x axis) at Forester Marsh. Influx in grains.cm^{-2}.year^{-1}.

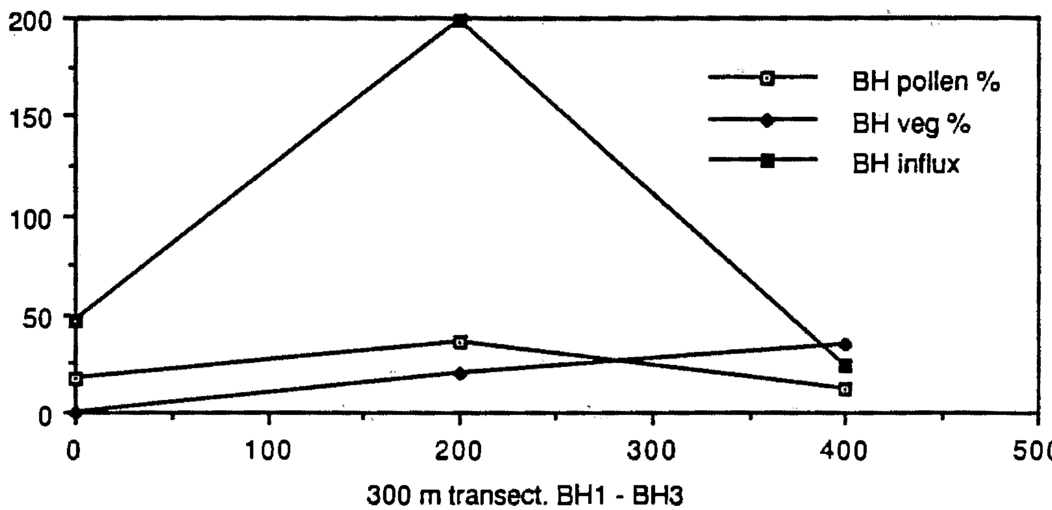


Figure 5.9. The response of *Eucalyptus* pollen across a 300 m transect (x axis) at Big Heathy Swamp. Influx in grains.cm^{-2}.$year^{-1}$.

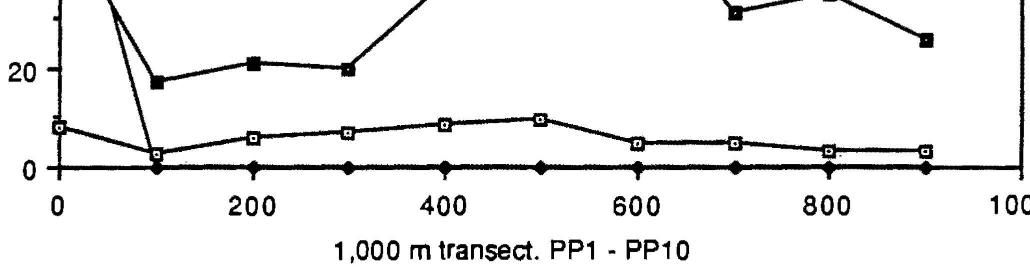


Figure 5.10. The response of *Eucalyptus* pollen across a 1,000 m transect (x axis) at Paradise Plains. Influx in grains.cm^{-2}.$year^{-1}$.

depress percentages. Influx varies between 103 and 143 grains.cm2.yr, again with little variation.

The results of the Big Heathy Swamp transect display a marked peak at trap BH2 (Figure 5.9). This trap was set in a grove of *E. rodwayi* which account for the variation. Percentages vary from 12 to 37% and do not form a basis to discriminate between dry sclerophyll and wet sclerophyll forests. Likewise, influx is even more variable with values ranging from 24 grains.cm^2.yr^{-1} to 198 grains.cm^2.yr. It is perplexing that BH2, with a lower local cover of *Eucalyptus* (20%) has a higher influx than BH3 with a cover of 35%. It is possible that *Eucalyptus* values at Big Heathy may be subject to the same sort of forest edge effects described for *Nothofagus* at Paradise Plains. Local phenological differences could also account for the variation.

This notion seems also to be valid for the *Eucalyptus* data from Paradise Plains. At PP1 eucalypt cover, percentages and influx are all high but fall off within 100 m to lowest values for the entire transect. Figure 5.10 displays trends very similar to those described for *Nothofagus*, only in reverse, for the percentage cover of vegetation types is reversed along the transect.

Poaceae

The grasses are an interesting taxon because they are often assumed to be an example of regionally dispersed and prolific pollen producers (Dodson, 1983; Macphail, 1976, 1979;). The data show that it is possible to record high percentages and influx values in the absence of a grassland. At Waterhouse Point percentages range from 23% - 33% in heath vegetation with only a 6% cover of grasses (Figure 5.11). Likewise, the cover of grass at Forester Marsh is less than 5%, yet percentages rise above 16% in a thicket of *Melaleuca* (FM2), and attain 45% in the center of the marsh at FM3 (Figure 5.12).

Once again, the presence of understory shrubs greatly impedes the dispersal of pollen so that FM1 has influx rates of 194 grains.cm^2.yr, while FM2 has 90 grains.cm^2.yr. This could lead to severe overestimates concerning the extent of grasslands based on pollen abundances.

At Big Heathy Swamp, Poaceae pollen is best represented in BH1 and BH2 which are open to pollen influx from grassy forests to the west. Percentages vary from 15 - 30% while influx rates vary from 37 - 79 grains.cm^2.yr (Figure 5.13). This also points to the local over representation of grass pollen.

The Paradise Plains traps show variable responses (Figure 5.14). When grass cover is extremely high as at PP2 (60%), pollen pecentages do not exceed the cover abundance value. However, when local grass cover is low (5%), as at PP4, pollen

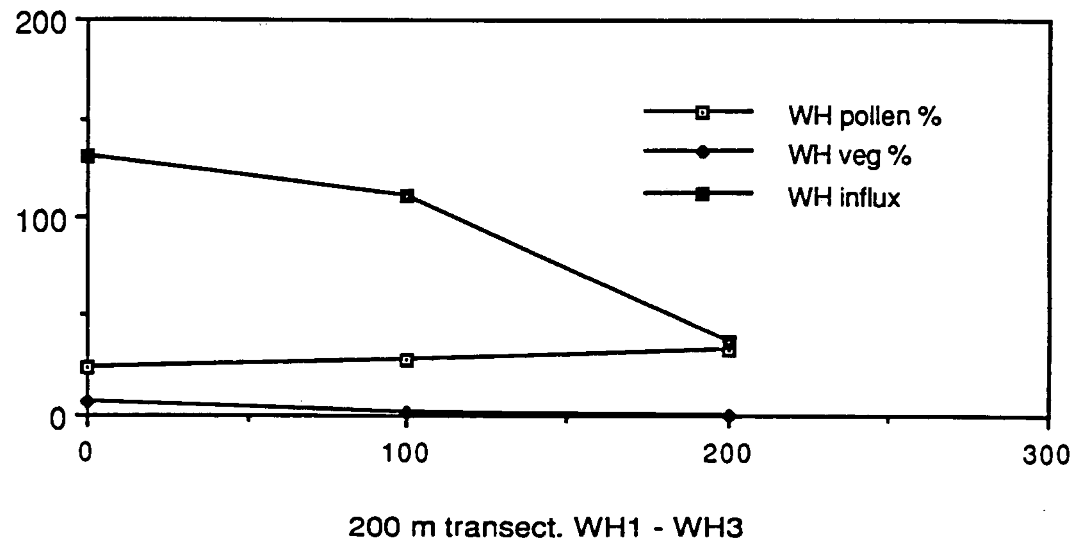


Figure 5.11. The response of Poaceeae pollen across a 200 m transect (x axis) at Waterhouse Marsh. Influx in grains.cm^{-2}.year^{-1}.

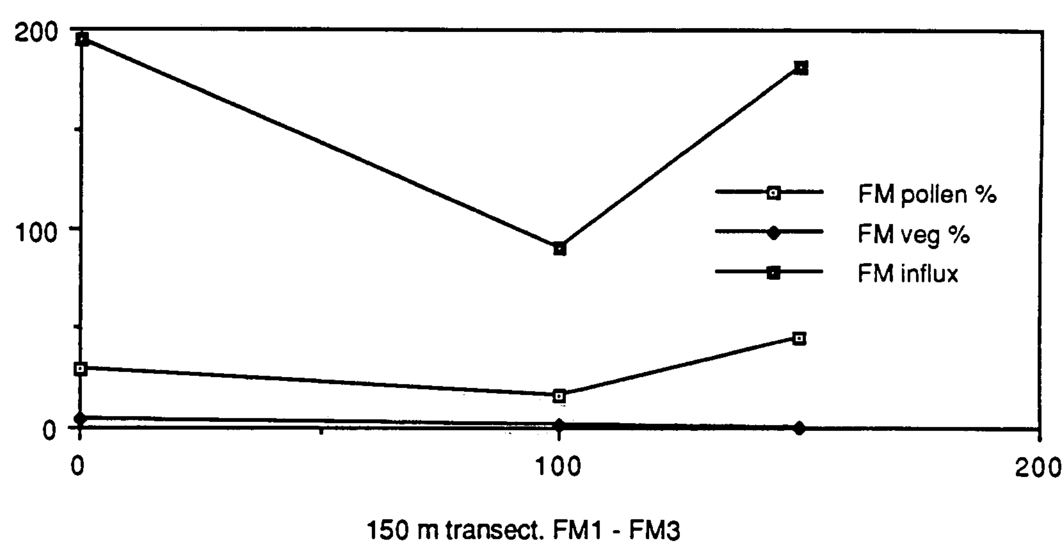


Figure 5.12. The response of Poaceae pollen across a 150 m transect (x axis) at Forester Marsh. Influx in grains.cm^{-2}.year^{-1}.

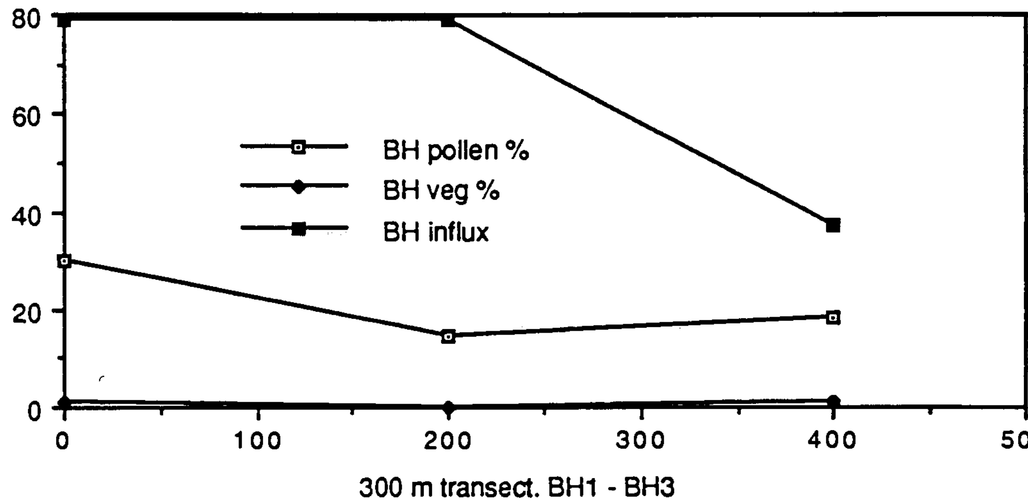


Figure 5.13. The response of Poaceae pollen across a 300 m transect (x axis) at Big Heathy Swamp. Influx in grains.cm^{-2}.year^{-1}.

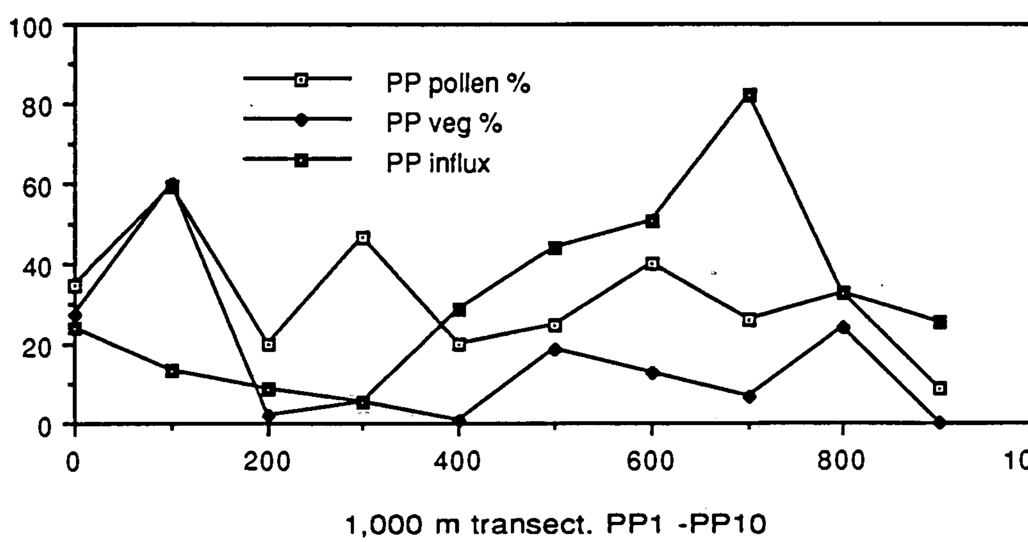


Figure 5.14. The response of Poaceae pollen across a 1,000 m transect (x axis) at Paradise Plains. Influx in grains.cm^{-2}.year^{-1}.

percentages can be as high as 50%. These results indicate that Poaceae is blown across the plains in ever increasing abundances before sharply declining at PP9 at the grassland / forest transition. At PP10, 100 m in from the forest edge, Poaceae pollen drops to low levels of about 8%. This leads to the hypothetical possibility of grasslands existing adjacent to rainforest and yet remaining palynologically invisible. This could occur if a core were taken from within a rainforest. It is important therefore, that palaeo-ecological reconstructions be based on a thorough examination of all pollen types, rather than focusing on the abundance of a single type.

Pomaderris and *Allocasuarina* have similar responses to the above taxa. The percentages in Appendix 1 show that certain other taxa, notably *Leptospermum, Melaleuca, Tasmannia,* Fabaceae and Dilleniaceae behave erratically depending on their local abundances. In keeping with the findings of Dodson (1983) and Kodela (1990), herbs and most small woody shrubs have very low powers of dispersal and or production and rarely attain values above 1 - 3%.

5.5 Discussion

The analyses show that pollen rain, even at the isolated points as represented by pollen traps, does provide a good indication of the composition of local plant communities (Tauber, 1965, 1967; Janssen, 1973). It is also clear that the regional component of the pollen rain allows highland communities to be distinguished from lowland communities. However, it is also obvious that the ubiquitous Australian eucalypt forests are difficult to separate on the basis of pollen representation of *Eucalyptus*. This has also been found to be a problem in New South Wales (Dodson, 1983; Dodson & Myers, 1986).

The DCA analysis displays the relationships between traps along continuous gradients and thus provides a qualitative view of the real vegetation complexity which underlie the dimensional simplifications of the analysis. In contrast, the TWINSPAN analysis produces groups which can be differentiated on a quantitative basis. The analysis clearly separated coastal from highland assemblages on the basis of quite small percentages of *Melaleuca squamea* (< 2%). Lowland pollen assemblages were characterized by high percentages of *Allocasuarina* (20%+), *Eucalyptus* (20%+), *Melaleuca squarrosa* (20%+) and lesser values for *Ricinocarpus* (10 - 20%) and *Banksia* (10 - 20%). In contrast highland traps below the alpine zone have high values for *Nothofagus* (20%+), *Dicksonia* (5 -10%) and consistent traces of *Tasmannia* (2 -5%) and *Microsorum* (2 - 5%). To this can be added *Atherosperma moschatum* (see below).

It is possible in this case to differentiate between coastal heaths and inland dry sclerophyll forests on the basis of low percentages of *Leptospermum lanigerum* (<2%), a species commonly found on the fringes of coastal freshwater marshes. This may not be a general rule however, for that species is widely distributed. A more diagnostic feature is that coastal sites are dominated by an assemblage of *Allocasuarina* (20%+), *Leptospermum lanigerum* (20%+) and *Banksia marginata* (2 -5%). Although no traps were set in coastal *Allocasuarina* forests, it is expected that the sparse understories in those places would give a totally different pollen signature to the species rich *Allocasuarina* heathlands. The dry sclerophyll sites have high eucalypt percentages (20%+) in association with *Leptospermum scoparium* (20%+) which fills the role of *L. lanigerum* on the wet margins of marshes. In addition, occasional high values in Fabaceae and consistent trace values of Goodeniaceae, *Ricinocarpus* and *Acacia* pollen mark this assemblage as one with origins in forests with heathy rather than grassy understories .

Upland wet sclerophyll forests are distinguished from montane grasslands by the presence of *Melaleuca squamea* (<2%), *Pittosporum bicolor* (2 -5%) and Fabaceae (5 - 10%). The Paradise Plains grasslands are surrounded by rainforests which contribute *Tasmannia* (2 -5%) and *Dicksonia* (10 - 20%).

A major factor in the composition of pollen assemblages in traps, and presumably also in moss polsters, is over-representation occasioned by the dominance of local shrubs. At Waterhouse and Forester Marsh, *Melaleuca squarrosa, Leptosperum lanigerum* and members of the Fabaceae fall into this category. Fabaceae pollen is exceedingly numerous in the heathy understories at Forester and provide large quantaties of very poorly dispersed grains.

At higher altitudes, *Melaleuca squamea, Leptospermum scoparium* and Fabaceae (*Oxylobium ellipticum*) behave in a similar fashion. A peculiar example is provided by *Atherosperma moschatum,* a rainforest dominant at Paradise Plains, which is usually considered to be very poorly dispersed (Macphail, 1984). In this case, the dispersal qualities of *Atherosperma* conform to Macphail's expectations, for its pollen does not travel distances greater than 50 m. However, the pollen production capabilities of the tree far exceed that of its co-dominant, *Nothofagus cunninghamii* ,which is usually considered to be a prolific producer. It is possible that *Atherosperma* is better adapted to reproduction in shaded forest situations than *Nothofagus,* which seems to flower prolifically at rainforest edges.

The TWINSPAN groups are used in the following chapters to allow basic environmental distances between fossil pollen assemblages to be compared. It is not claimed that the modern groups have direct analogues in the past, but it is expected that on the basis of dominance, and in consideration of the discriminatory capacity of a number of understorey species, that past heaths, sclerophyll forests and rainforests will be identifiable.

Chapter 6

The Bassian Margin

6.1 Introduction

The Bassian province occupies a crucial link between continental scale trends on the Australian mainland and the intensely local developments of Tasmania. Cosmic scale Milankovitch phenomena which resulted in events such as the lowering of sea levels during the Late Last Glacial and the Holocene marine transgression have set the climatic and physiographic parameters within which subsequent natural processes have operated.

Aspects of the evolution of landforms (Bowden, 1981; van de Geer, 1981), biotic communities (Hope, G, 1978) and cultural systems (Bowdler, 1984; Brown, 1988; Jones, 1967, 1971a, 1971b, 1975, 1977, 1984; Sim, 1989), are to a large extent, controlled by relationships between water depth and sea-surface temperatures. The sensitivity of the Bassian province to cosmic scale pertubations provides the necessary tension between water and land that gives Bassian studies their general interest.

In this chapter, fossil pollen and archaeological evidence are combined with a reassessment of other palaeo-environmental data to construct a model which incorporates 10,000 years of landscape history. Pollen recovered from a marsh near Waterhouse Point provides details of the dynamic interplay between vegetation, climate, soil formation processes, sea-level changes and anthropogenic influences. Results from this chapter provide direct evidence of the wider effects of glacial interglacial cycles on temperate systems. (Chappell, 1990; Clark, 1990).

Fossil pollen studies in Australia have traditionally concerned themselves with climatic reconstructions based on percentages of pollen taxa (eg. Colhoun,1985b; Colhoun & van de Geer, 1986; Dodson, 1974; Kershaw, 1981; Macphail, 1975, 1976, 1979; Singh *et al.*, 1981). This tradition is well established in Europe (see extensive references in Birks & Birks, 1980) and North America (see Huntley & Webb, 1988) and is based on the assumptions that fossil pollen abundances reflect the vegetation present at any particular time and that taxa have specific climatic requirements.

The interpretation of pollen sequences for climatic reconstructions developed along side geomorphological studies concerned with glacial cycles (Flint, 1971). On mainland

Australia, the virtual absence of active glaciers at any stage of the Pleistocene has forced students of climate change to concentrate on far more subtle indicators. Thus, Bowler *et al.*, 1976) and Bowler (1982) were able to deduce patterns of glacial and interglacial cycles from hydrological and geomorphological evidence in western New South Wales, some 1,000 km from the nearest Quaternary glacial deposits. In Tasmania, glacial landforms provide the opportunity to correlate geomorphological and pollen evidence.(Colhoun, 1978; Colhoun 1985c; Colhoun *et al.*, 1990) Fitzsimons *et al.*, 1990a, 1990b; van de Geer *et al.*, 1989).

In comparison to mainland Australia, Tasmania has generally higher rainfall and lower temperatures which combine to provide a wealth of sites suitable for palaeoecological research. In this respect, the central and western parts of the state have provided most pollen records. Fewer records exist for the drier eastern or northeastern regions (Noble, 1984) where the effects of direct glacial activity during the late Pleistocene was minimal (Caine, 1968, 1983). However, in the humid environment of western Tasmania, subtle changes during the Holocene are likely to have been masked by local surfeits of moisture. In contrast, in the drier northeast, small changes in water budgets might be expected to have dramatically affected the composition of plant communities. Because water budgets are affected by both precipitation and temperature fluxes, pollen records from the drier parts of the east and northeast will be more sensitive to subtle Holocene climatic changes

The nexus between people and environment can be profitably explored through analyses of extant plant communities and surface cultural deposits (Cosgrove *et al.*, 1990; Jackson, 1965; Kirkpatrick, 1977a; Kirkpatrick & Dickinson, 1984; Lourandos, 1983a, 1983b). By extending this concept to a combination of fossil pollen, geomorphological and dated archaeological data it is possible to more fully understand the long term dynamics of a region.

The northeast of the state offers opportunities to study environments which although conditioned by the presence of Bass Strait, still bear the hallmarks of Bass Plain. In particular, the present mixed coastline (Bowden, 1981; Stockton, 1982) which stretches from Georgetown to Musselroe Bay contains a stunning variety of Holocene and Pleistocene landforms. These provide mute testimony to past processes and offer the bonus of containing ancient Aboriginal sites. In short, the region is exactly suitable for process oriented palaeo-reconstructions.

This chapter owes a considerable debt to previous geomorphological investigations which have defined the landscape in terms depositional environments (Bowden, 1981; Bowden, 1983; Sigleo, 1978; van de Geer, 1981). In particular, Bowden's research has provided a testable chronological framework which is suitable for both palynological and archaeological purposes.

Extensive heathlands at Waterhouse Point, some 60 km east of Georgetown (Figure 4.3) cover one of the dune fields examined by Bowden. The favourable conjunction of fire dependent vegetation communities containing the supposedly fire sensitive genus, *Allocasuarina* (Singh *et al.*, 1981) growing on putative Pleistocene landforms allowed a number of significant questions to be asked.

1) What changes occurred in the vegetation of the northeast consequent with the demise of an arid glacial phase and its replacement by an interglacial characterised by warmer and more humid climates?

2) What part did the rise of Bass Strait and its eventual stabilisation, play in the long term vegetation dynamics of the northeast?

3) What effects did Aboriginal burning of the bush have on the vegetation of the northeastern dunefields?

4). How old are the heathlands of northeastern Tasmania?

5) What pollen evidence exists for the long term survival of *Allocasuarina* in a fire prone environment?

The above questions and a number of related issues are dealt with by an analysis of pollen and sediments from a wetland located in a putative late Pleistocene longitudinal dune field.

6.2 Methods

Sediment samples were retrieved from the deepest parts of deposits with a D-section corer. Each 50 cm core segment was extracted from alternate holes within 0.5 m^2 at the same site. Segments were double wrapped in plastic film prior to storage in trays.

X-ray photographs of each 50 cm segment of cores were taken in the Department of Radiology, Repatriation Hospital, Hobart (Plate 9). The use of this technique allowed an appreciation of sedimentary characteristics to be gained prior to sub-sampling (Karlen,1976; Saarnisto, 1986).

Sub-samples of 8 cm^3 were taken at 3 cm intervals and passed through a low magnetic field loop attached to a Bartington Portable Magnetic Susceptibility Meter to measure volume magnetic susceptibility (K) on a scale of 10^{-6} G.Oe.cm^2.

Silt and clay sized particles carry a magnetic signal which is dependent on certain intrinsic characteristics such as crystal shape, internal stresses and composition. The measurement of K allows a rapid non-destructive method to estimate the inorganic mineral content at any particular stratigraphic level (Mullins, 1977; Oldfield *et al*, 1985; Thompson *et al*, 1975; Thompson *et al.*, 1980). Interpretive problems do exist, especially in regard to the discrimination of biogenic and minerogenic sources of ferric minerals (Mullins, 1977; Richardson, 1986). In general however, it has been shown that peaks in K are usually produced by inputs of mineral particles with distinct magnetic characteristics. In the case presnted below, it is possible to observe that curves of K plotted against depth are entirely concordant with sedimentological changes and thus strengthen the asumption that K fluctuates according to mineral content (Figure 6.22).

Sediment was characterised by the Troels-Smith system (Aaby & Berglund, 1986; Birks & Birks, 1980). For pollen analysis, 1 cm^3 sub-samples were cut from cleaned core surfaces at three centimeter intervals. The three uppermost samples had a sampling interval of 1 cm.

Additionally, duplicate sub-samples were weighed, dried in ovens at 105^0C for 24 hours, weighed again and then placed in a furnace at 550^0C for 1 hour in order to calculate total water loss and loss on ignition, relative to dry samples (*sensu* Hakanson and Janssen, 1983).

Known volumes of sediment were weighed to an accuracy of 0.001 g and then subjected to a sediment reduction and pollen concentration procedure involving the following steps (Clark, 1983b; Moore and Webb, 1983).

1) Sieving through 100 micron screen.

2) Addition of exotic marker grains (*Lycopodium fasciculatum*) as *per* Bonny (1972) and Maher (1972).

3) Hydrochloric acid treatment.

4) Potassium hydroxide treatment

5) Hydrofluoric acid treatment.

6) Sulphuric acid and acetic anhydride acetolysis

7) Staining and mounting.

From each final preparation, 10 microlitres of pollen concentrate were measured by micro-pipette and mounted under 22 mm x 22 mm coverslips.

Pollen counting was conducted at x300 with difficult identifications at x600 or in exceptional circumstances under oil at x1,000. Counting proceeded until a minumum sum of 150 grains per sample were counted, although in most cases in excess of 300 were identified. Identifications were made with reference to the Tasmanian Pollen Collection housed in the Department of Geography and Environmental Studies, University of Tasmania.

Percentage diagrams were calculated by the counting program POLLEN (Eisner and Sprague,1987) and drawn by the program MACPOLLEN (Eisner and Sprague,1987).

The pollen sum

The basic dry land pollen sum chosen for all analyses was the total of all dryland pollen types including Asteraceae and Poaceae. This sum allows a balance to be struck between the highlighting of local trends, which is a prime concern of this thesis, and the highlighting of widely dispersed taxa, for regional comparisons and climatic purposes. A sum composed solely of arboreal taxa for instance, would allow an appreciation of regional vegetation changes at the expense of local trends, whereas a sum restricted to local taxa would overemphasise idiosyncratic local changes at the expense of regional and climatic trends.

Aquatic taxa, Restionaceae, Cyperaceae, pteridophytes (excluding *Dicksonia* and *Cyathea*) are expressed as a percentage of their own individual counts per level, added to the pollen sum for that level.

Carbonized particles greater than 10 microns along their major axis were counted at the same time as pollen. For each level, these figures were divided by the pollen sum to form cp/pollen ratios (*sensu* Swain, 1973). These remain substantially independent of accumulation rates and may more realistically portray the responses of vegetation following fire compared to simple counts of cps (Swain, 1973, 1978; Tolonen, 1986).

Numerical methods

All stratigraphic levels from WH/3 and pollen trap data from Waterhouse Point and the Forester Marsh were analysed by the divisive classificatory programme, TWINSPAN (Hill, 1979) and ordinated by the DCA technique (see Chapter 5).

6.3 The Study Area

The study area is unusual in Tasmania for a number of reasons. A low annual precipitation and a gently undulating topography emphasise mainland Australian visual planes. Also, the vegetation tends to have more affinities with .Australasian elements than with the Gondwanan derived flora of western and southern Tasmania (Kirkpatrick 1977b).

The physical geography of the northeast was first described in some detail by Stephens and Cane (1938) who proposed a synthetic classification which related vegetation to soils and landforms. Although their basic classificatory tripos of coastal heath plain, sclerophyll forests and scrubs, and wet sclerophyll and rainforests has proved valid, it remains for a full investigation of soil - plant relationships to be attempted.

Waterhouse Marsh is the informal field designation for an unnamed reed marsh located in the Waterhouse Point Protected Area in northern Tasmania. The area is one of the driest in Tasmania (Gentillii, 1972). The nearest meteorological stations with any continuous records are located at Bridport, on the coast 15 km to the west of Waterhouse Point and at Scottsdale, 40 km south of Waterhouse Point (Figures 6.1 - 6.6). The marsh is situated on the 'heathy plains with coastal dunes' unit of Stephens and Cane (1939) and on the 'Ainslie Sand' sand unit which Bowden (1981) considers to be of late Last Glacial age.

The pollen site: Waterhouse Marsh

Waterhouse Marsh is a wetland 1 m deep at the center and approximately 0.3 km^2 in area. The wetland is an example of 'Deep Freshwater Marsh' as defined by Kirkpatrick and Tyler (1988). Even during protracted droughts, the majority of the marsh does not dry out, however the margins do exhibit limited seasonal variations.

The marsh is dominated to a singularly large degree by the tall sedge, *Baumea arthryophylla* (Plate 1) with a fringing aquatic herbfield consisting of *Myriophyllum, Villarsia* and *Triglochin.* At the eastern end of the marsh is a series of lunette like transverse dunes. Paralleling the northern and southern shorelines are the sandsheets and longitudinal dunes described by Bowden (1981). The western end of the marsh is partially drained by a series of small pools and marshes which eventually peter out in a sand sheet which extends to the coastline at North Croppies Point.

The dryland vegetation of the Waterhouse Point area has been described by Kirkpatrick (1977b). Wetland vegetation has been described by Kirkpatrick and Harwood (1983). In general the heaths are dominated by *Allocasuarina monilifera, Xanthorrhoea* spp., *Banksia marginata* and a large number of woody shrubs, especially those in the families Fabaceae, Dillenaceae and Epacridaceae. Grasses and graminoids are well represented

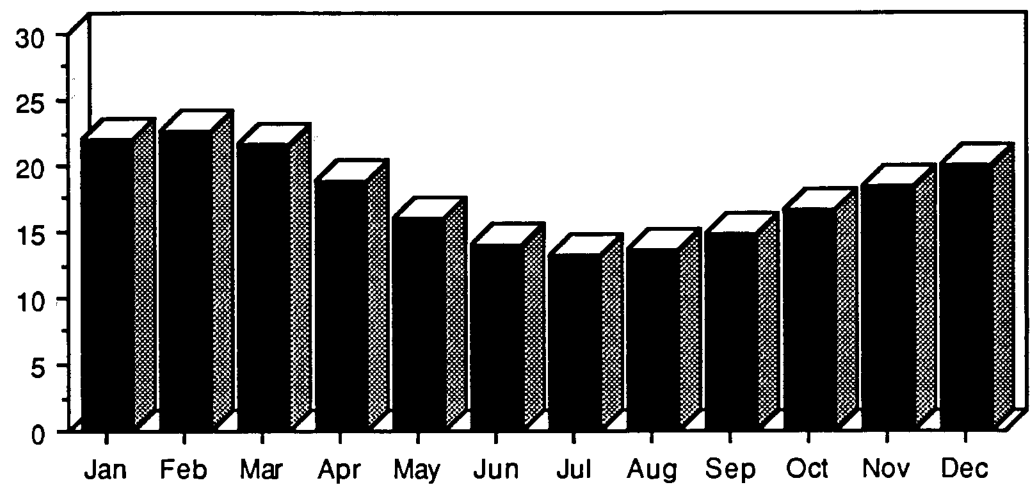


Figure 6.1. Temperatures (C) at Bridport. Mean monthly maxima

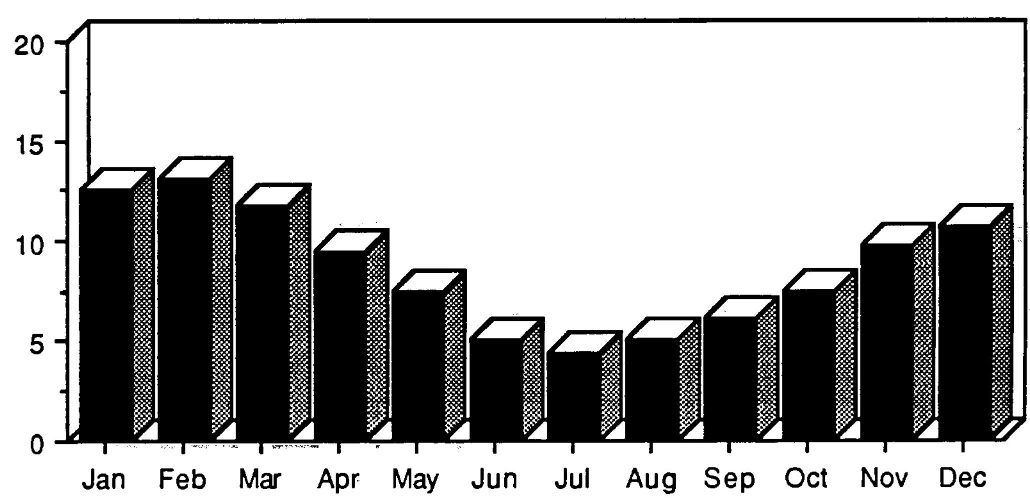


Figure 6.2. Temperatures (C) at Bridport. Mean monthly minima

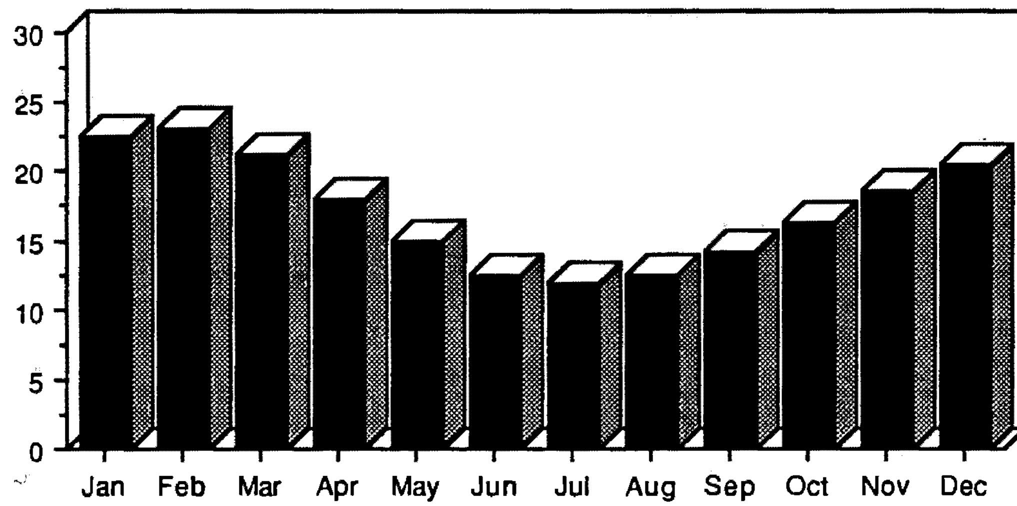


Figure 6.3. Temperatures (C) at Scottsdale. Mean monthly maxima

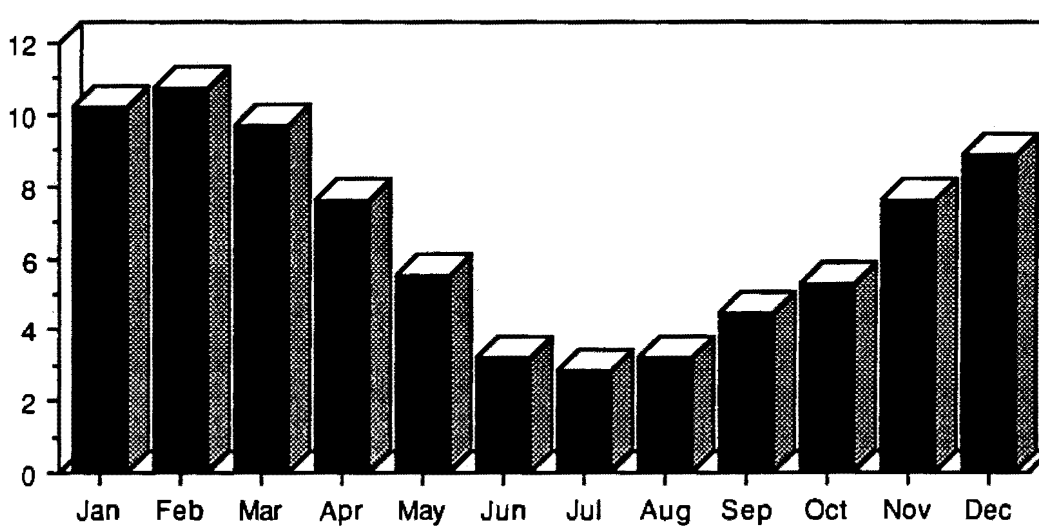


Figure 6.4. Temperatures (C) at Scottsdale. Mean monthly minima

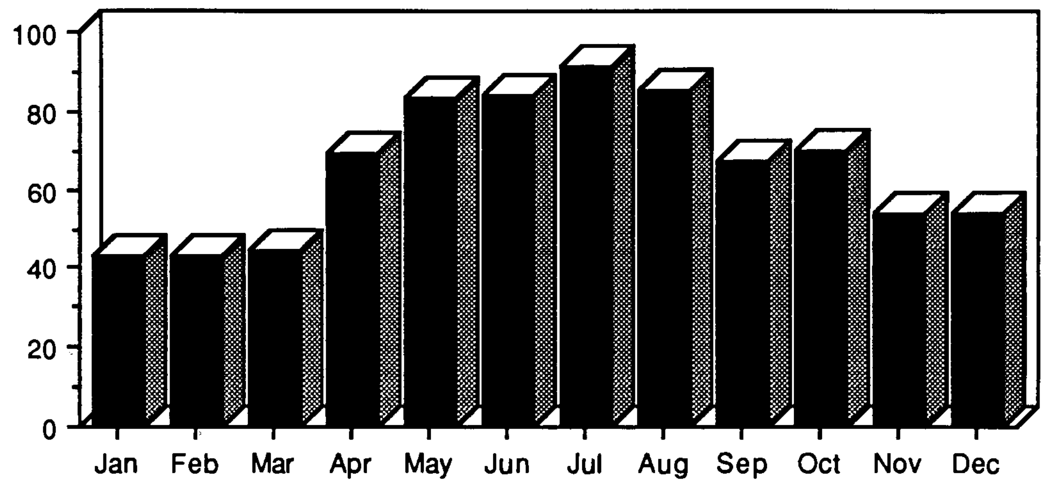


Figure 6.5. Rainfall (mm) at Bridport. Mean monthly precipitation

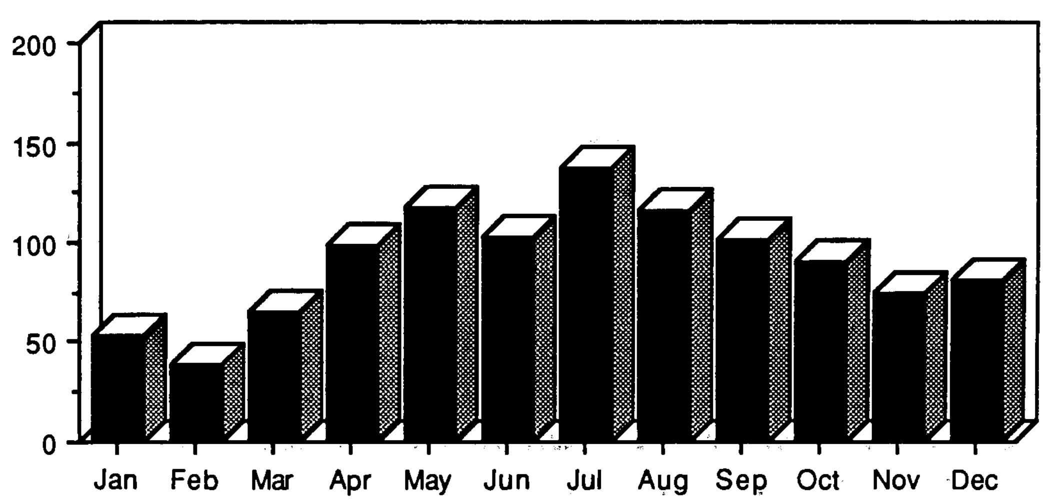


Figure 6.6. Rainfall (mm) at Scottsdale. Mean monthly precipitation

by members of the Poaceae, Cyperaceae and Restionaceae (Plate 1).

Soils formed on the dunes are characterised by well defined horizons typical of the podsols. In general, A1 horizons vary from 10 cm to 20 cm and overlay classic bleached A2 horizons, consisting of pale loosely consolidated sands. A2 horizons are seperated from an orange slightly indurated B horizon by an irregular and somewhat diffuse boundary which extends over a depth of about 10 cm. (see Bowden, 1981, 1983).

Bowden (1981: 23) noted that the moderate podsolization of the longitudinal dunes contrasted with the weakly zoned soils formed on parabolic dunes nearer to the coast and concluded that the sandsheets and longitudinal dunefields are older than the parabolic systems (see discussion below).

6.4 Results and analyses

A total of 11 cores were taken from the floor of the marsh in an attempt to delineate the extent and depth of organic deposits. The evenly graded floor of the marsh is mantled with cyperaceous peats which are deepest in the center of the marsh before quickly thinning out towards the margins.

The longest core (WH/3) was selected for further analysis because it had, by northeastern Tasmanian standards, a long sequence of peat (101 cm) overlying an equally long sequence of sands and silty-clays (110 cm). Below this was a further section of peat (20 cm).

6.4.1 Dating

A total of eight samples was submitted for dating from the Waterhouse Point area (Table 6.1). Three samples were submitted for dating from core WH/3. A further sample was submitted from the base of the upper peat section in core WH/1. A fifth sample was collected from the basal peats of Leedway Lagoon (Figure 4.1) some 7 km from Waterhouse Marsh (Bowden, 1981: 29). All five samples had organic fractions greater than 70%, based on loss on ignition. Only sample WH3/2 (49 - 53 cm) contained significant numbers of rootlets, but these were removed prior to dating. Samples were pretreated by removing all visible rootlets and then subjected to acid/alkali/acid treatments.

An interesting comparison can be made between WH/1, with 9,920 +/- 360 BP (ANU - 5113) and WH/3/2 with 10,480 +/- 170 (Beta-21728). Both samples were taken from different cores (50 m apart), and from stratigraphically similar levels at the base of upper sections of peat. They represent the beginning of organic accumulation following an undated period characterised by clays and sands. The dates very nearly overlap at one standard deviation and easily overlap at two deviations. On this basis, the dates are considered to represent the synchronous onset of organic accumulation in the Waterhouse Marsh basin at the Pleistocene/Holocene transition.

Sample WH/3/3 (Beta-21730) which was taken from immediately below the sequence of clays and sands returned a date of 21,320 +/- 850 BP. Below WH/3/3 is an unknown depth of coarse sands. There is no evidence or suspicion of contamination by younger carbon.

The sample from Leedway was large enough to justify the dating of NaOH soluble (humic) and NaOH insoluble (non-humic) fractions in an effort to see if significant contamination by humic acids and humate colloids had occurred. This was suspected because the lagoon had been drained for agricultural purposes, with the removal of up to 30 cm of surface sediments. The analysis showed a significant difference in age between the two samples with the NaOH insoluble fraction being older (12,440 +/- 120 BP), than the insoluble fraction (11,020 +/- 150 BP). The older determination is therefore preferred as being most reliable.

Sample WHD 1 consisted of clean hard black charcoal taken from 60 cm depth in a sandsheet / dune which forms the northern bank of the marsh. The dune is ascribed to the Ainslie Formation of late Last Glacial age (Bowden, 1981, 1983). The horizontal section of the charcoal deposit suggested that it represented a small Aboriginal fireplace. The presence of artefacts eroding out of the same level, some in-situ, strengthed this view (Plate 13).

The charcoal returned a date of 4,840 +/- 80 BP (Beta - 17291) which is at odds with Bowdens assessment. Single dates from charcoal in sand dunes rarely inspire confidence as there is a strong possibility of humic acid contamination (Colhoun, 1986).

Accordingly a sample of quartz sand grains (90 - 125 microns) was collected from 5 cm higher in the profile and dated by the technique of thermoluminescence. The result of this analysis was 6,400 +/- 0.7 Ka calendar years. After re-calibration this amounts to 6,350 +/- 700 BP. At one standard deviation, the charcoal and TL dates disagree by 730 years. At two standard deviations the dates overlap. If, as seems likely, the charcoal sample was even slightly contaminated by younger carbon, then the difference between the two samples becomes even less. The TL date is regarded as reliable and is hereafter taken to indicate a good estimate for the last exposure to sunlight of what is now the A2 horizon of the sandsheet at 50 - 60 cm depth. The carbon date gives a minimum age for the same period.

Sample	Depth (cm)	Date
WHI	60 - 65	9,920 +/- 360 BP ANU-5113
WH3/2	49-53	6510 +/- 90 BP Beta-21728
WH3/3	98-102	10,480 +/- 170 BP Beta-21729
WH3/5	183-187	21,320 +/- 850 BP Beta - 21730
LW1/a	40-43	11,020 +/- 150 BP ANU-5111
LW1/b	40-43	12,440 +/- 120 BP ANU-5111
WHD /1	40 - 45	4,840 +/- 80 BP Beta-17291
WHD/2	40 - 45	6,400 +/- 700 (TL) W1192

Table 6.1. Radiocarbon and Thermoluminescence (TL) dates taken from peat and sand samples in the Waterhouse Point area.

6.4.2 Sediment accumulation rates by the C^{14}dating method

The calculation of accumulation curve for a basin depends on the number of dated samples from any particular core. In this case, 3 radiocarbon dates and the modern surface sample allow a first approximation to be attempted.

The most noticeable feature of the age/depth curve for WH3 is the almost perfectly linear nature of the data. An R^2 score of 0.994 for a regression performed on age against depth confirms this. A number of objections can be raised against the reliability of regular rates of accumulation obtained from cores composed of disparate sediment types. Firstly, it seems highly unlikely that minerogenic sediments would have accumulated at the same rate as did organic deposits. Secondly, it has been argued that an increase in organic accumulation rates occurred in southeastern Australia during the late Holocene (Macphail and Hope, 1985). In the light of this, it is theoretically possible for undated changes in accumulation rates to occur anywhere between 4 - 48 cm.

The dates divides the upper part of the WH/3 core into a section (0 - 53 cm) with accumulation rates of 123 years per cm or 0.008 cm per year and a lower section (55 cm - 101 cm) of 82.7 years per cm or 0.01 cm per year.

6.4.3 Sediment accumulation rates by the pollen concentration method

In order to provide an independent check on the reliability of accumulation rates and radiometric dates, estimates of age were made based on pollen concentrations from WH/3, and known deposition rates derived from pollen traps over a three year period following the methods of Harle (1989.) The following calculation was made for each sample level.

The mean number of grains.cm^3, from any particular zone divided by grains $cm^2.yr^{-1}$ from a relevant pollen trap gives an estimate of the age for each 1 cm level in a zone (Table 6.2). Multiplication of this figure by the depth of sediment in a zone gives an estimate of the age of a zone.

In order to provide realistic figures for trap influx, averages (pollen grains.cm^2. yr^{-1}) were made for 3 traps from Waterhouse Point, 3 traps from Mt. Horror and 3 traps from Paradise Plains. These figures thus provide general estimates of pollen influx in heaths, forests and grasslands respectively. The trap data was then used to calibrate sections of the core (zones) which the traps most resemble. Rainforest taxa were deducted from the Paradise Plains data in order to provide a more realistic approximation of a low altitude dry grassland.

Zone	Age	sd	accumulation rate
W4	391	134	0.008
W3	4776	1821	0.01
W2	5003	1497	0.006
W1	1360	867	0.01
Total years	11,530	4,319	0.009

Table 6.2. Age (calendar years) and accumulation rate (cm per yr) estimates for all WH pollen zones, including standard deviations. Calculated by the pollen influx method.

The inherent variability of pollen influx is obviously a major factor contributing to large standard deviations. Even more important is the lack of perfectly compatible data from modern traps. For example, zone D has no known modern analog. The use of trap data from Paradise Plains is clearly no more than a gross estimate of grassland pollen productivity and does not take into account the potential effects of altitude or geology.

It is not possible without further C^{14} dates to refine the pollen influx calibration. Large pollen influxes in zone W2 tend to lower apparent accumulation rates, and therefore increase ages. In much the same way, very low influxes in zone W1 raise apparent accumulations, and therefore lower age estimates. Similarly, low influx rates in zone W3 result in artificially high accumulation rates.

In spite of large differences in standard deviations, it appears that both methods result in roughly equivalent means. Certainly, the mean pollen influx value is close to the basal C^{14} result and easily overlaps at one standard deviation. Similarly, an influx derived basal date from Leedway is estimated (using MH traps for calibration) to be 13,160 calendar years compared to 12,440 BP C^{14} years. In general, pollen influx measurements seem to provide overestimates of age compared to radiometric methods. Dabrowski (in Birks and Birks, 1980) and Harle (1989) report similar findings from forests in Poland and southern Tasmania respectively.

Although there is evidence to suggest that accumulation rates differ from zone to zone (Table 6.2), the mean accumulation rate from pollen influx (1 cm per 118 years or 0.009 cm per year) is comparable to the mean rate (1 cm per 104 years or 0.01 cm per year) calculated from C^{14} results. In the analysis that follows, rates based on the C^{14} dates are adopted as a realistic compromise between real rates and constructed rates derived from imprecise estimates of modern community / fossil pollen analogs. From 53 - 0 cm, the rate is assumed to be 0.008 cm.yr, while from 101 - 53 cm, the rate is 0.01 cm.yr.

Upper organic section of WH/3

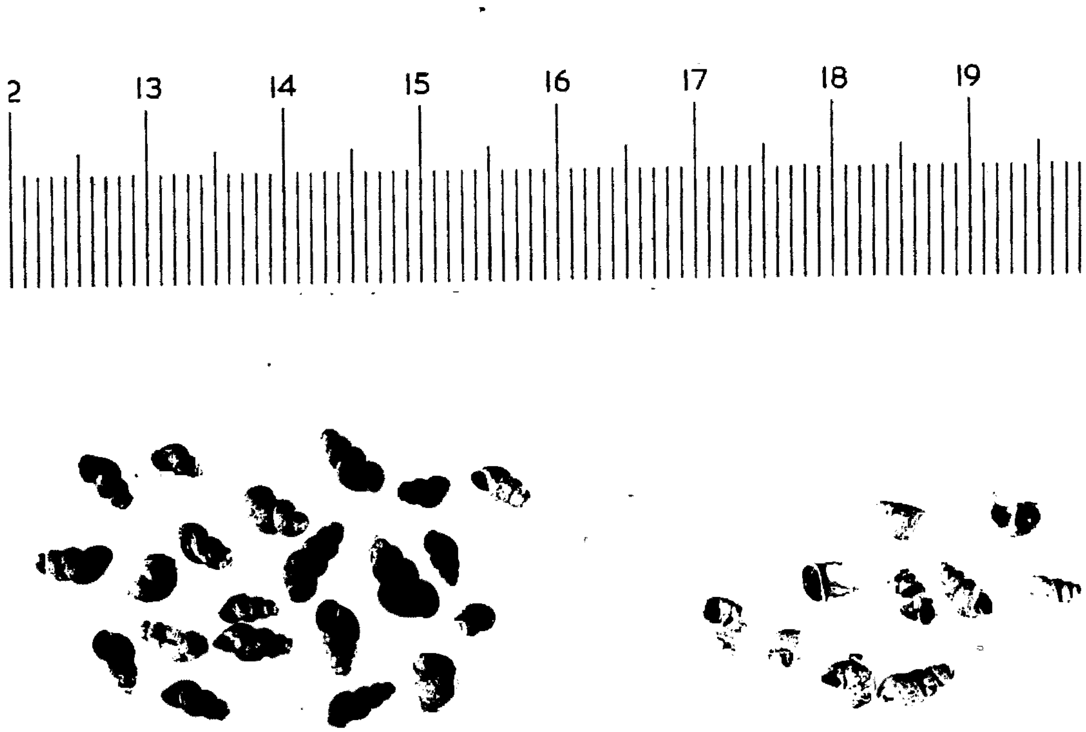
The top 90 cm of the core is uniformly dark peat. At 0 - 5 cm the core is a dense mat of fresh and partially decomposed *turfa herbacea*. From 5 - 90 cm the peat is *substantia humosa*. This section has been invaded by a number of rootlets which penetrate down from the upper root mat. Despite this, few of the rootlets are large and none are evident below 50 cm. A date of 6,510 +/- 90 BP (Beta - 21728) was obtained from root free peat between 49 - 53 cm. Loss on ignition results show that a significant increase in the inorganic fraction occurs at the 48 - 49 cm level (Figure 6.21). A prominent peak in magnetic susceptibility at the same level (Figure 6.22) confirms that mineral material had entered the marsh at this time.

Below this, from 95 - 105 cm is a section of grey/brown *limus detrituosus* (gyttja) which

Plate 9. X Ray of a section of core from Waterhouse Marsh. Organic material including rootlets and fragments of plant fruits are visible. Above this section is 1 m of highly organic sediment with no trace of sedimentary structures (core WH/3, described in Chapter 6). The X ray photograph is actual size.

Plate 10. Shells of *Coxiella striata* (estimated to be greater than 10,500 years BP in age), obtained from 105 cm to 115 cm in the WH/3 core. For comparison, modern *Coxiella* shells are grouped to the left. Size can be gauged from the1 cm interval scale.

Plate 11. Fruits of *Ruppia megacarpa* recovered from the 100 - 110 cm level of the WH/3 core. For comparison, a complete modern fruit is placed below the fossils. Size can be gauged from the 1 mm interval scale.


2 13 14 15 16 17 18 19

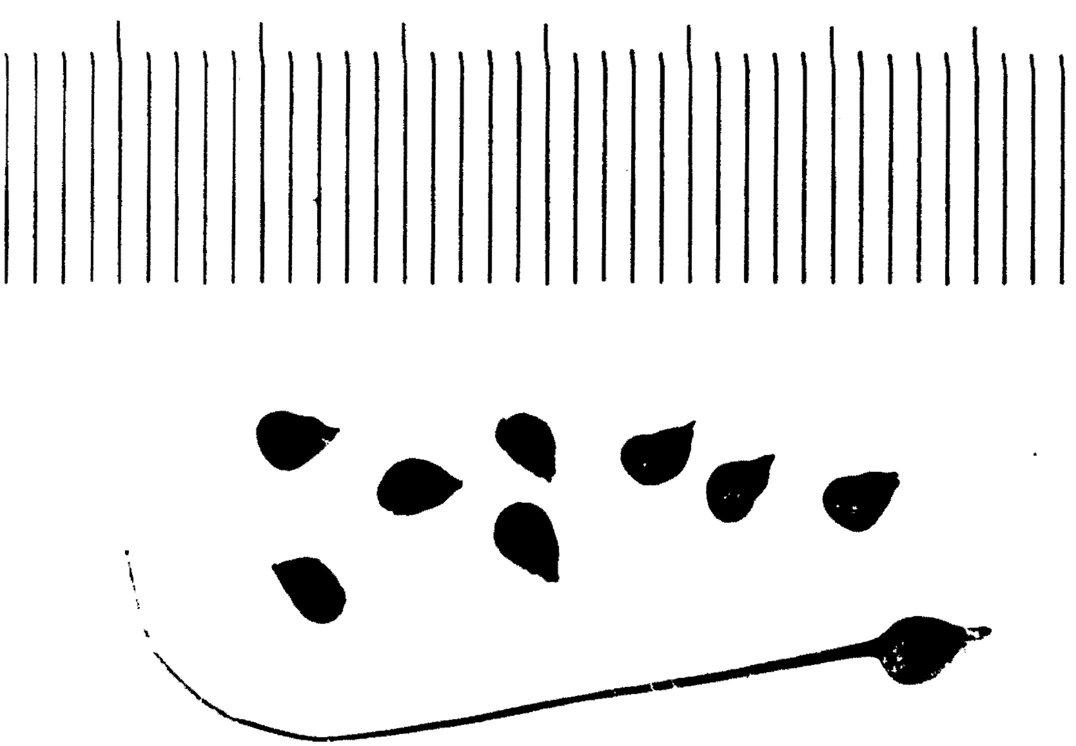


Plate 12. Multiple soil horizons in a dune blowout at Croppies Point near Waterhouse Marsh. Aboriginal artefacts can be seen lying exposed on the partially exposed B horizon to the right.

Plate 13. Location of charcoal and sand samples used for dating the cover sands on the north bank of Waterhouse Marsh. Aboriginal artefacts can be seen above and below the prominent charcoal stain. The soil is a moderately well developed podsol.

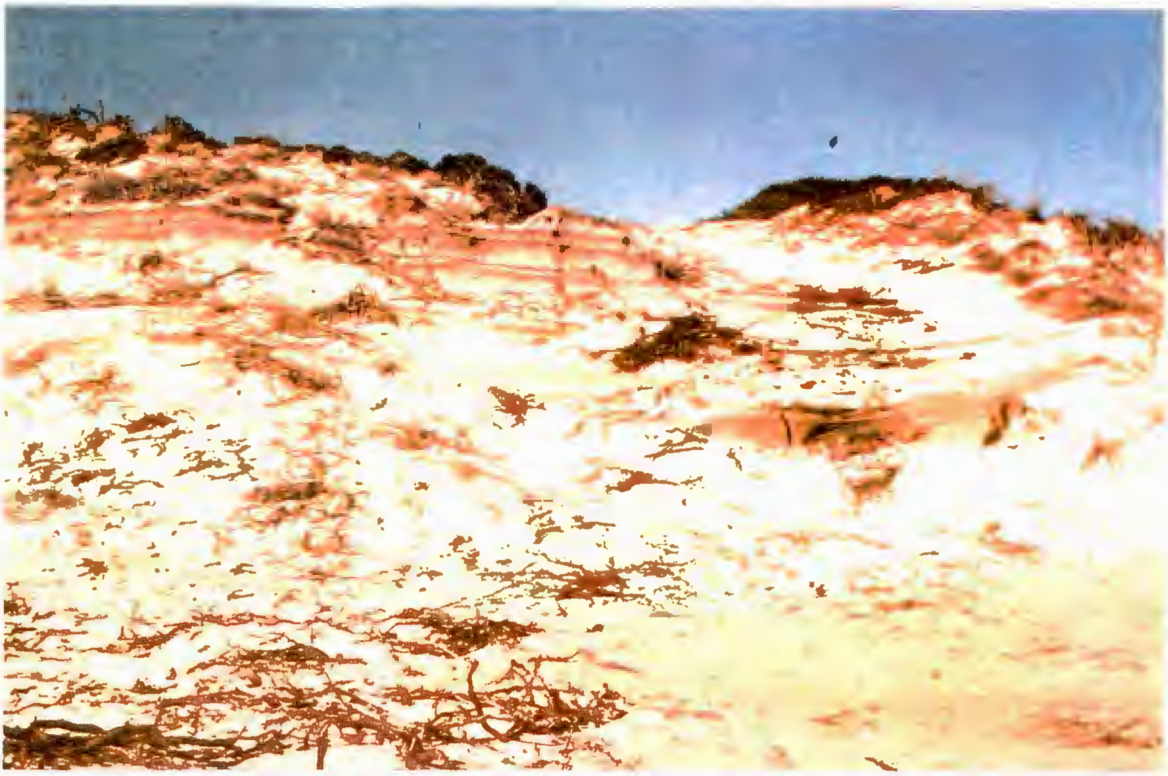
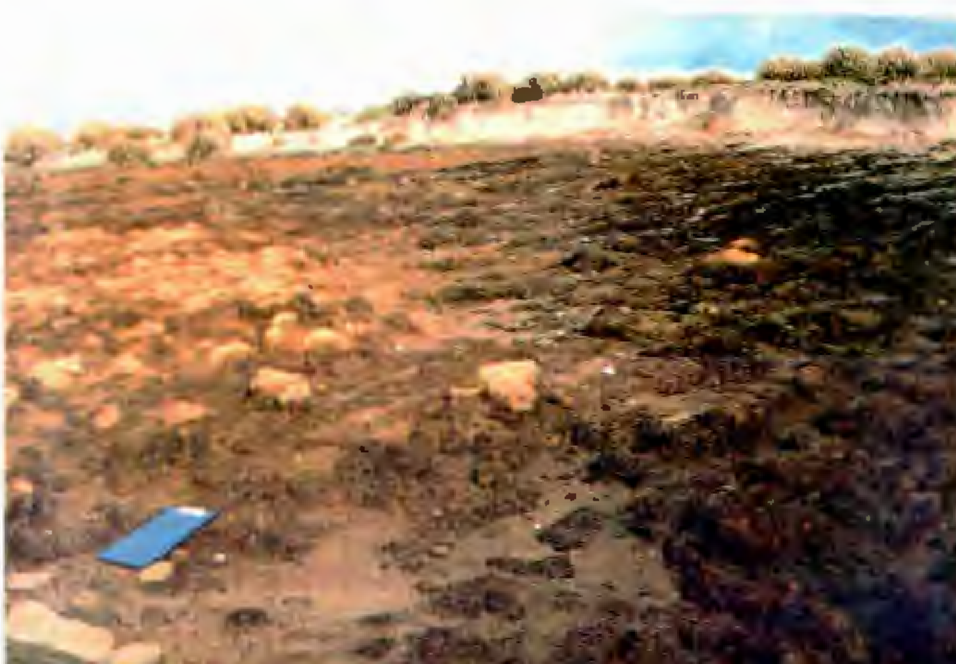


Plate 14. Aeolian sand blowing from an eroded sand sheet near Waterhouse Point under the influence of a strong northwesterly wind. The sand plume extended for nearly 300 m to the right.

Plate 15. A cliff top podsol soil at Croppies Point stripped of its A horizons by wind action. The indurated coffee rock of the exposed B horizon has become the resting place for thousands of Aboriginal artefacts.



grades into a distinct level of *limus calcareus* which extends from 105 - 115 cm. This level is partly composed of well preserved whole shells of *Coxiella striata* (Plate 10). This gastropod is today commonly found in salt marshes and on low energy shores characterised by muddy substrates and large tidal ranges (*pers comm.* E. Turner, Tas. Museum) in saline lagoons on the eastern parts of Flinders Island and in shallow muddy embayments of southeastem Tasmania (Smith & Kershaw, 1981). Bowler *et al.*, (1971: 331-332) recovered *Coxiella* tests from the saline Lake Keilambete at about 20,000 BP. From the WH/3 core, a date of 10,480 +/- 170 BP (Beta - 21729) was obtained from root free peat at 98 - 102 cm. On this basis the *Coxiella* shells have a minimum age of 10,500 BP.

A number of well preserved fruits of *Ruppia megacarpa* (*pers comm.* D. Morris, Tasmanian Herbarium) were recovered from between 100 - 110 cm (Plate 11). *Ruppia* is a genus containing species which prefer brackish or estuarine environments. It is also found in saline lagoons in inland central Tasmania (Kirkpatrick & Harwood, 1983). The association of *Ruppia* at the same level as *Coxiella* suggests that at about 10,500 BP, Waterhouse Marsh was a muddy saline expanse, probably no deeper than 20 cm at the centre. It is not possible to determine if the marsh was subject to seasonal drying. *Ruppia* is known from both seasonally inundated and permanent wetlands but prefers the latter (Kirkpatrick & Harwood, 1983). Herbarium records indicate that *Ruppia* is especially plentiful on the southeastern and eastern coasts of the state where large tidally influenced embayments are common (Hughes, 1987). *Ruppia* has not been recorded from any of the coastal lagoons at Waterhouse Point (Kirkpatrick & Harwood, 1983).

Lower minerogenic section of WH/3

The 100 - 105 cm level effectively marks a gradual division between an upper organic section and a lower minerogenic section of core. There are an additional number of organic rich layers to be found between 105 - 200 cm.

X-rays of the core (Plate 9) reveal a complex layering in which clean levels of fine sand, *grana arenosa*, altemate with clays, *argilla steatodes* (some of which are sandy while others which have a some organic content). The base of the core is composed of a firm fine sand *grana arenosa* which underlies a sub-basal level of brown *detritus herbosus*. A sample taken between 183 cm and 187 cm, returned 21,320 +/- 850 BP (Beta-21730). The sequence above 21,320 BP and below 10,480 BP therefore represents accumulation sometime during the late Last Glacial maximum.

Unfortunately, despite many attempts, no pollen was recovered from any of the organic layers of the minerogenic section of core and thus it is not possible to comment on the environment at that time without further data.

6.4.4 TWINSPAN analysis

In this classification (restricted to dryland taxa), pollen trap results from WH1, WH2, WH3 and FM1, FM2 and FM3 were included in order to test if modern pollen assemblages from coastal heath and dry sclerophyll forest correlated with fossil pollen groups determined from the core samples.

Figure 6.7 is the dendrogram of the weighted TWINSPAN analysis. Percentage envelopes used to define pseudospecies are given in Chapter 5, Table 5.1.

The dendrogram was terminated after the completion of 4 dichotomies. To facilitate interpretations, groups were defined at the first level which placed either set of pollen traps (FM1, FM2, FM3 or WH1, WH2, WH3) with a set of core samples. Higher level splits are referred to whenever such groups allow a rational ecological interpretation.

Groups described below are derived from the weighted TWINSPAN analysis and are used later to objectively define pollen zones to guide the interpretation of conventional percentage diagrams.

Weighted TWINSPAN analysis

Four groups (A, B, C and D) were recognized as providing a sound basis for zonation and which are consistent with results obtained from other ordination techniques.

TWINSPAN groups

Figure 6.7 is initially split into two types in which the negative side is characterised by the indicator species *Allocasuarina* >20% and *Sprengelia incarnata*. The positive split is characterised by *Eucalyptus* >20%. The samples are therefore divided between communities in which *Allocasuarina* is dominant and those with high values for *Eucalyptus*. The second pair of dichotomies expand the two 'types' into 4 groups, A, B, C and D. Each group is regarded as being equivalent to a generalized vegetation formation similar to those described by Kirkpatrick and Dickinson (1984). Groups A and C are closely linked with pollen trap samples, and by analogy, are easily associated with the contemporary vegetation surrounding the traps. Groups B and D are more distant from the trap samples and have more problematical affinities in terms of modern analogues.

Group A. This group contains core samples 1 (0 - 1 cm) and 2 (2 - 3 cm) and trap samples 28 (WH1), 29 (WH2) and 30 (WH3). Although not included in this analysis,

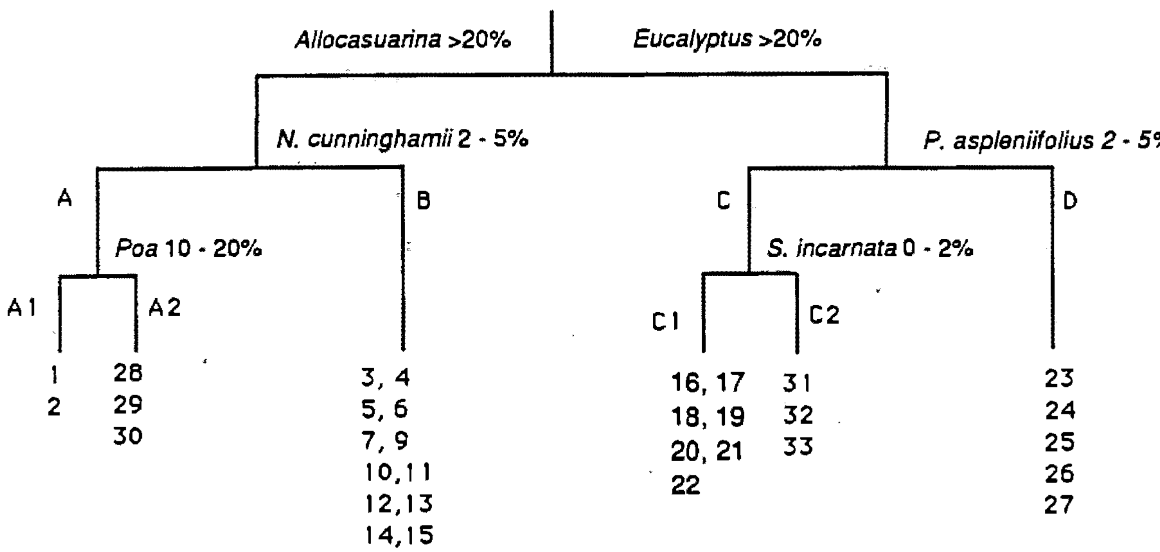


Figure 6.7. Waterhouse Marsh. Abundance weighted TWINSPAN dendrogram for WH/3 core samples (1 - 27). Included are pollen traps from Waterhouse Marsh (28 - 30) and Forester Marsh (31 - 33). Core samples 1 - 27 are in increasing order of depth from 0 cm - 101 cm. TWINSPAN groups, indicator species and values at each major split are shown.

exotic taxa such as *Pinus radiata* and *Plantago lanceolata* are present and thus date these levels to the modern period. *Poaceae* 10% - 20% and *Melaleuca squarrosa* 5% - 10% are the indicator species for group A. The close association of samples 1 and 2 with 28, 29 and 30 is good evidence that the extreme upper section of the Waterhouse core has been a heathland for the European phase of settlement. The group can be further divided into sub-groups A1 and A2 which divide the upper two core samples from the Waterhouse pollen traps assemblages.

It is highly likely that the surface area of Waterhouse Marsh affords a more heightened sensing of regional pollen taxa than do the small receptor surfaces of pollen traps. This results in rainforest and wet forest pollen in samples 1 and 2 being overrepresented in relation to the modern treeless vegetation which surrounds samples 28, 29 and 30.

In this instance, group A is correctly split into core samples 1 and 2 (A1) which have collected regional pollen over about 200 years, and trap samples 28, 29 and 30 (A2), which have collected pollen over a far shorter period of time .

Group B. Samples 3 (5 - 4 cm) to 15 (53 - 52 cm) comprise this group which represents the greater part of the upper section of the core. *Nothofagus cunninghamii* 2% - 5%, *Dicksonia antarctica* 2% - 5% and *Cyathea* 2% - 5% are the indicator species for group B.

Other preferential species included in group B are *Eucalyptus* 5% - 20%, Asteraceae 2% - 5%, *Ricinocarpus pinifolius* 2% - 5% and shrubs 2% - 5%. Shrubs include traces of the wet forest and sub-alpine species *Phebalium* and *Nothofagus gunnii.* These well dispersed types define the regional pollen and suggest regional climatic conditions suitable for rainforest at this time.

Although no pollen trap analog exists for this assemblage, two major possibilities suggest themselves. The pollen mix may represent an *Allocasuarina* - *Eucalyptus* woodland or alternatively a heathland in which *Eucalyptus* occupied a more significant proportion of favourable fertile sites during pre-European times. Such places might include a number of exposed dolerite and granite knolls and protected dune crests which rise above the B_2 horizons of locally extensive groundwater podsols (Bowden, 1981). Kirkpatrick (1977b) has documented the rate of destruction of heathland in the Waterhouse Point area since 1950. The present patterns of *Eucalyptus* in and around the grazing lands within 10 km of Waterhouse Point suggest that many eucalypt groves have also faced the bulldozer. The loss of *Eucalyptus* during the European period would have resulted in a diminution of the amount of available pollen.

Group C. Samples 16 (56 - 57 cm) to 22 (80 - 81cm). Group C has no absolute indicators and is divided from group D on the basis of the presence of *Phyllocladus* *aspleniifolius* 2% - 5% in group D. Included in the group are samples 16 to 22 and traps 31 (FM1), 32 (FM2) and 33 (FM3). Preferential species include *Eucalyptus* >20%, *Allocasuarina* 10% - 20%, *Pomaderris apetala* 5% - 10%, *Melaleuca squarrosa*, 5% to 10% and less than 2% of *Fabaceae*, *Sprengelia*, *Leucopogon*, other *Epacridaceae*, *Coprosma* and *Amperea xiphoclada*.

As in group A, the association of core samples with modern pollen trap assemblages allows a strong argument to be drawn regarding the general type of vegetation present during the period represented by samples 16 to 22. In this case, the pollen traps indicate a *Eucalyptus* forest with a heathy understory. It is clear that samples 16 to 22 represent a *Eucalyptus* forest very similar in composition to that now found in the area south of the coastal plain and north of the wet forests near Scottsdale.

Included in the group are traces of the Apiaceae, *Gunnera cordifolia* and *Acaena novae-zelandiae*. *Gunnera* is today restricted to sub-alpine regions of central and western Tasmania. It is usually associated with places where the ground surface is regularly flushed by water. Herbaceous taxa are generally considered to be local pollen dispersers and many are commonly restricted to sub-alpine locations (Macphail, 1986). The presence of these taxa, especially *Gunnera*, seems to indicate a greater availability of surface water. This could be accomplished by either an increase in precipitation or a decrease in temperature leading less effective evaporation. Alternatively the taxa may represent relict populations which were formerly more widespread during the late Last Glacial.

Group C can be split into two further sub-groups. Group C1 contains the core samples 16, 17,18, 19, 20, 21 and 22 while group C2 contains traps 31 (MH1), 32 (MH2) and 33 (MH3). This sub-group is finally differentiated from the core samples by the presence of *Sprengelia incarnata* in the traps and its absence in the core samples. *Sprengelia* pollen is rarely dispersed more than a few metres from its source. At Waterhouse Marsh, *Sprengelia* is separated from the marsh edge by a wall of *Melaleuca squarrosa* while the coring site is located well beyond the normal dispersal limits of the species.

The reclassification of sample 32 from group A to group C needs some explanation. Group A contains samples 1, 2, 28 (WH1), 29 (WH2), 30 (WH3) and 32 (Figure 6.7). Samples 1 and 2 are the uppermost levels in the core and are presumed on the basis of the presence of exotic taxa and the presence of partly decomposed organic matter, to be less than 200 years in age. Samples 28, 29 and 30 are modern trap samples from treeless vegetation at Waterhouse Marsh, while sample 32 is a trap sample from the margin of Forester Marsh, located in dry sclerophyll forest with a heathy understory. The placement of 32 in this group demonstrates the palynological similarity of the understorey at Forester Marsh to the heath at Waterhouse. The high percentages of locally derived and poorly dispersed *Melaleuca squarrosa* and Fabaceae pollen at the site caused trap 32 to be classified with the WH traps. However, these taxa are not dominant around the other FM traps

The next TWINSPAN division, which separates 32 from the remainder of group A, is based on the presence of *Dodonea viscosa* <1% in samples 1, 2, 28, 29 and 30. *D. viscosa* is a common element in forests and woodlands within 10 km of Waterhouse Marsh. The nearest occurrence is just 1 km to the northeast on the slopes of a prominent hill. In contrast, *D. viscosa* is not commonly found on the granitic soils and gravels surrounding the Forester Marsh.

The allocation of sample 32 with group C recognizes differences between Waterhouse Marsh and Forester Marsh in terms of overstory dominants and yet affirms similarities between the ground level communities. It is therefore permissible to rationalize the classification and subsume sample 32 into group C which contains the remaining two Forester traps. On this basis, the placement of 32 with group C is explained in terms of local vegetation composition and particular pollen dispersal characteristics.

Group D. Samples 23 (84 - 85 cm) to 27 (100 - 101 cm). The group contains samples which date to ca 10,500 BP. The indicator species for this group is *Phyllocladus* 2% - 5%. Preferential species include Asteraceae 5% - 20%, *Ricinocarpus* 2% - 10%, Xyridaceae / Iridaceae 2% - 10%, *Banksia marginata* <5%, *Plantago* 2% - 5% and Liliaceae 2% - 5%.

The assemblage appears to represent a *Eucalyptus* woodland with an open, shrub rich understory dominated by daisy bushes with a *Xyris / Iris* association fringing the marsh.

Group D differs from group C by the presence of significant proportions of the indicator species *Phyllocladus* 2% - 5%. This period represents the local onset of organic accumulation following the Last Glacial stage. The presence of a peak in *Phyllocladus* prior to the development of *Nothofagus* dominated rainforests is a well known trend in the development of western post-glacial forests (Colhoun and van de Geer; Hill *et al.*, 1988; Macphail, 1976,1979,1980,1986, 1988).

6.4.5 DCA analysis

The ordination of samples and species allowed a spectacular demonstration of vegetation changes. By joining stratigraphic levels (*sensu* Birks and Gordon,1985) an appreciation is gained of the direction of changes and their relative strengths. This is achievable because the position of samples along gradients in DCA space is directly related to the degree of similarity between samples. Thus, samples which fall far apart in Figure 6.8 are considered to be only remotely related in terms of pollen assemblage. Samples which fall close together are regarded as being more similar.

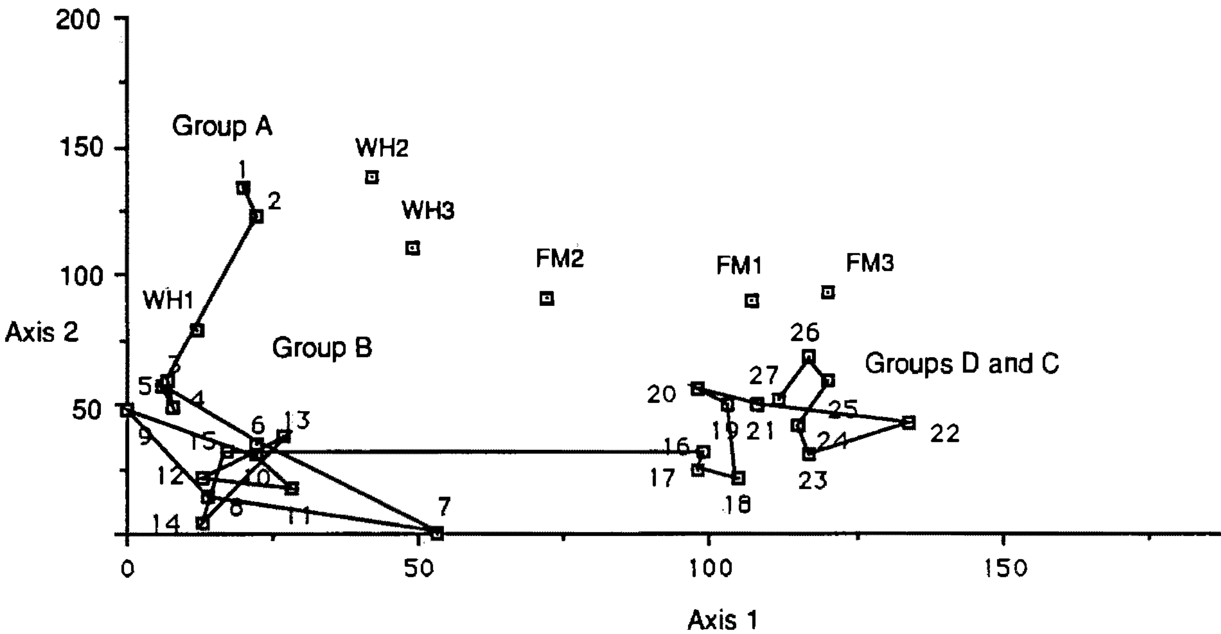


Figure 6.8. WH/3 core. DCA axis 1 versus axis 2. Core samples 1 - 27 (0 -101 cm), WH traps, FM traps and TWINSPAN groups A, B, C and D are shown. Solid lines join adjacent stratigraphic levels.

Axis 1 clearly spreads the samples into two major groups; the first contains groups A and B while the second contains groups C and D. This mimics exactly the first division of samples into *Allocasuarina* and *Eucalyptus* made by TWINSPAN (Figure 6.7). These results demonstrate that the major groups, and some of the sub-groups, recognized by TWINSPAN are identifiable in the ordination plots. Differences and partial overlaps are accounted for by the realistically continuous nature of the DCA ordination plots which tend to blur distinctions made by the strict classificatory nature of TWINSPAN (Stevenson, 1985).

The 1st axis separates the samples and sites into those which resemble the heathlands at Waterhouse Point and those which more closely resemble the dry sclerophyll forests at Forester Marsh. Species scores on Axis 1 (eigenvalue 0.205) follow a gradient which extends from*Eucalyptus* dominated communities to those dominated by*Allocasuarina*. The positions of the pollen traps indicate that axis 1 has indeed spread samples primarily on the basis of *Eucalyptus* and *Allocasuarina* This is to be expected in a data set which is dominated by high percentages of inversely related taxa.

The second axis (eigenvalue 0.102) fails to spread the majority of samples with any great distinction other than describing an important distinction between modern core samples (group A) and all others. Waterhouse pollen traps are more closely related to group A than to other groups.

Axis 2 species scores for local pollen taxa show that high values are attained by *Melaleuca squarrosa*, *Sprengelia incarnata* and Poaceae. These taxa are characteristic of the vegetation which today surrounds Waterhouse Marsh.

Species scores on the 2nd axis detects differences between modern marsh bank communities and fossil fringing communities. Samples 1 and 2 have high values for Poaceae derived from adjacent farmland. Similarly, high scores for *Melaleuca squarrosa* indicate the recent development of a dense shub thicket surrounding Waterhouse Marsh. In terms of changes through time, the second axis represents a broad change from marsh edges with open communities to those fringed by more shrubby communities. Because the upper two modern samples are differentiated from all other, the environmental gradient responsible must have acted over a very short period of time. The only factor which is likely to have acted so rapidly is fire.

Axis 1 of the ordination definitively separates groups A and B from C and D on the basis of dominance by *Allocasuarina* and *Eucalyptus*. Higher order axes detect gradients within the first major division. Axis 2 divides group B from group A so that major differences between modern and pre-modern samples are emphasised.

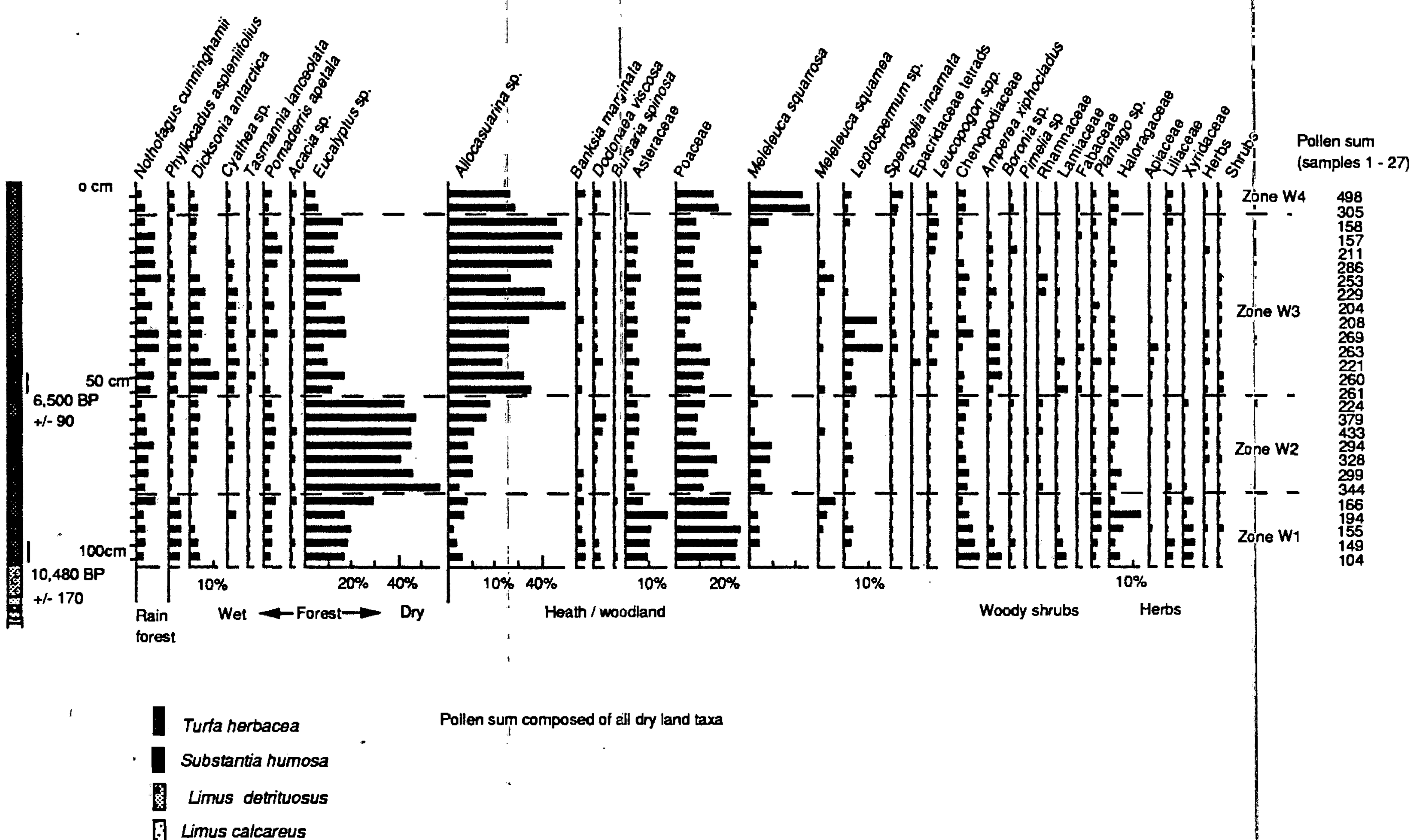


Figure 6.9. Waterhouse Marsh. Percentage pollen diagram, dry land taxa only.

6.4.6 Pollen analysis: dry land taxa

The conventional diagram (Figure 6.9) for the upper 100 cm of the Waterhouse Marsh core is characterised by occurrences of Casuarinaceae, *Eucalyptus* spp. and Poaceae. The relative percentages of these three taxa determine the major dominants in local and extra-local dry land vegetation communities. The discussion in Chapter 2 indicates the most likely pollen dispersal characteristics of these, as well as many minor taxa, in the modern pollen rain. The sediment accumulation rates adopted are those listed in Table 6.2.

The upper 53 cm is dominated by Casuarinaceae percentages in excess of 30%. The regional background percentage in northeastern Tasmania for this type is close to 5% and thus a major part of the actual representation must have a source in the vicinity of Waterhouse Marsh.

Likewise, *Eucalyptus* pollen dominates the diagram from 53 - 81 cm. Macphail (1976) and Dodson (1983) consider that *Eucalyptus* is a type with limited powers of dispersal offset by an obvious enormous source area. The regional representation of *Eucalyptus* pollen is estimated to be in the vicinity of 10%. The modern pollen results in Chapter 5 suggest that most *Eucalyptus* pollen will have a source within 5 km of a small enclosed basin.

The third major pollen type includes representatives of the Poaceae. This type achieves dominance in the lower 20 cm of core. Poaceae is usually regarded as a well dispersed type (Macphail, 1976; Dodson. 1983). The present study indicates that Poaceae best senses an area less than 1 km in radius. Regional percentages in eastern Tasmania are estimated to be 15%. Percentages greater than this are likely to be locally derived.

6.4.7 The pollen zones

The following discussion utilizes TWINSPAN groups A, B, C and D as derived from the weighted TWINSPAN analysis described above. The groups are similar to the concept of 'pollen zones' as devised by Godwin (1940). TWINSPAN groups are however, objectively calculated with no reference to other diagrams. The groups or 'zones' are therefore more similar to Cushing's (1967) and Birks' (1970. 1986) notion of 'pollen assemblage zones', which generally have local explanations based on site characteristics and pollen dispersal factors. Zones W4 to W1 are described in ascending order of depth from the base of the upper organic section of core. Paired percentages quoted below are means and standard deviations.

Zone W1. (samples 27 to 23; 101 - 81 cm)

This zone is characterised by high mean values for Poaceae (24.1%, 2.6%), Asteraceae (10.5%, 4.1%) and Chenopodiaceae (5.3%, 2.8%). Moderate values for *Eucalyptus* (19.3%, 5.1%) and low values for *Allocasuarina* (4.4%, 2.4%) together indicate a relatively open *Eucalyptus* association. This may represent either open woodland, scattered copses in a grassland or fringing trees surrounding the Marsh.

The values for Chenopodiaceae sit nicely with the evidence described in Section 6.4.1 which argues for the presence of brackish or saline conditions just prior to this time. Chenopodiaceae are known to be tolerant of salt rich environments (Curtis, 1967) and were probably locally abundant in the levels immediately prior to 10,500 BP. As climate changed from drier glacial to humid post-glacial (Macphail, 1979), at least some species from this widely dispersed family remained, probably as relict pockets on the margins of a ground water system which was transforming from salt to freshwater.

An interesting feature of this zone is the absence of *Sprengelia incarnata*, other Epacridaceae tetrads and *Leucopogon*. These taxa are common elements in the heath vegetation of coastal northeastern Tasmania. Low percentages of *Melaleuca squarrosa* (2.0%, 1.9%) and *Leptospermum lanigerum* (1.2%, 1.4%) probably indicate an open fringing wet heath or marsh edge community structure. In consideration of the postulated brackish conditions, an isolated peak in *Melaleuca squamea /gibbosa* type (2.1%, 2.7%) suggests that at this point the species involved was *M. gibbosa*, a species known to tolerate sandy and brackish conditions (J. B. Kirkpatrick, *pers comm*).

In terms of modern analogues the vegetation is similar to the open *E. viminalis* forest surrounding the Mt. Horror pollen traps, especially in regard to high Poaceae percentages. However, as discussed in Chapter 2, a substantial proportion of the grass pollen entering theForester Marsh traps comes from adjacent cleared farm lands and thus the true heathy nature of the Mount Horror forests is somewhat obscured.

Instead of a heathy understory, Poaceae predominated in a varied open forest composed of *Eucalyptus* (19.3%, 5.1%) and *Banksia* (2.1%, 0.9%) with a prominent contribution from members of the Asteraceae (10.5%, 4.1%). This mix seems very similar to a hypothetical Bassian community mooted by Hope and Kirkpatrick (1988:15). It is possible that the major eucalypt involved was the mainland snow gum, *E. pauciflora*, which today has disjunct lowland populations at Waterhouse Point (Hope and Kirkpatrick, 1988; Williams, 1989; see below). In Tasmania today, *E. pauciflora* is typically associated with *Themeda triandra* understories (Fensham, 1989; Williams, 1989).

Banksia may have existed as large trees rather than the as the dwarfed form commonly found today at Waterhouse Point. Also in the understorey were consistent but low level traces of *Bursaria spinosa* (0.3%, 0.5%) and *Acacia*.(0.4%, 0.6%) Representatives of the Lamiaceae (1.3%, 1.6%), possibly *Prostanthera, Westringia* or *Mentha* would have been found back from the edges of the freshening marsh. Enclosing the marsh were fringing communities of Xyridaceae (3.3%, 1.6%), Liliacaeae (1.2%, 1.2%) and Halagoraceae (4.8%,4.6%). Moderate values for *Amperea xiphoclada* (1.6%, 2.0%) at the base of the zone suggest that by this time the Bassian plain had sufficiently poor soil to promote the growth of this ubiquitous member of coastal heathland and forest communities.

At the regional level, interesting developments in the evolution of Holocene forests were occurring which seem to parallel changes observed in western and central Tasmania. In particular, W1 displays *Phyllocladus* (4.2%, 0.5%) achieving an early post-glacial dominance over *Nothofagus* (3.3%,2.2%) prior to a reversal in W2. In western Tasmania, the initial development of *Phyllocladus* rainforests *ca* 12,000 BP is generally seen as reflecting the initial expansion of forests into open herbfields and grasslands (Colhoun & van de Geer, 1986; Hill *et al.*, 1988; Macphail, 1976, 1980).

The ability of *Phyllocladus* to prosper on relatively infertile substrates is well known (Macphail, 1979, 1980; Barker, 1991). At present in the northeast, *Phyllocladus* is generally found on fertile upland sites (Ellis, 1985; Ellis & Thomas, 1988). Soils formed on the extensive shales and indurated mudstones of the Mathinna Beds (Mc Clenaghan *et al.*, 1982) are infertile, and may have provided post-glacial regeneration opportunities. However, under present conditions, *Phyllocladus* never achieves the dominance that it does on similar sites in western Tasmania. *Phyllocladus* is often dispersed by birds (Barker, 1991) and thus has the advantage of having a convenient vector into competition free environments.The initial pulse of *Phyllocladus* pollen in this zone is more likely to represent superior early dispersal characteristics into soils of all types. The levels which make up zone W1 represent roughly 1,660 years which is equal to two or three completed generations of *Phyllocladus.*

Cp/pollen ratios in W1 are the lowest in the entire sequence. Pollen free sediments below W1 contain infrequent counts of cp's. As soon as organic accumulation increases at the base of W1, ratios also increase. This could relate to a regional increase in the available fuel or an increase in ignition sources.

Zone W2: (samples 22 to 16, 81 - 53 cm)

This is the most distinct and unusual zone in the diagram. The chief characteristics of the zone are high values for *Eucalyptus* (45.7%, 5.6%). This is a remarkable finding, especially when considering the extremely well developed nature of the present day heaths at Waterhouse Point. The dating of the change from forest to heath, the community transitions and the explanations for the changeover have implications for fire ecology, Aboriginal history and the evolutionary history of heathlands.

The local and extra-local pollen indicate that *Eucalyptus* forest communities existed from about 9,000 years BP to 6,000 years BP. The development of the forest must relate to an expansion of which ever previous *Eucalyptus* association existed near to the marsh.

It is probable that various mixes of *E. viminalis, E. ovata, E. pauciflora* and *E. amygdalina* dominated the forests of W2. In association with the eucalypts were increasing percentages of *Allocasuarina* (10.2%, 4.4%) and the continual presence of *Acacia* (0.5%, 0.5%). As *Allocasuarina* increased, Poaceae decreased (11.9%, 3.0%). This is likely in situations which exhibit progressively decreasing soil fertility or with increasing canopy closure. The soils formed on last glacial and interglacial deposits in the northeast all display podsol profiles (Bowden, 1981,1983). The development of infertile soils and the formation of hard pans would have favoured the development of woody taxa which can tolerate the infertile and drought prone upper 25 cm of the soil profile. (Gimingham, 1972; Kirkpatrick, 1977b; Specht, 1979). The replacement of a grassy understory by *Allocasuarina* represents a first step in the transition from forest to heath.

The varied complement of minor species present in zone W1 survived into early zone W2. An interesting trend is the virtual absence of the once common *Amperea xiphoclada*. This could have occurred in response to lower light levels present under the forest conditions of zone W2.

Local fringing communities changed substantially with Xyridaceae and Liliaceae being replaced by *Melaleuca squarrosa* (4.5%, 3.3%) and *Leptospermum* (1.3%, 0.9%). The previously open margins of the marsh appears to have transformed into banks covered with myrtaceous shrubs.

The regional pollen suggests that conditions were generally more humid than those which prevail today. *Nothofagus cunninghamii* (3.3%, 2.2%) increases from the base of the zone, then continues at values twice as large as modern values, before gradually decreasing towards the top of the zone. *Phyllocladus* (0.8%, 0.5%) initially drops to very low levels but recovers slightly by 56 cm.

Pomaderris apetala (2.8%, 1.0%) retains consistent but fairly low levels similar to those in W1. A feature of Holocene pollen diagrams from western and southern Tasmania is an early to mid-Holocene peak in *Pomaderris* percentages (Hill *et al.*, 1988; Macphail, 1976,1979, 1983). In the northeast, this trend is not expressed as a distinct and extended peak. Rather, values are simply more consistent over the first 4,000 years of the Holocene than during the final 6,000 years.

Cp/pollen ratios increase during this phase until sample 17 at 60 - 61 cm, where a significant decrease occurs. This low is not correlated with any significant change in pollen percentages, with the exception of *Dodonea viscosa*, which reaches its highest values for any zone. Subsequently, ratios rise to peak values at 56 - 57 cm. *Dodonea* is a widespread minor species in dry sclerophyll forests (Williams, 1989) and can be eliminated if the fire frequency is greater than the period required to set seed, germinate and attain reproductive maturity. This cycle may take up to 10 years (Kirkpatrick, pers. comm). The frequency of fires immediately after the 60 cm to 61 cm level may therefore have been greater than one fire every 10 years.

Ratios from sample 16 (56 - 57 cm) show a small but significant peak which correlates with a final flourish by *Eucalyptus* and gains by *Melaleuca squarrosa*. It seems highly unlikely that such low ratios (compared to those from zones W4 and W3) can be solely responsible for the demise of a pyrophile such as *Eucalyptus*. It is possible however, that frequent cool fires could have acted to eliminate seedlings prior to reproductive maturity and thus contribute to a long term decline. *Melaleuca* can resprout after fire, as well as having the ability to set large amounts of seed. This dual strategy enables it to survive moderate fire frequencies and thus may have been favoured by an increase in frequencies.

Zone W2 represents about 2,300 years or somewhere between 6 and 10 undisturbed *Eucalyptus* generations. To place this in perspective, it is salutary to reflect that less than one fully completed eucalypt generation has elapsed since the European settlement of northeastern Tasmania in the 1830's and 40's (Loone, 1928).

Zone W3: (samples 15 to 3, 53 - 3 cm)

This zone contains more samples than any other. A date from the base of the zone (49 - 53 cm) returned 6,500 BP. This level marks the most significant change in relative pollen percentages for the entire core. The change is heralded by a dramatic fall in *Eucalyptus* (13.8%, 4.3%) as *Allocasuarina* attains maximum values (35.8%, 9.9%). The relationship between these two taxa has provided grist for the palaeo-ecological mill in Australia for the past two decades and continues to attract attention (Clark, 1983a, 1983b; Hooley *et al.*, 1980; Ladd, 1988; Macphail, 1981; Singh and Geissler, 1985).

Leaving aside this relationship for the moment, other trends are as follows. Poaceae percentages (8.8%, 3.0%) fall slowly, but differ little from those in the preceding zone. Similarly, Asteraceae (3.5%, 1.6%) maintains levels attained during zones W1 and W2.

Zone W4: (Samples 2 and 1: 3 - 0 cm)

This is the zone of European influence. In these two uppermost samples are contained all of the clearing, burning and replanting so evident in the northeastern landscape today.

The exotic taxa, *Pinus radiata, Rumex* spp., *Plantago lanceolata* and *Taraxacum* spp. are not found any deeper than 3 cm. It seems fair to assume that vertical pollen movement has not exceeded 3 cm during the past 160 years of European settlement.

The most obvious trends in these zone are substantial increases in Poaceae (16.5%, 1.7%), *Melaleuca squarrosa* (23,4%,1.8%) and *Sprengelia incarnata* (3.2%, 1.7%). Since settlement, large areas of natural heathland have been converted to pasture planted with exotic grasses. Increases in Poaceae pollen during this period are considered to result from this process (Kirkpatrick, 1977b).

At present, *Melaleuca squarrosa* and *Sprengelia incarnata* form dominant elements in the wet heath which fringes the marsh. Both of these species have limited powers of dispersal and significant increases can be attributed to much enlarged local populations. These increases seem to be correlated with peak values in cp/pollen ratios between 5 - 2 cm and seem a plausible response to high fire frequencies from 1860 to the present (Jennings, 1983).

Eucalyptus (4.4%, 0.8%) percentages fall, as do *Allocasuarina* (26.4%,1.6%). These falls may owe more to the effects of the relative percentage method than real ecological trends. Despite this, some part of the reduction probably relates to land clearences in which forests and woodlands were removed.

Also interesting are rises in Liliaceae (2.0%, 0.6%), *Banksia* (1.3%, 1.8%) and Haloragaceae (3.1%, 0.4%). The Liliaceae component seems likely to be *Xanthorrhoea* spp. Species of this genus are noted pyrophiles and form conspicuous elements in the present day heaths. *Banksia marginata,* like *Allocasuarina* and *Xanthorrhoea* spp.are dwarfed under todays conditions and all three seem to benefit from frequent firing. In this study, Haloragaceae (excluding *Myriophyllum*) is undifferentiated. *Gonocarpus tetragynus* is likely to be well represented as it is today the most common family member at Waterhouse. This species has the ability to colonize bare ground following fire.

The regional wet forest pollen types all have lower values than in zone W3. Once again, the across the board response may be in part the result of large percentage increases in *M. squarrosa* and Poaceae. None the less, it is certain that contractions in the ranges of these taxa have occurred since 1830. The clearing of massive areas of wet forests from near Mt. Horror and the basalt country around Ringarooma and Scottsdale would have resulted in declines in *Nothofagus*, *Phyllocladus*, *Dicksonia*, *Cyathea* and *Pomaderris* pollen. Such widespread losses cannot be easily distinguished from any trend towards drier climates.

6.4.8 Leedway Lagoon: an early phase of forest development?

Four peat samples taken from between 43 - 30 cm at Leedway Lagoon show pollen spectra very similar to those described for Waterhouse Marsh zone W2 (Figure 6.10). Basal dates taken from peat (*Detritus herbosus*) directly over clean, white sand, returned a date of 12,500 years BP (Table 6.1).

Unfortunately, the upper 30 cm of the profile had been totally removed for drainage purposes. What peat remains shows that forests were established in parts of inland northern Tasmania by 12,500 BP, some 3,000 years before similar forests were established at Waterhouse Point, a short distance away to the north.

Two scenarios are possible at this point :

1) Forests and woodlands had existed in the northeast and perhaps across the Bassian Plain throughout the Last Glacial. Places such as Waterhouse Marsh and Leedway Lagoon were groundwater windows that opened when water availability were raised to critical levels. Dates for the onset of forest development represent the crossing of local temperature and moisture threshholds which allowed the accumulation of organic deposits.

2) The early date for forest development at Leedway Lagoon represents the intersection of an advancing front of forests, perhaps invading from the protected hills to the south.

On the high plateau of Ben Lomond; an area which is considered to be relatively dry, considering its altitude (815 m), pollen analysis has shown the maintainence of a *Eucalyptus* forest since at least 10,000 BP (Caine, 1983; Noble, 1981). This interpretation differs somewhat from Macphail's (1979) prediction that in eastern Tasmania, forests did not expand until after 9,500 BP and continued with little change until the present. Noble (1981) considered that the presence of full forest conditions at an altitude of 815 m at 10,000 years BP, indicates that forests are likely to have existed for a considerable time prior to 1that date. The evidence from Leedway and Waterhouse support Nobles contention.

6.4.9 The development of heathlands

Banksia (0.6%, 0.7%) and *Dodonea* (0.7%, 0.9%) remain as consistent but lesser elements in the understory. The most significant trend in minor species is the development of a community mix which closely resembles the heathlands present in the

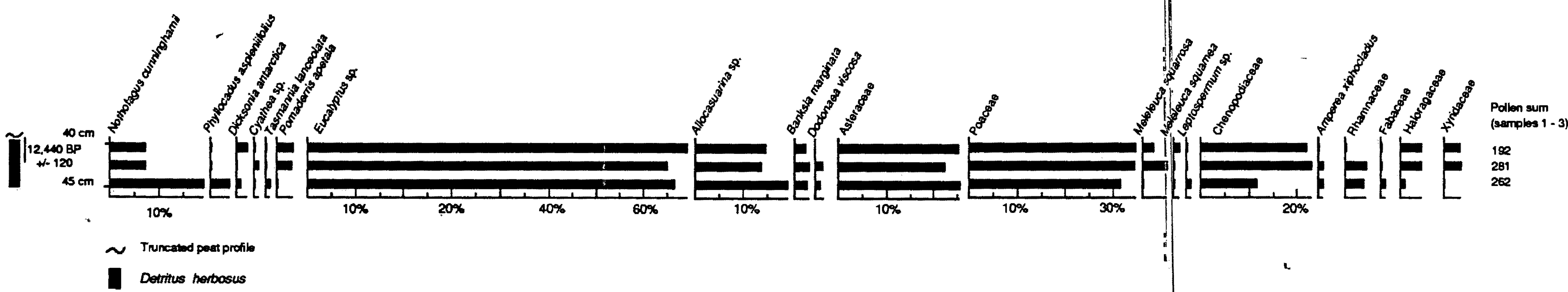


Figure 6.10. Leedway Lagoon. Percentage pollen analysis, dry land taxa only.

northeast today. Important in this regard is the first significant appearance of an Epacridaceae complex consisting of *Leucopogon* (1.3%, 1.5%), undifferentiated Epacridaceae tetrads (0.3%, 0.8%) and *Sprengelia incarnata* (0.8%, 0.6%). Both *Sprengelia* and *Epacris lanuginosa* are prominent components of the wet heath communities which today fringe Waterhouse Marsh. *Leucopogon* pollen is likely to represent a mix of *Leucopogon virgatus*, *L. collinus* and perhaps *L. ericoides*; all three of which favour open locations, tending towards and including the drier heath communities. Another prominent epacrid in most northeastern heaths is *Epacris impressa* (Kirkpatrick, 1977b). This species is found in dry heaths, commonly in association with *Leucopogon* spp.

The development of heath complexes is also suggested by consistent traces of Fabaceae pollen (0.6%, 0.6%). The pea flowers are a feature of northeastern heaths and open forests, and although not satisfactorily discriminated to high taxonomic status, the pollen most probably represents members of the genera, *Bossiaea*, *Aotus*, *Platylobium*, *Kennedia*, *Pultenaea* and *Dillwynia*. These genera are widely dispersed throughout heaths and open forests in southeastern Australia (Specht, 1979) and Tasmania (Kirkpatrick, 1977b; Kirkpatrick *et al.*, 1988)). The very poor pollen dispersal characteristics of the Fabaceae and Epacridaceae suggests that even minimal representation of these taxon may be significant for local vegetation reconstructions.

At the base of W3, *Leptospermum* (3.4%, 5.1%) continues the low level presence established in W2 but then dramatically increases at 41 cm. Two marked peaks of *Leptospermum scoparium* type pollen occur at 32 - 33 cm (13%) and 40 - 41 cm (15.6%). Neither of these peaks is associated with significant changes in other taxa. Nor is there any suggestion that peaks in cp/pollen ratios are directly involved, although rises in the ratios are apparent.

Melaleuca squarrosa pollen (1.6%, 2.3%) is less apparent than in preceding zones. A small but significant peak is attained by *M. squamea/ M. gibbosa* type (1.1%, 1.6%) between 16 - 25 cm. *M. gibbosa* is found today on wetter sites than *M. squarrosa* while *M. squamea* usually occurs on more acid sites (*pers. comm.* J. B. Kirkpatrick). The same period is marked by an unexplained lowering of *Allocasuarina* and a rise in *Eucalyptus* values.

6.4.10 Climate changes at Waterhouse Point

The regional pollen show certain percentage characteristics which run counter to trends established in southern and western Tasmania (Colhoun, 1985b; Colhoun and van de Geer, 1986; Macphail, 1976,1979,1980, 1983, 1986, 1988; Macphail and Jackson, 1978). Those works demonstrate a clear trend from warm humid conditions to cooler drier climates between about 12,000 BP and 5,000 BP. The transition is exemplified by high values for *Nothofagus* followed by irregular reductions after 5,000 BP. A sustained peak in *Pomaderris apetala* pollen from approximately 10,000 BP to 5,000 BP is regarded as marking a southeast Australian climatic optimum. Macphail (1980:186) advanced the notion of an early temperate humid phase culminating: "well before the middle Holocene", and a subsequent late temperate drying phase beginning: "in the middle Holocene and continuing up to the present, in which many forests became more open in structure".

An examination of *Nothofagus* pollen (6.0%, 2.3%) from WH/3 indicates a much later phase of rainforest development, beginning just prior to 6,350 BP and tailing off in the very late Holocene. This unexpectedly late period of rainforest development is initially characterised by increases in *Phyllocladus* (2.0%, 1.6%), *Cyathea* (2.2%, 1.3%) and *Dicksonia* (4.6%, 3.0%). Wet forest understories as deduced from percentages of *Pomaderris apetala* (as distinct from other Rhamnaceae pollen) do not display the climatic optimum of Macphail and others. Instead, values are somewhat irregular with a pronounced late peak between 8 - 17 cm or about 984 BP to 210 BP. *Tasmannia lanceolata* (0.4%, 0.8%), a shrub characteristic of high altitude rainforests in the northeast, makes its only appearance in zone W3.

Nothofagus, usually considered a super regionally dispersed taxa, actually displays characteristics which indicate a fairly rapid drop off in deposition rates over distances greater than about 5 km (see Chapters 5 and 7). Similarly, *Pomaderris apetala* pollen is usually thought to be reliable for statewide generalizations, yet the Holocene *Pomaderris* curve from Waterhouse is not consistent with curves from other parts of Tasmania. From this it can be hypothesised that the data considered by Macphail and others is only truly reliable for western and southern Tasmania. All pollen sites in those regions have a large source area of wet forest on which to draw supplies of pollen. In contrast, Waterhouse Point is sufficiently far removed from the large western reservoirs of wet forests to be more influenced by local developments in both vegetation and climate.

With this in mind, the opening of Bass Strait and the stabilizing of Holocene sea levels can be considered as important to the development of northeastern forests as the west to east precipitation gradient that crosses Tasmania. The Waterhouse data show that from just prior to the time of sea-level stabilization, the development of rain forests increased until the end of zone W3. While it is true to say that the western sequence is still apparent in this diagram, especially in the early development of *Phyllocladus*, it is stressed that local trends overlie the statewide picture.

The full development of atmospheric conditions suitable to convey moist northwesterly and northeasterly winds to the rain catching peaks of inland northeastern Tasmania could not develop until the final sundering of the Bassian Plain. Prior to the rise of Bass

Strait, westerly winds would have been subject to the dessicating continental effects of Bass Plain. The instigation of a consistently moist wind regime, not long before 6,350 years BP, provided the mechanism which allowed the full and late development of rain forests in the hinterlands and mountains of the northeast.

In Macphail's terms, there is some evidence in the regional wet forest pollen for an early temperate phase in which a *Phyllocladus* dominated forest preceded the development of *Nothofagus* rainforest. There is however, little to suggest in the Waterhouse sequence that rainforests in the northeast gradually opened in structure due the combined effects of drying climates and developing soil infertility. To the contrary, wet forests in the northeast were late developers, culminating in their maximum development during the middle to late Holocene.

Ironically, an examination of the pollen likely to have had its source within 10 km of Waterhouse Marsh seems to provide more agreement with Macphail's climate model than the regional pollen. During the late Pleistocene, the development of wet forests in eastern Tasmania has probably always centered on places with a combination of fertile soil and high rainfall (Noble, 1981, 1986). In the sandy coastal locations of the northeast, no local topographic features exist which might deflect rain bearing winds. Such places remained subject to the droughting effects of a statewide west to east precipitation gradient and did not have either the water catching or water holding capabilities of the hinterland.

A timely review of the Casuarinaceae (Ladd, 1988) points out that most species of *Allocasuarina* are unusually well adapted to drought stress, having distinct xeromorphic characters. This generalization is supported in Tasmania where *Allocasuarina verticillata* is known to be highly drought resistant (Withers & Ashton,1977, cited in Hope & Kirkpatrick, 1988: 12). Explicit in Ladd's argument is that for many areas, high *Allocasuarina* pollen values may indicate times of dry climate, while abundant *Eucalyptus* pollen may point to wetter conditions. It would not be surprising if putative drying climates from the mid-Holocene to the present favoured drought tolerant species of *Allocasuarina* over *Eucalyptus* on sites which failed to intercept moist rain bearing winds.

Acting with climate change were declines in soil fertility and increases in waterlogging as podsolization progressed (Bowden, 1981,1983). The gradual replacement of Poaceae by *Allocasuarina* in the forests of zone W2 is evidence of a trend towards the development of understorey heaths. Heaths are generally accepted to be co-agents with rainfall and drainage in affecting rates of podsolization. Thus, the development of heaths actually tends to change soil character in a direction which favours heaths. Groves (1981) notes that most Australian heaths occur on sandy, podsolized soils which are chiefly deficient in phosphorus and nitrogen. The xeromorphic traits displayed by *Allocasuarina* (Ladd, 1988) are considered by Beadle (1966,1968) to represent primary adaptations to soils of low fertility. In general, *Allocasuarina* seems well placed to cope with drought and infertility, including stresses imposed by saline groundwater supplies.

6.4.11 Sea level rise as an agent for vegetation change

More significant than climate change may have been the indirect effects of Bass Strait stabilizing at its current position at the same time as the species turnover occurred . That postglacial sealevels achieved a general world wide stability sometime about 6,000 years BP to 6,500 years BP is well accepted (Chappell, 1990; Chappell and Shackleton, 1986; Chappell and Thom, 1977; Shackleton and Opdyke, 1973; Thom and Roy, 1985).

Kirkpatrick (1977b), Parsons (1981) and Parsons and Gill (1968) have detailed some of the effects of salt spray on coastal vegetation of southern Australia. Much of their work was inspired by the classic paper on the subject by Boyce (1954) who demonstrated the effects of salt spray on coastal vegetation communities in eastern United States.

Boyce considered that mechanical abrasion of tissue and the uptake of chloride ions combined to promote typical coastal community forms and mixes. He noted that the orientation of beaches to prevailing winds was a determinant in spray effects. This is important on the north coast of Tasmania where all the major heathlands are on broad peninsulas, exposed to strong salt bearing northwesterly winds.

Parsons and Gill (1968: 7), examined coastal heaths on granite soils at Wilsons Promontory in Victoria and concluded that whereas *Allocasuarina verticillata* had adaptations to cope with salt spray, *Eucalyptus* in exposed positions always showed asymmetry of form and higher leaf salt levels than plants in protected locations. They go on to report that "It appears that the eucalypts occurring adjacent to the study area --- are intolerant of salt spray, and that this factor excludes them from exposed coastal locations' (Parsons and Gill, 1968: 8).

In a review of the status of heathlands in Tasmania, Kirkpatrick (1977b) recognized the role that salt spray effects have on heathland vegetation, while Parsons (1981) emphasised the potentially crucial role that salt spray has in the exclusion of trees from heaths, and pointed to isolated severe storms as having major effects on community composition. Kirkpatrick and Wells (1987) have shown that trees on exposed plains in northeastern Tasmania are subject to considerable stress occasioned by salt laden winds. The peninsular shape of Waterhouse Point and other heath bearing points on the northern coast ensures that most low heaths exist within 5 km of a coastline (see Figure 4.1).

In spite of general agreement that salt spray excludes *Eucalyptus* from most coastal heaths, little attention has been paid to the possibility that spray effects may be implicated in the formation of coastal heaths; yet this seems plausible, especially in combination with other environmental factors.

Parsons (1981: 226) notes that there is a rapid fall of salt spray concentrations after about 0.5 km and that little further difference can thereafter be detected between 3km and 10 km. The heaths at Waterhouse Point are exposed to strong winds with a very large fetch (Bowden, 1981). Although no data are available, it is likely that the salt carrying capacity of winds across Waterhouse Point may be greater than that anticipated by Parsons. Even so, it is probable that salt spray only became an effective agent of vegetation change at Waterhouse Point in the final phase of sea-level rise when the coastline approached its modern configuration.

From this, it seems likely that increases in the salt content of winds at the time of sea level stabilization can be implicated to some degree in the decline of *Eucalyptus*. At this point, the additional factor of burning needs to be introduced as the final element in a complex of pedogenic, climatic, oceanic and pyrogenic factors which combined to remove *Eucalyptus* forests from the Waterhouse Point area.

6.4.12 Burning as an agent for vegetation change

The problems of interpreting carbonized particles have been discussed by Clark, J. (1988) and Clark, R. (1983b). Although Swain (1973, 1978) and Green (1983) have shown that fine resolution pollen records are admirably suited to cp analyses, this is cold comfort when confronted with cores such as the one from Waterhouse where 1 cm samples may represent up to 120 years at 360 year sample intervals. Further problems are evident in Tasmania where a lack of detailed observations concerning the longterm effects of fire on plant community organization is particularly evident (Bowman and Brown, 1986). Fire behaviour is better understood in more humid environments than in dry locations (Brown & Podger, 1982a; Ellis & Thomas, 1988; Jackson, 1966, 1968, 1973; Mount, 1979; Podger *et al.*, 1988), but even here, basic experimental field work has not yet produced a corpus of data from which fire intensities and frequencies can be reliably deduced from community composition.

On this basis, the cp/pollen ratio curve from Waterhouse must be interpreted with caution. Until future research provides a basis for discriminating between forest, heathland and marsh fires, little can be said with certainty except in the most general of terms.

Cp/pollen ratios in zone W2 do not vary much from level to level with the notable exception of sample 17. Low ratios in sample 17 during a phase of full forest probably reflects either a fire free period or a phase of cool burning which did not produce great numbers of cp's. Higher ratios in sample 16 are interpreted as reflecting either high intensity fires with a low frequency, or a very high frequency of low intensity fires. Either regime could produce large quantities of cp's. At the present state of knowledge it is impossible to discriminate between the two on the basis of cp type or frequency (Clark, 1983b).

Zone W2 has very high *Eucalyptus* percentages and is regarded as representing a dry open forest. The lack of response by *Eucalyptus* pollen to fluctuating cp values between 56 - 65 cm indicates that the forest displayed a marked degree of resiliance to changes in fire regimes. This is not unexpected considering the pyrophilic nature of most species of *Eucalyptus*.

In spite of the close relationship between eucalypts and fire, it is possible for fire to have eliminated *Eucalyptus* from the vicinity of Waterhouse Marsh. Forests can easily survive frequent firing, at low intensities and might exist for as long as 400 years (Jackson, 1968; Kirkpatrick, 1989). Survival beyond that age would depend on the availability of regeneration niches for seedlings. Infrequent, high intensity fires provide bare ground and ash beds suitable for the growth of seedlings to reproductive maturity. If on the other hand, fire frequencies are less than the period required for *Eucalyptus* to produce seed then it could be eliminated in less than 400 years. Indeed, Kirkpatrick (1989) has documented the replacement of a *Eucalyptus* forest by *Allocasuarina* after a single wild fire 25 years previously.

Observations in the northeast suggest that in areas subjected to frequent fires, *Eucalyptus* can be eliminated and replaced by sedgy heaths or *Allocasuarina* woodlands. This process is observable on the margins of the Freycinet National Park, at Musselroe Bay in the far northeast and on the flanks of Mt. Cameron to the east of Waterhouse Point. In places, copses of eucalypts grow where knolls of underlying dolerite or granite manage to protrude through overlying Quaternary sands. Such places appear to be buffered from the effects of fire by the availability of rocky fire protected niches and the availability of fertile soils. Few such places exist on the infertile sand plains which surround Waterhouse Marsh.

Ladd (1988) considers that many species of *Allocasuarina* are fire resistant. Into this category falls the entire Tasmanian suite of *A. verticillata, A. monilifera, A. paludosa* and *A. littoralis*. In the northeast, *A. monilifera* is dominant in heaths surrounding Waterhouse Marsh and copes well with high fire frequencies by resprouting (Plate 2). *A. paludosa* is a localized species which grows in situations which are subjected to less frequent but more intense fires than those experienced on the heathlands (*pers obs*). Kirkpatrick (1986) notes that *A. verticillata* is favoured by low intensity burns which act to reduce eucalypt growth. *A. littoralis* is a common understorey species on dry, moderately fertile hill slopes. These places are usually subject to low intensity burns (Kirkpatrick, 1981, Kirkpatrick & Marks, 1986; Duncan & Brown, 1985).

In places where fire intensity is too great, *Allocasuarina* populations may be substantially reduced. Hill slopes are especially prone to intense burns and in such places *Allocasuarina* may be restricted to locally protected rocky or damp locations.

Cool burns have two major characteristics. The first is that fire progress is often impeded by moisture and density variations which results in patch burns (Plate 2). This allows the rapid recolonization of burnt areas by species which were present prior to the fire. The second point is that the regime will tend to favour plants which can resprout and recover vegetatively (Gill & Groves, 1981: 69). *Allocasuarina* is known to be able to resprout in post-fire conditions (Gill & Groves, 1981; Kirkpatrick, 1981). Gill & Groves (1981) suggest that *Allocasuarina* can become dominant in southeastern Australian heaths in the five or six years following fire. *Allocasuarina* has the ability to store seed in its canopy as well as resprout after fire (Gill and Groves,1981: 75); this dualism gives it a wonderful ability to cope with either frequent cool burns or infrequent hot burns.

A. monilifera is a prominent understorey member in contemporary northern dry forests and coastal heaths. It is likely that the species was present as a sub-dominant in forests at Waterhouse before 6,350 years BP, and as a dominant in heaths after that date. As *Eucalyptus* forests disapeared, *A. monilifera* managed to survive the combined effects of salt spray, increased burning and developing soil infertility. The continued success of *Allocasuarina* at Waterhouse Point rests on its ability to alter form and habit to cope with environmental changes acting through both short (fire, salinity) and long (soil, climate) time scales.

In contrast to the Atlantic dwarf-shrub heaths of western Europe (Behre, 1988), no clear, single indication of unaided anthropogenic origins can be ascribed to the heaths of northeastern Tasmania. Although fire is implicated in the maintainence of European heaths, a more important causal factor was the wholescale deforestation by agricultural societies (Gimingham, 1972). However, burning by Aborigines was probably an important causal element and a major maintainence factor for the heathlands of the northeast.

A crucial fact is that the dates obtained from the Ainslie Sands also define a period of Aboriginal site formation. Massive numbers of artefacts are eroding from exposed A horizons which have been dated to about 6,000 years BP. The location of Aboriginal campsites on the fringes of Waterhouse Marsh would have provided many opportunities for fire lighting.

That the species turnover was so complete (at Waterhouse Point at least) can be ascribed to the intersection of an entirely natural combination of soil infertility and salt spray, with a potentially lethal (for forests) cultural practice. Many other parts of Tasmania have *Eucalyptus* forests which extend almost down to the littoral zone, but those places are generally in protected locations with good soil and with a rainfall high enough to wash excess salt off green tissue. It is not coincidental that the most expansive and well developed coastal heathlands are on deep infertile sands in locations exposed to salt laden winds (see maps in Kirkpatrick, 1977b).

6.4.13 Pollen analysis: aquatic taxa

This analysis (Figures 6.11 - 6.18) helps to clarify trends apparent in the local dryland pollen. Water availability is likely to be a key variable in terms of the composition and abundance of vegetation communities in the northeast. This is because the west to east gradient which controls precipitation today is thought to have been equally, if not more effective in the past (Colhoun, 1975,1978; Macphail, 1979; Bowden, 1981). As conditions ameliorated following the Last Glacial maximum, small closed depressions with floors just above the water table would have transformed into mires in response to increased precipitation. Local water table characteristics would have determined water depth and rate of rise. Subsequently, during the late Holocene, drying or variable climates (Macphail, 1979) would have reversed this process to some extent, resulting in progressive moisture loss.

Although general agreement is achieved between the dryland and aquatic diagrams, some changes are not synchronous. This can be attributed to the sensitivity of aquatic plants to changes in hydrological cycles (Briggs, 1981). Zones derived from dry land taxa are not expected to be exactly commensurate with changes in aquatic taxa.

Rising water tables caused by post-glacial sea level rises, might also have radically transformed seasonally innundated wetlands into deeper free water communities, with only inconsequential re-alignments of dry land community boundaries. This is especially so in places which were protected from westerly winds and which are underlain by deep dolerite, granite or alluvial soils. Such places might be expected to display a degree of resilience to change (Holling, 1973; Gigon, 1983) and may have allowed woodland or even forest communities to survive arid glacial conditions. River valleys and depressions on the east coast of Tasmania offer examples of places which were below the tree line during the Last Glacial and which are buffered against environmental change.

In contrast, Waterhouse Point, with its mobile and infertile sands, seems less well buffered against change. Consequently, major changes are seen in both the dryland and aquatic complements. Such site specific characteristics present few problems for studies such as this, where the primary interest is in dryland changes. For this purpose, aquatic taxa provide important highly localized ancillary information, and in this case at least, are not considered for the purposes of boundary definition.

Aquatic zone W1

This zone is dominated to a large extent by *Myriophyllum* spp. (36.1%, 25.0%). The large standard deviation points to a large variation in abundances from level to level with percentages varying from 3.7% at 100 cm to 65.2% at 84 cm. *Typha* is present in low levels (0.4%, 0.9%) while *Triglochin* is absent. Cyperaceae (3.7%, 2.3%) values are low enough to suggest either a fringing or scattered presence. Likewise, Restionaceae (4.7%, 2.5%) has percentages which do not suggest more than a minor presence in the local vegetation.

Myriophyllum has quite low basal values but these rapidly increase to a peak of 65% at 84 - 85 cm, before diminishing to 4.2% at 21 - 22 cm. It should be remembered that in the 10 cm of sediment immediately below 101 cm, gives good evidence to demonstrate the existence of a saline mud flat in which *Ruppia megacarpa* grew. The brackish / saline conditions preferred by *Ruppia*, and the gastropod *Coxiella*, may have persisted into zone W1.

M. salsugineum is known to be tolerant of shallow saline waters. Based on present day distributions, water depth probably did not exceed 50 cm (*pers obs*). The community may have been seasonally inundated but as *Ruppia* communities are today, more often than not, correlated with permanent water (Kirkpatrick and Harwood, 1983), this may also have been the case in the past. *Myriophyllum* dominated communities are regarded by Kirkpatrick and Harwood (1983) as having low to moderate species richness.

Gleichenia spp. (0.9%, 0.9%) is absent from 100 - 96 cm. After this, *Gleichenia* is present until the end of the zone when abundance levels drop to trace levels. Other undifferentiated pteridophyte spores are completely absent from the zone.

The lack of *Triglochin*, and low levels for *Typha* and Cyperaceae suggest a simple level of community organization in which *Myriophyllum* achieved prominence. Emergent rushes and sedges were absent from the center of the marsh and were probably confined to damp edges. Low percentages for emergent rushes, a peak in *Potomageton*, and the dominance of *Myriophyllum*, suggest that this community was similar to the present day 'Shallow brackish Aquatic Marsh' (Kirkpatrick and Tyler, 1988) with 'Aquatic Herbland' (Kirkpatrick and Harwood, 1983) or the 'Floating and Floating Leaved Herbfield' defined by Briggs (1981).

Aquatic zone W2

The transition from zones W1 to W2 is marked by a dramatic decline in *Myriophyllum* (6.2%, 3.8%) and gains by *Nymphoides* type (0.9%, 0.6%). Most other taxa show little change from zone W1. Restionaceae values (1.4%, 1.2%) drop overall as Cyperaceae

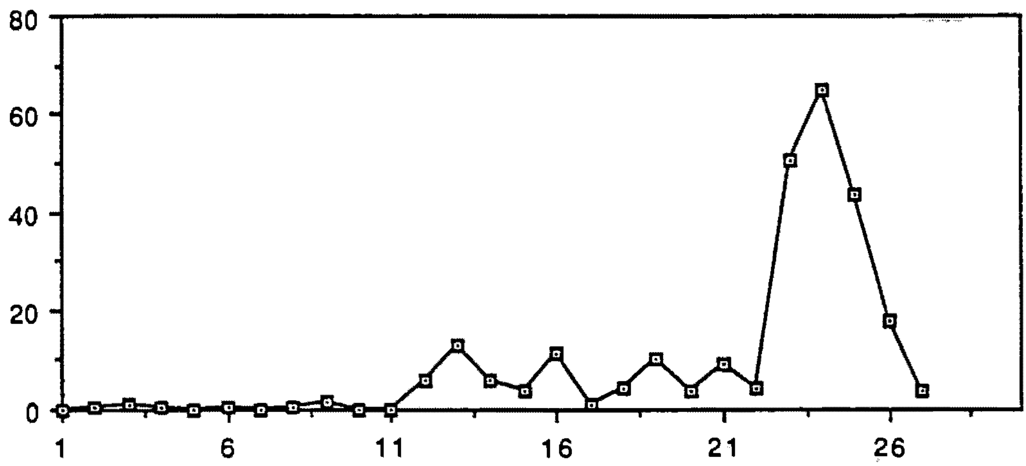


Figure 6.11. WH/3 core. Percent *Myriophyllum* pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

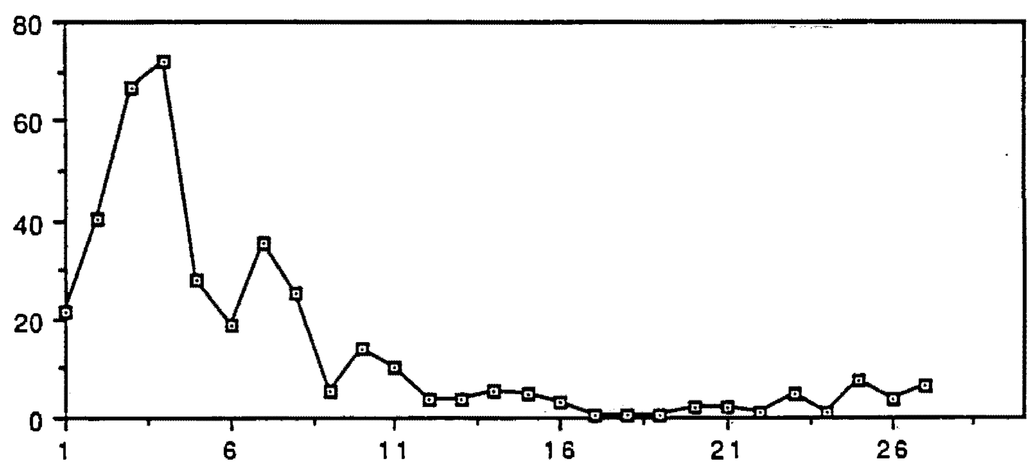


Figure 6.12. WH/3 core. Percent Restionaceae pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

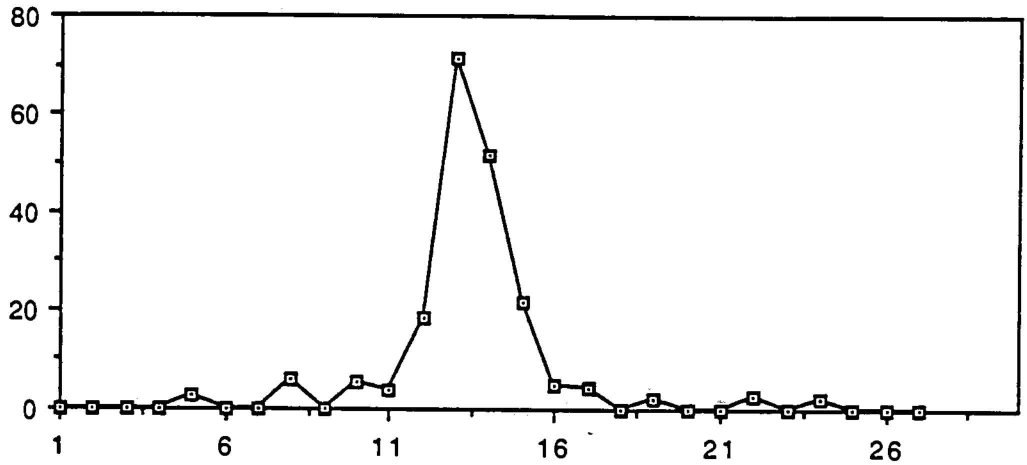


Figure 6.13. WH/3 core. Percent *Typha* pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

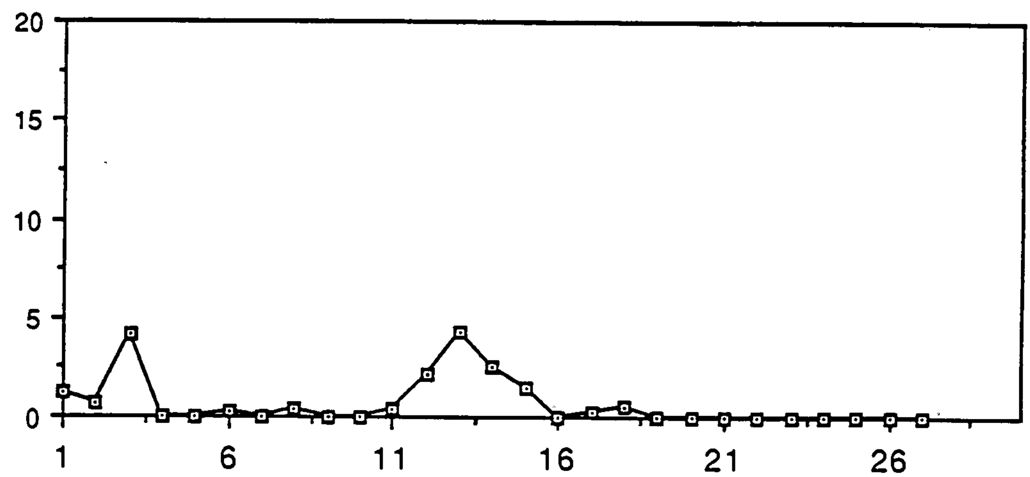


Figure 6.14. WH/3 core. Percent *Triglochin* pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

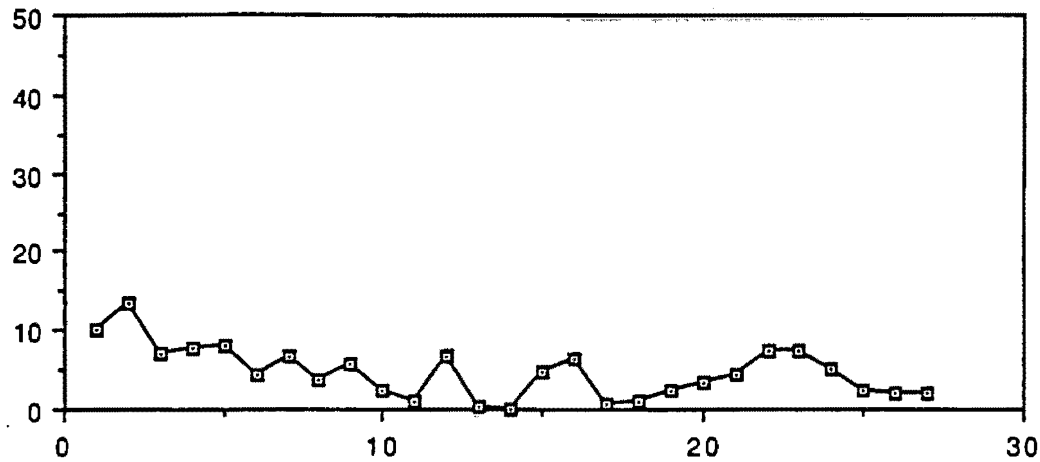


Figure 6.15. WH/3 core. Percent Cyperaceae pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

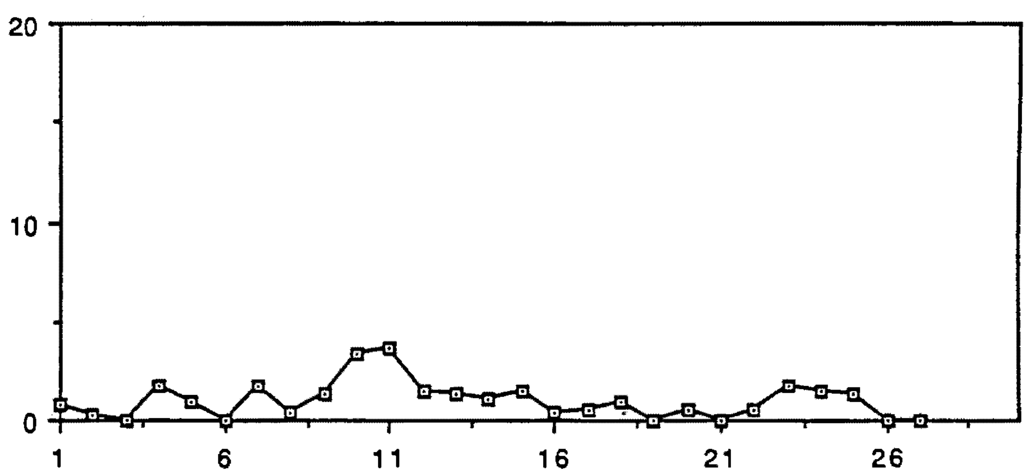


Figure 6.16. WH/3 core. Percent *Gleichenia* spores (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

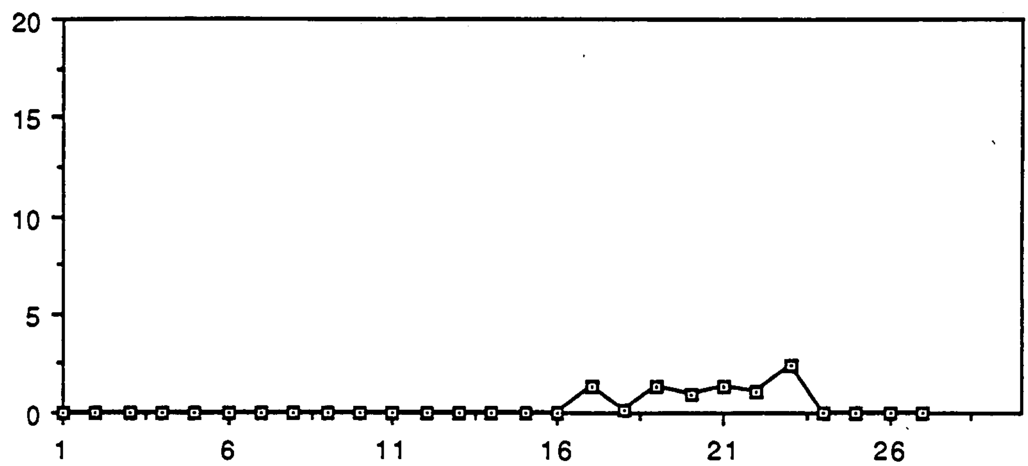


Figure 6.17. WH/3 core. percent Nymphoideae pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

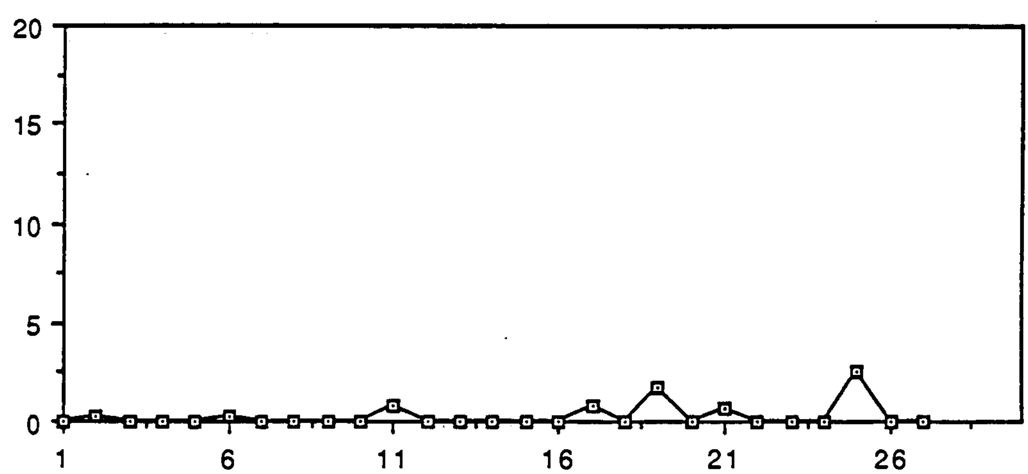


Figure 6.18. WH/3 core. Percent *Villarsia* pollen (y axis).
Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm to 101 cm.

percentages rise. *Typha* (0.4%, 0.9%) varies somewhat, but appear to stabilize by the end of the zone.

Gleichenia (0.4%, 0.3%) drops to less than 1% and never achieves a significant presence again until the first level of zone W3. Undifferentiated pteridophytes (1.5%, 0.8%) make some gains, which suggests that opportunities for ferns increased during the forested phase.

Changes in the zone reflect the forested environment suggested by the dry land analysis. This is supported by the behaviour of *Gleichenia*, and Restionaceae. The coral fern, *Gleichenia microphylla*, is today found in great abundance on the open treeless margins of Waterhouse Marsh. This habit is commonly observed throughout northeastern Tasmania and seems to indicate a preference for high light levels (Duncan & Isaac, 1986). During the forest phase of W2, light levels may have been generally lower with a consequent reduction in the abundance of *Gleichenia*. Present day spore counts are artificially suppressed by the development of fringing wet heath communities which restrict the passage of minor spores and pollen into the marsh.

A similar drop can be observed for Restionaceae pollen. This family has a wide range of habitat preferences. Today in the northeast, members of the Restionaceae are more commonly found as bog and wet heath elements than as semi-aquatics. The decline in values during a full forest phase might be related to lower light levels and a lack of open bank spaces.

Significantly, *Nymphoides* type pollen is confined to zone W2, which suggests that the marsh possessed some quality during its forested phase which favoured the the water lily. Two species of *Nymphoides* are extant in Tasmania, *viz N. crenata* and *N. exigua*(Curtis, 1967). The former is now possibly extinct while the latter is found from alpine ponds to coastal salt marshes (Curtis, 1967; J. B. Kirkpatrick, *pers comm*). The occurrence of *Nymphoides* type pollen suggests that shallow water conditions occurred at this time.

The demise of *Nymphoides* type pollen at the end of zone W2 may be explained by a combination of progressive increases in water depth and freshness and a rapid rise to astronomically high levels in percentages of *Typha* spp. pollen. The domination of the water surface by *Typha*and *Triglochin* would have restricted opportunities for *Nymphoides*.

The increased importance of Cyperaceae, the continuing presence of *Myriophyllum* and the restriction of *Nymphoides* type to W2 indicate a community similar to Kirkpatrick and Tyler's (1988) 'Shallow Freshwater Herb Marsh' or 'Shallow Brackish Herb Marsh'.

Aquatic zone W3

The characteristic pollen types are Restionaceae (22.6%, 23.16%) and *Typha* spp. (13.9%, 22.6%) The standard deviations exhibited by these taxa in W3 indicate large variations in pollen abundances. Restionaceae has a maximum value of 71.9% at 12- 13 cm and near to zero percentages at the base of the zone. *Typha* has a maximum of 71.3% at 44 - 45 cm and a minimum of zero at a number of levels.

Cyperaceae (4.5%, 2.7%) are somewhat inconsistent, but tend to rise a little during this long period. *Triglochin* (1.2%, 1.6%) has a pronounced peak between 40 - 53 cm. *Myriophyllum* (2.6%, 3.8%) continues to diminish in importance while *Villarsia* (0.08%, 0.2%) and *Potomageton* (0.4%, 0.5%) show little more than trace values while *Nymphoides* drops out altogether.

Undifferentiated small pteridophytes (3.3%, 2.1%) attain higher percentages during this zone than at any other time. Two peaks are exhibited, the first being a sustained rise from 36 - 53 cm, while the second is a less sustained rise centered on 4 - 5 cm. These trends are roughly similar to peaks recorded for the large tree fern, *Dicksonia antarctica* and suggest that the fortunes of monolete and trilete spores are tied to regional wet forest histories.

Gleichenia (1.4%, 1.1%) attains peak values in this treeless heathland phase. For zones W1 and W2 it was argued that *Gleichenia* abundances were possibly determined by light levels with the result that during the open W1 *Gleichenia* expanded, while during the forested W2, its habitat contracted. This also appears to be the case in the upper part of the core, where Gleichenia thrives in the open fringe of W3, but appears to be shaded out by *Melaleuca squarrosa* in Zone W4.

More interesting is a major peak displayed by *Typha* and a smaller peak at the same level visible in the *Triglochin* curve. *Typha* is an emergent aquatic, commonly found in nutrient rich situations (Aston, 1977; Briggs, 1981). In agricultural locations, *Typha* growth is typically favoured by the addition of superphosphate to its hydrological catchment (*pers comm.* J. Hughes, University of Melbourne). The abundance of *Typha* can also be stimulated by fire. Burning releases nutrients, principally phosphorus, into the growth cycle and results in impressive bursts of growth (Tallis, 1981). Additional to this is the possibility that increased post-fire light levels and the presence of soluble nitrogen in ash, contribute to minimize inhibitions to *Typha* germination provided by living green tissue extracts (Rivard and Woodard, 1989).

Triglochin is also found in nutrient rich environments and is especially common in coastal brackish and freshwater lagoons (Aston, 1973; Hughes,1987; Kirkpatrick & Harwood, 1983). A significant point is that both *Typha* and *Triglochin* are known to have been important energy sources for Aborigines. It has been suggested that in south western Victoria, people managed wetland vegetable resources by deliberately burning stands of these species (Head, 1983).

It is tempting to explain the massive size of the *Typha* peak with recourse to an hypothesis based on anthropogenic burning. An examination ofFigure 6.19 shows that no correlation exists with peaks in cp/pollen ratios. Even so, ratios were rising, which probably indicates a general increase in fire frequencies. Although it seems reasonable to assume that such levels of burning might maintain and even favour stands of *Typha* and *Triglochin*, it is not possible to argue from this data that changes in an established burning regime resulted in the overwhelming dominance of *Typha* over all other aquatics.

A more significant factor is the correlation between peaks in *Typha* with increases in inorganic influx as determined by loss on ignition. The prominent decline in organic matter at 48 - 53 cm is accompanied by a peak in magnetic susceptibility (Figure 6.22). No streams flow into the marsh and the only possible way for inorganics to be deposited into the center of the marsh is by aeolian action.

A particle size analysis (Figure 6.20) of the 6,500 BP level in the sandsheet adjacent to Waterhouse Marsh shows that the deposits are classified as medium and fine sands with a mean Phi size of 2.07 and a sorting coefficient of 0.753. Sands of this type are usually of aeolian origin (Folk, 1971; Bowden, 1981, 1983). Therefore, at about 6,500 BP, aeolian sands were active at Waterhouse Point. The coincidence of that date with increases in mineral input into the marsh at the same time, makes a strong case for at least some of the surrounding sand being redeposited in the marsh.

From this, and from the knowledge that *Typha* and *Triglochin* respond to nutrient fluxes, it seems highly likely that air borne salt and phosphorus rich sands were blown into Waterhouse Point at that time, to give increases in net productivity and spectacular increases in *Typha* and *Triglochin* populations.

Equally interesting was the decline of these taxa some 7 or 8 centuries later. Although no firm explanation is at hand, the most parsimonious interpretation is that the initial input of marine sand derived nutrients simply ran out. Continued burning of the surrounding wet heaths and the marsh surface itself (Plate 2) may have led to an eventual depletion of crucial elements. Tallis (1981) and Gimingham (1972) consider that the regular burning of wetlands eventually leads to the probability of long term degradation of the habitat, through nutrient losses. There is however, no evidence in the cp counts for sustained burning of the marsh during this time.

Higher in the core, at the top of W3, Restionaceae values gradually rise before sweeping to a substantial peak. It is possible to describe a correlation between this trend and a similar rise in cp/pollen ratios. *Restio complanatus*, *Hypolaena fastigiata* and *Leptocarpus tenax* are the species which today dominate twig rush communities in the northeast. These species, with the exception of *H. fastigiata*, are typically located in low lying depressions and in transitions from wet to dry heaths (Kirkpatrick, 1977b). They are not obligate aquatics or even semi-aquatics. The decision not to include them in the dryland pollen sum was made on the basis of their ability to produce pollen in massive quantities.

The Restionaceae recover very quickly after fire by resprouting from the base. In many cases, the open, damp nature of the habitat ensures that fires will be patchy and cool in nature. Under such circumstances, the plants have an ability to survive fire and to invade bare patches. The gradually rising fire frequency as indicated by increases in cp/pollen ratios, would have provided conditions suitable for increases in Restionaceae.

Considering the frequent, cool and patchy nature of fires in heathlands today (Gill and Groves, 1981; Kirkpatrick, 1977b), it seems reasonable to assume that coastal heathlands in the past experienced roughly similar fire regimes. If such were the case during zone W3, an increasing frequency of fire would have favoured taxa which resprout and thus explain the rising importance of Restionaceae. Ethnographic evidence (Chapter 2) shows that Aborigines regularly collected rootstock from reed marshes. Another attraction of coastal lagoons was the easy access offered to waterfowl and waterfowl eggs. It is possible that burning of lagoon edges during the spring egging season, would have kept lagoon banks open. These conditions would have favoured the development of rushy heath communities in fringing open depressions.

Aquatic zone W4

The uppermost samples are characterised by declines in Restionaceae (31%, 13.3%), small but significant increases in Cyperaceae (11.7%, 2.5%) and declines in pteridophytes (2.0%, 0.5%).

Restionaceae and *Gleichenia* (0.6%. 0.4%) fall away during this modern phase. Today, these taxa are overtopped by dense fringing communities of *Melaleuca squarrosa*.

The present dominance of Cyperaceae in the marsh is explained by the ability of *Baumea* to reproduce vegetatively. This trait is favoured by regular burning which suppresses flowering and increases stolon and bud development (Kirkpatrick & Harwood, 1983). Observations of present day fires demonstrate that with favourable winds and temperatures, it is possible for a fire to burn across the wetland surface in spite of a 1 m depth of water at the center of the marsh. Plate 2 shows the effects of a fire, lit by campers in 1986, in which approximately 30% of the marsh was burned, while heath growing more than 100 m from the marsh edge remained unaffected (*pers obs*).

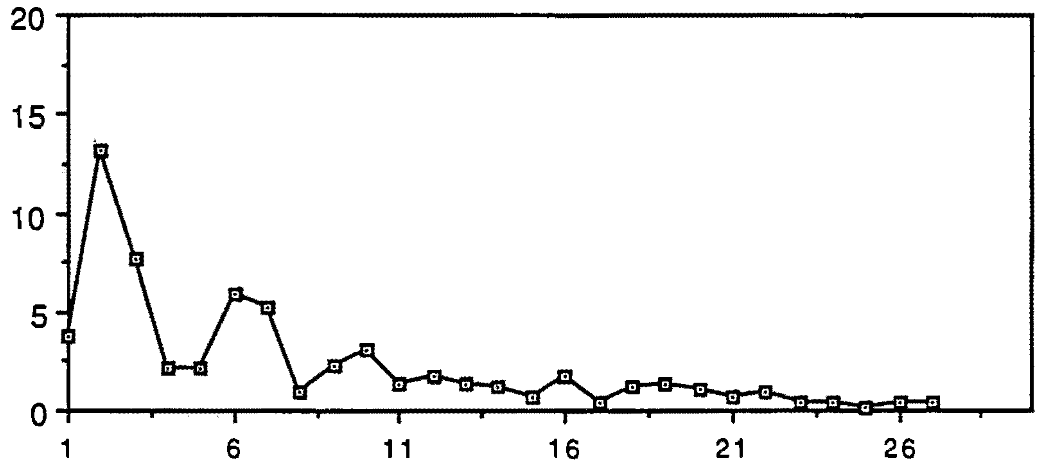


Figure 6.19. Waterhouse Marsh, WH/3 core. Carbon particle / pollen ratios y axis). Samples 1 - 27 (x axis) are in increasing order of depth from 0 cm t0 101 cm.

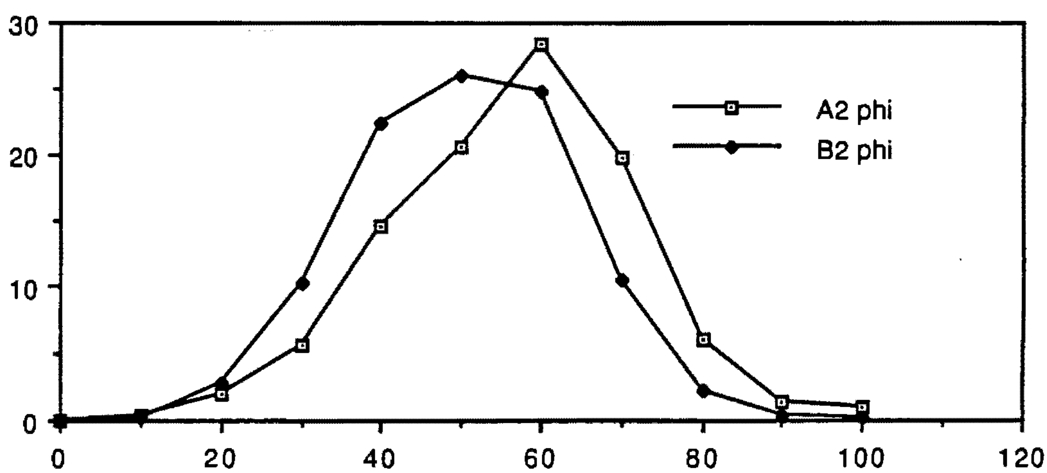


Figure 6.20. Particle size distributions for the A and B soil horizons of the Waterhouse sand dune.

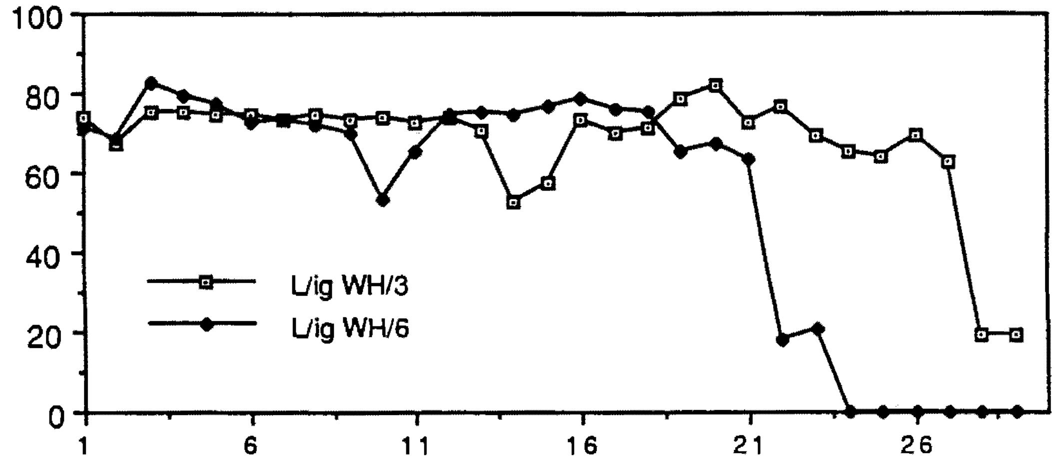


Figure 6.21. Waterhouse Marsh. Loss on ignition (y axis) for cores WH/3 and WH/6. Samples 1 - 29 (x axis) are in increasing order of depth from 0 cm t0 110 cm. Note different accumulation rates.

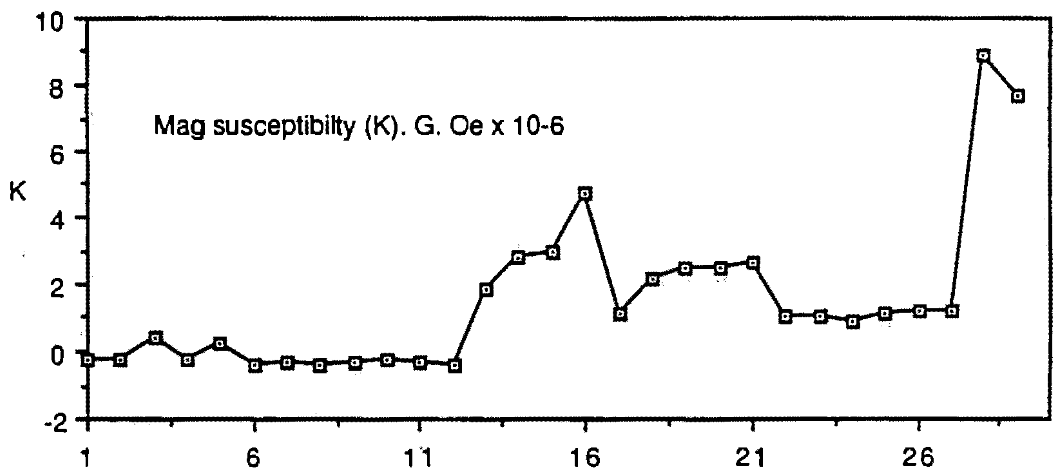


Figure 6.22. Waterhouse Marsh. Magnetic susceptibility (y axis) for core WH/3. Samples 1 - 29 (x axis) are in increasing order of depth from 0 cm t0 110 cm..

The restriction of the fire to the marsh surface and vegetation within 100 m of the waters edge suggests that cp counts must be used with caution and may only reflect local events. The observation suggests that the use of cp's for regional forest histories, derived from marsh or bog sites, must be treated with a great deal of circumspection.

6.4.14 Pollen concentrations: dry land taxa.

This section briefly describes pollen concentration data from WH/3 (Figure 6.23). In the absence of a closely dated framework, the data are not considered sufficiently detailed to enumerate a level by level or zone by zone description. More useful is an approach which evaluates the performance of selected taxa through time. An overview of major trends is offered which provides a valuable adjunct to the interpretation of other analyses.

The accumulation rates used are not intended to convey an impression of perfect resolution, but merely to provide a comparative platform which can be adjusted as future dates become available.

Allocasuarina

Concentrations of this taxa are very low in zone W1 and gradually rise towards the top of zone W2. Agreement with the percentage data is not good at the transition from W2 to W3. At this point in the percentage diagram, *Allocasuarina* rises rapidly to levels which suggests the presence of a locally established forest, while *Eucalyptus* declines to regional values. The concentration figures however, show that *Allocasuarina* never achieves levels which are characteristic of forest communities.

Heath taxa generally have low pollen productivity because of their entemophily (Clifford and Drake, 1981) and their ability to reproduce vegetatively (Birks and Birks,1980; Specht, 1981). Furthermore, a generally low wind profile acts to limit pollen dispersal (Chapter 5). The contrast between high percentages and low concentrations for *Allocasuarina* in zone W3, suggests a structural change from sub-dominant understorey tree to dominant heath component.

Eucalyptus

The most significant features of the *Eucalyptus* curve are very low values in zone W1, high to very high values in zone W2 and very low values in zones W3 and W4. Extreme peak values are noted at 80 - 81 cm and between 60 - 61 cm. In contrast to the percentage data, concentrations suggest that during zone W1, *Eucalyptus* was initially

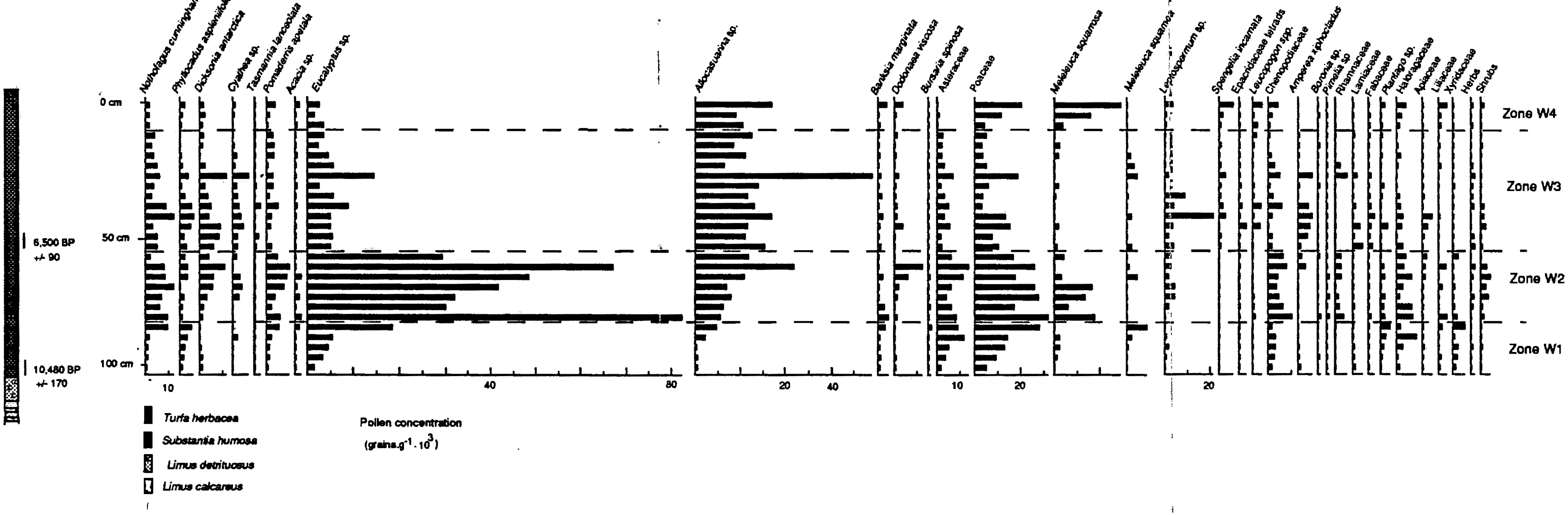


Figure 6.23. Waterhouse Marsh. Pollen concentration diagram, dry land taxa only.

absent from near the site . As populations developed, pollen concentrations increased until the beginning of zone W2 when an explosion in concentrations suggests that *Eucalyptus* had established in sufficient numbers to dominate the local vegetation. The extraordinary peak values at 80 - 60 cm, at the beginning and end of zone W2 are difficult to explain. The most plausible explanation is that the peaks relate to a forest edge effect whereby individuals with spreading crowns are able to flower more freely than trees in dense forest centers. Pollen concentrations in zones W4 and W3 suggest that *Eucalyptus* did not exist within about 5 km radius of Waterhouse Point.

Poaceae, Asteraceae and dry forest shrubs

Trends in concentrations are generally similar to percentages, with the exception of zone W1 where values are uniformly low. It is concluded that the vegetation of zone W1 must have been very open and sparse; perhaps an open steppe formation with large areas of Poaceae covered sand dunes.

Peaks in Poaceae concentrations during zone W2 are in keeping with the percentage and TWINSPAN analyses which suggested the presence of an open forest with a grassy understorey. The rapid decline in Poaceae concentrations in zone W3 are in keeping with changes from grassy forest to heathland.

Similarly, Asteraceae attains peak values during zones W2 and W1. It is not possible to determine if the pollen is derived from herbaceous or woody taxa. Today in the northeast, grassy forests often contain clumps of the woody shrubs *Helichrysum*, *Olearia* or *Cassinia*, and it seems likely that these may also have been prominent in the past.

Acacia, Banksia, Bursaria and *Dodonaea* all have maximum concentrations in this zone. Even so, the low values suggest that the shrubs were scattered rather than abundant in the forest understorey. These figures point to a varied but open *Eucalyptus* forest very similar in composition to the open forests surrounding Forester Marsh.

Poaceae concentrations increase dramatically in zone W4. This is attributed to increases in pastoral holdings during the European period. Similarly, *M. squarrosa* concentrations increase and this can been attributed to European influences.

Total pollen concentrations show that values are highest during the forested zone W2 and lowest during the preceding zone W1. The heaths of zone W3 are poor pollen dispersers while zone W4 values are slightly higher because of influxes by exotic grasses.

Concentration or influx data are rarely available for Tasmania (but see, Colhoun & van de Geer,1986; Colhoun *et al.*, 1990; Hill *et al.*, 1988).The data from WH/3 (grains g x 10^3) are compared to fossil pollen concentrations from western Tasmania. Table 6.3 is constructed from data abstracted from (Colhoun & van de Geer, 1986) and reflects a gradient in which pollen concentrations increase from interstadial shrublands and late Last Glacial grasslands to forested post glacial communities. The gradient is largely driven by increasing precipitation levels consequent with climatic change.

A local factor that underlies the climatic gradient is variation in pollen influx according to height of plant community. Thus, tall temperate forests provide very high pollen influx rates compared to open grassland or shrub communities. It is likely that the relatively open atmosphere at forest / wetland margins allows a large proportion of pollen to be released into windstreams, eventually to be destroyed or incorporated into natural pollen traps. In contrast, wind pruned heathlands and grasslands do not allow pollen to be dispersed into rapidly moving air streams. This results in a large proportion of pollen being deposited close to parent plants (Tauber, 1965, 1967; Anderson, 1974a, 1974b).

Hypothetical plant community	Pollen concentrations	core
Interstadial wet subalpine	17.3×10^3	(Tulla)
Late glacial grassland	19.8×10^3	(WH/3)
Holocene heathland	29.2×10^3	(WH/3)
Holocene dry sclerophyll forest	71.4×10^3	(WH/3)
Holocene wet sclerophyll forest	182×10^3	(Tulla)

Table 6.3 Pollen concentrations (x 10^3 grains per g) for fossil pollen groups. Data from Appendix 1 and Colhoun & van de Geer (1986).

6.5 A consideration of landscape instability during the mid Holocene

Research shows that periods of slope instability, dune formation and alluviation occurred through out the Holocene. Sigleo (1978) and Sigleo & Colhoun (1975, 1982) have argued strongly that the reworking of many primary dunes in southern Tasmania in the late Holocene was caused by the local scale activities of Aborigines. Caine (1978, 1983) suggested that an apparent period of increased erosion in the northeastern highlands between 4, 500 BP and 2,500 BP might reflect Aboriginal burning which resulted in slope instability.

Caine (1983), Colhoun (1975, 1976) and Macphail (1979) consider that Holocene climates were generally stable. Indeed, Colhoun (1975: 34) notes that in his opinion:

"Any minor climatic fluctuations that may have occurred appear to have been so slight or temporary as to have had little or no detectable geomorphic or biogeographic consequences".

The most common evidence cited in support of a late Last Glacial age for inland dunes and sand sheets is a date of 15,740 years BP from a dune near Malcolms Hut road in southeast Tasmania (Colhoun, 1975, 1985). The date seems reasonable enough when compared to the evidence for dune formation from southeastern Australia (Bowler, 1971), but in the absence of corroboration, this single date should be approached with caution. Other dunes, for example, return different dates. Bowden (1981) and Cosgrove (1985) obtained dates of about 8,500 years BP from the Rushy Lagoon lunette in northeastern Tasmania. Charcoal from lunettes and sandsheets at Crown lagoon (Lourandos, 1977), Bells Lagoon (Kee, 1990), and Bridgewater and Old Beach (Sigleo and Colhoun, 1982) have all returned dates of between 5,800 years BP and 1,900 years BP.

Periods of slope activity on non-sandy substrates cluster between 2,000 and 4 ,000 years BP (Caine, 1978, 1983; Goede, 1973; Davies, 1974). The most parsimonious hypothesis which explains widespread slope instability is a mid Holocene reduction in mean annual temperatures. Pollen evidence from Forester Marsh (Chapter7) and data from northern Tasmanian speleothem analyses suggest the likelihood of a cool period during the mid-Holocene at about 4,000 BP (Goede & Hitchman, 1973; Goede *et al.*, 1990). These are significant findings in the light of Macphail's (1979:336) conclusion that up until that time there was 'no pollen evidence, to support geomorphic data for a cold episode at ca 3,000 yr BP'. Similarly, Macphail & Hope (1985) consider that a cooler period around 3,500 years BP may have been responsible for a period of accelerated organic accumulation. These data suggest that a cooler phase between 4,000 years BP and 3,000 years BP may have been responsible for the activationof slope and sand dune deposits.

Soil profile development

At Cape Portland, to the west of Waterhouse Point, sand dunes contain Aboriginal middens which are confined to 'a thick organically stained calcarenite that is overlain by up to 15 soil horizons comprising the large dune system that dominates the area.' (Murray & Ranson, 1981). Material from middens in this sequence are dated to about 4,000 years BP (Tasmanian Department of Parks, Wildlife and Heritage, 1989: 3). These horizons, and similar ones at Croppies Point (Plate 15), Musselroe Bay, Tam O'Shanter Bay and Double Sandy Cape, demonstrate that cycles of Holocene landscape instability occurred in northeastern Tasmania.

In a survey of sand dune activity in eastern Australia, Pye & Bowman (1984:190) found evidence of an episode of transgressive dune instability between 10,000 and 6,000 BP which resulted in the formation of podsol soil profiles. Van de Geer (1981:22) has convincingly explained the existence of well developed Holocene age podsol soil profiles in sand sheets and beach ridges in northwestern Tasmania. Colhoun (1975), has described similar profiles up to 1.5 m in depth developed on beach ridges, presumed to date from the mid Holocene marine transgression. On this basis, it would be unwise to assume that a moderate to well developed podzol profile necessarily indicates a Pleistocene age.

The degree of induration and humification of the B2 horizon is often used as a criterion whereby relative ages can be ascribed to sand profiles (Bowden, 1983, Cook, 1986; Pye & Bowman, 1984 ; van de Geer, 1981). A re-examination of dunes described by Bowden at Waterhouse Point suggest that the B_2H_{ir} horizon of longitudinal dunes is considerably more indurated and humic rich than the same horizon in the sand sheet surrounding Waterhouse Marsh (Plate 13). By Bowden's criterion, this is evidence that the sand sheet is younger than the dunes, and raises the possibility that a previously unrecognized phase of sand mobilization occurred sometime between the formation of the longitudinal dunes and the emplacement of late Holocene parabolic dunes.

Coastal slope deposits

Bowden's conclusion that the interbedding of slope deposits with sand dunes constitutes an argument for a late Last Glacial age for the Ainslie Sands does not stand up to close examination (1981, 1983). One kilometre inland from Croppies Point is an area of tabular dolerite slabs and rubble interbedded with sand deposits. The source of the sand appears to be a blown out Holocene parabolic dune. Similar deposits can be seen at Bellingham at the mouth of Pipers River and 1 km west of Tomahawk township and 10 km further west at Lulworth. Baillie (1982) also has reservations concerning Bowden's conclusion and cites other places where slope deposits appear to be interbedded with Holocene sands. One possible mechanism which can explain the occurrence of these slope deposits is that frosts action could have acted in concert with salt recrystallization to split closely jointed dolerite outcrops, thereby exposing them to mobile sands.

The radiocarbon and thermoluminescence dates (Table 6.1) force some local modification to Bowden's scheme. There seems little doubt for example, that at least 50 cm depth of Ainslie Sand in the vicinity of Waterhouse Marsh was emplaced or reworked at about 6,500 - 6,000 years BP.

Two independent dating techniques indicate that a sand sheet which fringed Waterhouse Marsh was active at about 6,300 years BP. Loss on ignition percentages and magnetic susceptibility values from the WH/3 core show a significant increase in the inorganic fraction at the 48 - 53 cm level. This level is dated to 6,500 BP and supports the notion that at least some sand had become mobilized by this time.

To this can be added the results of the aquatic taxa pollen analysis from WH/3. This shows an extraordinarily large peak for *Typha* spp. between 45 - 53 cm. This is explained as a response by *Typha* to inputs of aeolian transported nutrients.

On the margins of Waterhouse Marsh, the evidence points to a period of dune instability during the mid-Holocene. It remains to examine the reasons for landscape instability at this time.

Sources of supply and causes of sand movement

Four hypotheses are considered to explain the emplacement of sand masses on the margins of Waterhouse Marsh at *ca* 6,500 years BP :

1) The most parsimonious hypothesis is that the longitudinal dunes date from the Holocene. This explanation does not stand up to scrutiny. Bowden (1981, 1983) and Baillie (1982) both consider that lunette deposits (dated to 8,500 BP) overlie longitudinal dunes. The longitudinal dunes must therefore be older and are thought to have been emplaced sometime between 18,000 and 10,000 years BP.

By 6,500 BP, maritime conditions had developed while pollen analyses show that at that time at Waterhouse Point, vegetation differed little from today. Since the longitudinal dunes are not active under present day conditions, it seems unlikely that they were active at any time in the past 6.5 K years.

Furthermore, a lack of buried soil profiles in the dunes argues that the dunes were rapidly emplaced over a relatively short period of time, after which soil formation processes began to operate. The lack of visible sand horizons within the WH/3 core over the past 10,000 years is evidence that no great quantity of sand was deposited *en mass* into Waterhouse Marsh. The great volume of sand which makes up the longitudinal dunes must therefore have been deposited prior to 10, 500 BP.

2) Pye and Bowman (1984) have reviewed the evidence from eastern Australia for the mobilization of sand consequent upon the availability of a fresh source of sand. It is possible, that the Waterhouse sand sheet was formed during the Holocene when a new sediment source was provided by the prograding effect of the Holocene marine transgression. This would have resulted in previously unavailable sand being pushed forward by rising seas. From this new source, sufficient sand may have become available to cover older features.

Acting against this, is the fact that no buried soil profiles or uncomformities are known from any sands in the area which have a well developed podsol profile. Thus, there is no field evidence for stable/unstable phases or cycles of landscape development during the Holocene. Furthermore, Holocene marine sands, located on the Tomahawk Plain to the east of the marsh, contain numerous shell fragments, whereas the sands nearer to Waterhouse Marsh are free of shells (Bowden, 1981).

Although large quantities of marine sand probably became available as sea levels stabilized, it seems as though no great quantity was redeposited as dunes or sand sheets on top of existing landscape elements.

3) It is possible that a local disturbance of terrestrial sands occurred at the same time as marine sands became available. Increases in salt laden winds are implicated in the deforestation of the area at about 6,500 BP. Even if winds were not sufficiently strong to activate marine sands, the removal of tree cover could have provided sufficient opportunity for the local reworking of older dune sands.

Davies (1967, 1974) and Sigleo (1978) considered that many Tasmanian sandsheets might have had origins in the deflation of loosely packed A horizons from older podsol profiles. If the soil profile consisted of two phases of development with the upper sand having a different source to the lower sand, the process might be reflected in grain size variations between older B horizons and younger A horizons.

A particle size analysis of samples taken from the A and B horizons of the sand dune bordering Waterhouse Marsh shows that both horizons have similar grain size characteristics (Figure 6.20). The mean Phi size for the A horizon (x Phi = 2.07) is almost exactly the same as that obtained by Bowden (x Phi = 2.08) from a longitudinal dune to south of Waterhouse Marsh. This is in accordance to the findings of Folk (1971), who pointed out that the 2 Phi to 3 Phi range will always be strongly represented in dunes regardless of the wind regime.

Bowden's data indicated a distribution skewed towards the coarser Phi sizes and from a consideration of the coarsest fraction was able to estimate that mean wind strength at the time of formation of longitudinal dunes was some 10 km per hour stronger than during the Holocene. The distribution of grain sizes from the Waterhouse sand sheet has a mesokurtic distribution and is thus less inclined towards the coarser fractions. From this it can be assumed that if wind action resulted in the disturbance of the Waterhouse sand sheet, the regime was somewhat weaker than that in operation during the earlier phase of longitudinal dune building.

4) The final possibility to consider is in relation to Sigleo's (1978) and Sigleo & Colhoun's (1975, 1982) hypothesis that Aborigines are responsible for the disturbance of many primary sand dunes and sand sheets in in Tasmania.

The present coastline is, in effect, an east -west transect across the ancient Bassian Plain. When Tasmania was linked with southeastern Australia, tribal territories would have included all of Bass Plain. Archaeological evidence suggests that both the western and eastern corridors of Bass Plain were infrequently visited between 20,000 BP and 11,000 BP (Bowdler, 1984; Brown, 1988).

One plausible effect of sea level stabilization might have been to cause a re-allocation of tribal lands (Bowdler, 1977; Jones, 1971,1977). Although the demographics and movements of Bassian populations are poorly understood (Bowdler, 1984; Brown, 1989; Jones, 1971a, 1971b, 1977; Sim, 1989), it is reasonable to expect that the formation of a coastline might have acted as a focus for Aboriginal interests. What was once a random section of Bass Plain was transformed into a landmark, a pathway and a major economic zone.

Waterhouse Marsh, only 1 km from the coast and with abundant reed and birdlife resources would almost certainly have attracted the attention of Aborigines. Its high and well drained banks would have offered both sunny positions and protection from winds (during summer).

It is an indisputable fact that Aboriginal artefacts can today be found in the A horizons of soil profiles adjacent to Waterhouse Marsh. After numerous surveys for Aboriginal sites along many kilometers of exposed soil profile, no artefact was ever seen in or below the boundary of the A and B horizon. Considering that soil horizons are pedogenic and not stratigraphic entities, the restriction of artefacts to the A horizon suggests that people utilized the area for a short period of time in the last phase of dune building.

Alternatively, it is possible that in this local context, the A horizon is actually a distinct stratigraphic unit, substantially younger than and perched upon, a relict stripped B horizon.

A resolution

The isolated nature of the peak in inorganics in the loss on ignition curve suggests that emplacement or disturbance of the sandsheet occurred close to 6,500 years BP. The distinct nature of the peak and the lack of visible sand horizons in the core at the 6,500 year level, points to the occurrence of a local scale disturbance. It seems highly unlikely that a major phase of dune building took place in the local environs of Waterhouse Marsh during the mid Holocene. This proposition does not address the question of whether or not dune building or mobilization was taking place 1 km away on the recently stabilized coastline.

Rapidly approaching sea levels would have provided attractive economic reasons for living patterns to focus on what had become the northern Tasmanian coast. With the new coastline only 1 km distant, it seems likely that Waterhouse Marsh and similar wetlands would have experienced increasing visits by people.

A decline in forest cover due to a combination of salt necrosis, burning and inimical soil conditions provided the backdrop for increasing soil disturbance as people continued to take advantage of local resources.

Sigleo (1978) and Sigleo & Colhoun (1982) have shown the effectiveness of people as disturbance factors in areas with sandy substrates. Plate 16 demonstrates the local effect that short lived, high strength winds can have on disturbed sandsheets. The reworking of a portion of the Ainslie Sand sheet by a combination of Aboriginal burning and camping could easily account for the deflation of 60 cm of sand over about 1,000 years, and probably in an order of magnitude less than that. If this occurred at about 6,500 years BP there would be ample time for the re-establishment of a thin A1 horizon.

The coincidence of a decline in vegetation cover with a phase of Aboriginal occupation seems to offer the best explanation for the mid Holocene dates obtained from a supposed Pleistocene landform.

6.6 Conclusions

Waterhouse Marsh records the vegetation history of the Waterhouse Plain from 10,500 BP to the present. Contrary to previous investigations, the results suggest that the northeast has experienced geomorphological and vegetation changes during the Holocene. The influences of Bass Strait are considered to be paramount in producing these changes.

At the beginning of this chapter a number of questions were posed in regard to the landscape history of the Waterhouse Point area. Those questions are restated below with explanations derived from the current study.

What changes occurred in the vegetation of the northeast consequent with the demise of an arid glacial phase and its replacement by an interglacial characterised by warmer and more humid climates?

Increased precipitation from about 10,000 BP led to the recharging of aquifers and the raising of local water tables. This had the effect of stimulating changes within basins and allowing the establishment of forests on sites such as Waterhouse Point which had previously been occupied by a sparse association of eucalypt, grass and daisy species.

On the northern plains, eucalypt forests were able to either spread out from local refugia centered on the availability of ground water, or to advance as slow moving fronts from protected habitats in the hinterland. Organic deposition was initiated at Leedway at 12,500 years BP, with high percentages of *Eucalyptus* pollen in the basal sediments. This suggests that water availability, if not temperatures, had risen sufficiently by that time to create or refill small basins which had been dry throughout the Last Glacial maximum.

It is not possible to say whether *Eucalyptus* had established locally as a response to climatic amelioration or if it had survived at Leedway since before the maximum of the Last Glacial. The presence of high percentages of *Eucalyptus, Asteraceae* and *Poaceae*, in reasonably high concentrations suggests that an open grassy forest was established at Leedway prior to 12,500 BP. The initial effect of increasing post glacial temperature and precipitation levels was to provide the opportunity for local organic accumulation where none existed before.

There may be a relationship between the onset of organic accumulation and the arrival of a forest front moving northwards from the protected valley of the Forester River near Mt. Horror. However, the date of ca 10,000 years BP for a forested environment on Ben Lomond at 815 m (Noble, 1981) suggests that forests moved upslope from lowland refugia rather than the reverse. However, it seems equally likely that if forests were present in both the highlands and lowlands, a post glacial expanion could have radiated in any direction.

Although Markgraf *et al.*, (1986) have argued for a high degree of synchrony in the development of western Tasmanian rainforests, the same conclusion cannot be drawn for the east where plant communities are likely to always have existed in complex patterns and where a high degree of localized endemism in the flora points to a strong degree of control by micro habitats. (Coates, 1991; Colhoun *et al.*, 1990; Kirkpatrick & Brown, 1984).

At Waterhouse Marsh, a saline wetland existed prior to 10,500 BP. The local dryland vegetation was probably a grassy steppe like formation. Increasing water depth after 10,500 BP allowed the establishment of substantial aquatic communities and the development of an open grassy eucalypt forest. The salinity of the Waterhouse Marsh environment, in conjuction with glacially arid conditions may have precluded the growth of any substantial tree cover until temperatures ameliorated and precipitation increased.

During the Last Glacial it is possible that the southeastern margin of the Bassian Plain was cloaked in a mosaic of open grassy steppe and woodlands, with occasional copses of forest where soil fertility, weather protection and water supply allowed. Rivers such as the Forester, Ringarooma, Boobyalla, Pipers and Tamar would have provided growth corridors for forests.

As temperatures ameliorated around 10,000 years BP, forest communities would have expanded onto adjacent slopes. This was probably not the case on the topographically gentle and infertile slopes of what is now the northeast coast. Fewer buffered niches are available in such places and forest expansion may have proceeded at a slower rate than on more fertile and humid sites. Sites blessed with abundant ground water supplies probably acted as centers of diversity from which propagules radiated as precipitation increased, wind strength decreased and temperatures rose.

Nevertheless, sites such as Leedway suggest that forests may have already existed earlier than 13,000 BP in selected locations and thus the process may have been one characterized by increasing structural complexity rather than expansion *per se*.

Noble (1981) suggests that the slopes of Ben Lomond and Ben Nevis were best suited to act as local refugia for woody endemics. Macphail & Moscal (1981) present evidence that valleys of the eastern highlands acted as refugia for alpine taxa with poor rates of dispersal. If these hypotheses are correct, there seems to be no reason why, given an adequate supply of moisture, lower valleys and protected slopes should not have supported forest or woodland.

Recent work by Neyland (1990) has demonstrated the wide distribution of pockets of rainforest extending up the entire length of eastern Tasmania. All of these communities depend on precipitation derived from easterly winds and their location in protected valleys for their continued existence.

On the margins of the plains and in the eastern highlands, mountains would have acted as traps for moisture from northeasterly wind streams. Warm sea currents flowing from the north, unimpeded by the westerly flow of Bass Strait, might have provided moisture in the form of fogs whenever warm, moist air currents met with cold southerly air masses. The northeasterly aspects of the Mt. Horror, Mt. Cameron, and other middle altitude massifs would have provided protection from dessicating winds, and exposure to moist northeasterly winds. During the Pleistocene, these slopes and valleys may have supported cloud drip vegetation communities and rainforests in humid valleys.

What part did the rise of Bass Strait and its eventual stabilisation, play in the long term vegetation dynamics of the northeast?

Bass Strait has had a profound effect on all aspects of the cultural development of northern Tasmania. Jones (1971a, 1971b) has examined some of the possible changes in Aboriginal demographic patterns following the postglacial rise in sea levels.

Less obvious but equally important are likely to be the effects of a rising Bass Strait on the composition and distribution of plant communities. The most obvious of these is the dissection and isolation of formerly continuous populations into relict and disjunct populations from Victoria to Tasmania.

To a large extent, plant community composition is determined by historical factors and the interaction of a few key variables of which, moisture availability, temperature, light levels and nutrient status are the most obvious. The northern margins of Tasmania have substrates which vary from elevated, fertile basalt plateaux to low infertile Quaternary sands. In places, rivers provide protected valleys and local supplies of fresh ground water.

At Waterhouse, *Eucalyptus* forests developed from earlier steppe like associations which may have been typical for exposed sections of the previous Bassian Plain. After nearly 2,500 years of development, the forests dissapeared at about 6,500 BP. The coincidence of sea levels stabilizing at the same time forces a consideration of the hypothesis that the demise of *Eucalyptus* was caused by some factor associated with the formation of Bass Strait.

No single factor can be implicated but progressive soil podsolization leading to high levels of soil infertilitywas probably extremely important. The sand which forms the actual landscape of the coastal plains had its origins on the floor of Bass Strait and in a very real sense, Bass Strait can be considered to be the parent of the northeast.

Two other significant factors were the full development of salt laden northwesterly winds which open out forests and an increase in fire frequencies. Bass Strait itself would have brought a new focus to Aboriginal economic objectives by providing a new and dependable marine resource base. An increase in fires is likely to have been associated with these changes. These processes would have acted synergistically with soil infertility to ensure the development of heathy understories.

What effects did Aboriginal burning of the bush have on the vegetation of the northeastern dunefields.

There is no evidence from Waterhouse Marsh that massive burning resulted in the destruction of forests. CP counts do increase from 10,500 BP to the present but there is no firm correlation with major changes in the pollen record. Fire appears to have had a greater effect on minor taxa than the dominants. This is especially clear in relationship to long term increases in Restionaceae and short term increases in Haloragaceae and *Melaleuca squarrosa*.

Cp/pollen ratios from about 6,700 to 2,400 years BP are low and constant, indicating a reasonably constant rate of cp influx into the marsh. This is assumed to mean a constant frequency of firing. There is no firm evidence to suggest periods of intense wildfire which might have resulted in the destruction of forests. The removal of tree cover might have been accomplished by frequent cool burns.

From 6,500 BP to the present, ratios increase, which indicates an increasing frequency of fires. The gains made by Restionaceae may indicate that firing was conducted at a rate of not less than one fire every 5 years. The dominance of *Allocasuarina* suggests that fires were patchy and cool enough to allow the regeneration of this taxon.

High Cp/pollen ratios from 21 - 16 cm are not correlated with significant changes in either dry or wetland vegetation and remain unexplained. The highest ratios in the entire sequence are achieved in the uppermost three samples and are again uncorrelated with any changes except for increases in Restionaceae. It is not clear if increasing numbers of cp's relate to the final phase of Aboriginal occupancy or to an initial phase of increased burning by Europeans.

How old are the heathlands of northeastern Tasmania?

The evidence suggests that coastal heathlands evolved from heathy forests at about 6,500 BP. This date coincides with the stabilization of post glacial sea level rises. This situation may prove to be typical for many coastal heathlands on infertile Quaternary sands in northern Tasmania.

It would be of great interest to obtain a core for comparative purposes from the heathlands at Rocky Cape in the far northwest where an 8,000 year old cultural history has been fully documented (Jones, 1966, 1971a, 1977). It is also possible that some heathlands existed on the dry Bassian Plain during the Holocene (Hope, 1978). Such communities may have been pushed upslope by rising sea levels to eventually stabilize on the present coastline.

What pollen evidence exists for the long term survival of Allocasuarina in a fire prone environment?

The replacement of *Eucalyptus* by *Allocasuarina* at Waterhouse runs counter to trends established for other parts of southeastern Australia. A long pollen core from Lake George has provided evidence for the replacement of *Allocasuarina* by *Eucalyptus* in an explanation which has achieved paradigmatic status (Singh *et al.*,1981; Singh & Geissler, 1985)). In this case, fires lit by Aborigines provide the mechanism by which fire sensitive *Allocasuarina* succumb to invasion and relacement by *Eucalyptus*. Evidence from Lashmar's Lagoon on Kangaroo Island may support this thesis (Singh *et al*, 1981) as does an *Allocasuarina* decline at Sperm Whale Head in eastern Victoria (Hooley *et al*, 1980).

Macphail (1981) notes that even in the above cases, the elimination of *Allocasuarina* was never complete and that the short term response by vegetation to fire is on a site by site basis in which local factors and associations become dominant. Hooley et al (1980:361) consider that a general case can be made in which "it is fair to conclude that in many areas an Increase in the frequency or intensity of fire has led to the destruction or severe restriction of 'climax' *Casuarina*(sic) communities and the proliferation of eucalypt woodland or forest. This process may have been initiated or accelerated by the activities of aboriginal man (sic)".

Against this can be set the views of Clark (1983b), Head (1983, 1986 1988) and Ladd (1988) who see the Casuarinaceae as a diverse family which contains species tolerant to fire. The Waterhouse Marsh core and the present day ecology of the Tasmanian Casuarinaceae provides a stunning counterpoint to the view that *Allocasuarina* must be regarded as a fire sensitive.

It is not known if the trend indicates increases in fire frequency or intensity. Ecological considerations lead to the conclusion that *A. littoralis* and *A. monilifera* can survive single intense fires but may be eliminated after closely spaced hot fires. However, both species can survive and even expand under a fire regime characterised by frequent cool burns with an interval of one fire every 10 years or so. The dominance of the fire prone Waterhouse Point heaths by *A. monilifera* is sufficient proof that the species can prosper under a regime in which fires can vary from cool to hot, so long as there is sufficient environmental heterogeneity to promote patchy burns.

People and landscape

In the period which is known to encompass the spread of people across Australia, few events have had such a major effect on cultural systems than the rise of post glacial sea levels. For northwest Tasmania, Jones (eg. 1966, 1971a, 1974, 1975, 1977, 1984) and Bowdler (eg. 1974, 1975, 1977, 1984) have clearly ennunciated the dynamics of a cultural system under siege by rising sea levels. Jones views the people of 8,000 BP in the northwest as having being trapped between rising seas and impenetrable forest. The deep middens at Rocky Cape are seen by him as a plausible response to environmental change and mark the complete transformation of Aboriginal society from inland foragers to coastal gatherers.

Bowdler's explanations of archaeological sequences from Hunter Island amplify the vision of Jones by extending the time period to ca 23,000 years BP. This allows a before and after perspective in which the cultural and environmental transitions from Bass Plain to Bass Strait were made brilliantly clear.

With the notable exception of Hope's (1978) analysis of pollen contained in the cave sediments examined by Bowdler (1984), little existed from which to deduce Holocene environmental changes. Vegetation reconstructions were based on analogies from far distant pollen sites in southern Tasmania, or from sites in which the 10,000 years of the Holocene was a mere postscript to a larger and older volume.

What was missing from these and other Aboriginal sites were continuous local environmental histories. Even today, the situation has not changed appreciably, although at Waterhouse Marsh a start has been made. Here is a sequence which lays bare the notion of Holocene stasis. Just as Mulvaney & Joyce (1965), Jones (1966, 1971a) and others had unceremoniously dumped the notion of Aborigines being an unchanging people; the sequence at Waterhouse challenges the second portion of the equation which demands an unchanging land. The evidence presented above suggests that the vegetation shifts at Waterhouse Point were as spectacular as any of the well known Pleistocene to Holocene changes in western Tasmania.

The perspective offered by the northeast and the Waterhouse core is unique. Vegetation changes over the past 10,000 years are reflected in the distribution of present day communities which are arranged from coast to hinterland in a manner which precisely mirrors their developmental history. To apprehend vegetation change through the medium of pollen requires a laboratory and a microscope; to view the same changes in space rather than time requires only a short stroll to the summit of a hill which overlooks Waterhouse Point.

From its summit there is a view which encompasses the entire distance from Flinders Island in the north to Ben Lomond in the south and from the Asbestos Range in the West to Cape Portland in the east. This panorama includes all of the country owned by the northeastern tribes before about 1830. Beneath the waters of Bass Strait is an equally large area of submerged land that was probably owned by one the tribes of 12,000 years BP.

The vista encompasses an environment more varied than any on mainland Australia. Where on the mainland can a person sit on a low coastal hill and gaze at ridge after ridge of snow covered alpine plateaux? Where could a single glance take in the entire spectrum of major vegetation formations from coastal dune complexes to alpine shrubberies; from stunted mallee woodlands to dry scleophyll forests and dark primaeval rainforests?

Two hundred years ago, it was possible for a tribe of nearly 500 people (Jones, 1974) to live out their entire seasonal round within the amphitheatre which is the northeast. Archaeological discoveries at Cape Portland and Rushy Lagoon show that people were utilizing marine resources and camping on the banks of a freshwater lagoon between 4,000 and 8,000 years ago (Cosgrove, 1985; Tasmanian Department of Parks, Wildlife and Heritage, 1990, 1991). Before that, from 20,000 to 12,000 years BP, people took shelter in commodious limestone caves on what are now the Furneaux islands, never leaving more than a handful of stone flakes and never eating more than what amounts to a snack (Brown, 1988).

These three phases of settlement effectively bracket the major postglacial changes in the vegetation of present day coastal northeast Tasmania, which altered from open steppe with an occasional forest copses before 12,000 years BP, to well developed eucalypt forests at 8,000 years BP before finally transforming to heaths and woodlands after 6,500 years BP.

Chapter 7

Holocene vegetation changes in lowland northeastern Tasmania.

7.1 Introduction

Pollen analyses were carried out at a site in the lowland forests of the northeast in order to determine whether settlement and vegetation patterns suggested by ethnohistoric data could be identified though the medium of fossil pollen. Prior to this study the Holocene vegetation history of the northeast was almost totally unknown apart from a preliminary report from a site located on the flanks on Ben Lomond at 900 m. (Noble, 1981). With the exception of a single site in the far northwest of the state (Colhoun and van de Geer, 1982), some 150 km from the present study area, no vegetation history existed for any northern lowland forest.

Results from Chapter 6 suggested that coastal vegetation at Waterhouse Point had responded in a complex fashion to both environmental and Aboriginal influences which included climate change, salt spray, soil changes and burning. It was therefore considered essential to obtain an indication of vegetation dynamics from a lowland area which has always been free from the marine influence of Bass Strait.

In consideration of the enormous surfeits of moisture which might mask relatively minor Holocene temperature or precipitation fluxes at western Tasmanian pollen sites, it was considered that the warm dry climate of the northeastern lowlands should be more sensitive to changes which might not be visible in the western or southern pollen sequences.

7.2 Methods

A core was obtained from Forester Marsh (altitude, 90 m), about 1 km west of the Forester River near Scottsdale (Figure 4.1). Field and laboratory techniques used for core extraction, sub-sampling and standard pollen reduction techniques follow those described in Chapter 5 and 6. Results from magnetic susceptibility and loss on ignition analyses showed very little variation between samples and are not mentioned further except in general terms.

Pollen percentages from the 103 cm core extracted from Forester Marsh were subjected to TWINSPAN and DECORANA analyses using the methods described in Chapters 5 and 6.

7.3 The Study Area

Inland from the Waterhouse Point area are extensive tracts of dry sclerophyll forest, wet sclerophyll forest, rainforest and sub-alpine and alpine associations (Figure 4.3). The zones are arranged along a soil nutrient and precipitation gradient where dry sclerophyll occurs primarily in low rainfall and infertile situations. Wet forests usually exist on more fertile soils and in places with higher moisture availability.

Dry forests generally occupy, but are not restricted to, nutrient poor edaphic environments characterised by underlying marine sediments of Tertiary age. Extensive podsolization of gravels and sands has in many places caused the development of hardpans and subsequent conditions of impeded drainage. On these sites organic deposition has commenced wherever ground water allow soils to remain saturated even during long summer droughts. *Eucalyptus amygdalina*, *E. ovata*, *E. pauciflora* and *E. viminalis* are the major community dominants with a significant areas dominated by *Allocasuarina monilifera*, *Allocasuarina littoralis* and *Acacia dealbata*. Large understorey shrubs include *Bursaria spinosa* and *Dodonaea viscosa*, *Banksia marginata* and *Acacia verticillata*.

On well drained slopes, dry heathy understoreys are common whereas myrtaceous scrubs, wet heaths and sedgelands are characteristic of plains and depressions. Fire appears to be a common feature in all plant communities which compose lowland dry forests in the northeast, although the extent to which fire frequency and fire intensity interact is not clear.

Pockets of wet sclerophyll forest and rainforest can be found on southern slopes and in fire protected locations. An especially significant outlier of rainforest is located on Mt. Horror and in the various gullies draining its southern slopes into the Forester River (Neyland, 1990). Formerly extensive wetlands associated with the Forester River have been severely affected by agricultural enterprises and are now restricted to depressions adjacent to the river course. Annual flooding has allowed the development of swamp forests in cut offs and abandoned flood channels. These small but important remnants are characterised by *Acacia melanoxylon* , *Eucalyptus viminalis* and *Dicksonia antarctica* with a fern and sedge rich understorey. Tall *E. obliqua* forest with an open understorey of *Pteridium esculentum* is found on western and southern slopes, especially those on granite soils subjected to a high incidence of fire for at least the past 70 years (Jennings, 1983).

Ethnohistoric evidence (Chapter 2) and oral histories (Jennings, 1983) provide sufficient proof of the former existence of tall eucalypt forests and patches of rainforest on the hilly country between altitudes of about 200 m and 500 m. Many of these forests grew on deep basalt soils which today support productive agricultural holdings.

The pollen site: Forester Marsh

Forester Marsh is a small, low altitude mire, situated in an extensive forested area. The basin is located between areas, which on ethnohistorical grounds, represent polar opposites in terms of Aboriginal settlement patterns. The coasts with their marine resources and open vegetation are assumed to have a long history of Aboriginal settlement, and therefore, an equally long history of burning activities. Conversely the highlands are thought to have been unoccupied at the time of European settlement (Jones, 1971a, 1971b, 1974, 1977) and have been assumed to have been subjected to little or no influence from Aboriginal burning. What then was the vegetation and settlement history of the intervening forests? The Forester marsh core provides the first evidence for vegetation changes from the low altitude inland forests of the northeast.

A limited number of interesting organic deposits occur in the dry forests which extend along the Old Waterhouse road from Scottsdale to Waterhouse Point. Buttongrass sedgelands are mostly confined to valley bottoms although occasional patches can be found in situations where podsol soils appear to have developed hardpans. A small number of rather different mires exist in what appear to be deflation hollows on ridge tops and hill slopes. These are dominated by the sedge, *Lepidosperma longitudinale* and generally have no clearly defined stream influx. The development of hardpans in sandy gravelly soils has allowed perched watertables to develop in geologically controlled depressions, or in sandy places which have been deflated by northwesterly winds.

Forester Marsh (Plate. 4) occupies a small depression on the northwestern aspect of a spur which leads down to the Forester River located 1.25 km to the east. Streams neither influx nor efflux from the 100 m wide enclosed basin. At its deepest, the organic deposits attain 118 cm, although 75 cm is the average depth for the central part of the marsh.

Geologically, the area is characterised by extensive beds of non-marine Tertiary sands and gravels on which deep podsol soils have developed (Figure 4.2). The origin of the basin is unknown although it seems likely that deflation of the sandy soils by northwesterly winds has taken place.

Present vegetation

The vegetation within 1 km is dominated by *E.viminalis* and *E. amygdalina* forest with sub-dominants *Allocasuarina monilifera* and *Banksia marginata*. The understorey is composed of heath, sedge and fern species. Wet heaths surrounding the marsh are characterised by *Leptospermum scoparium, Melaleuca squarrosa, Epacris lanuginosa* and *Xyris operculata*. Ridge tops which have been subjected to a high incidence of burning, are dominated by *E. viminalis* and *E. amygdalina* with a ground cover of *Pteridium esculentum*. In low lying places which are not usually subject to seasonal innundations, but which are still damp for a large portion of the year, sedge and rush communities exist with *Lepidosperma concavum*, *Leptocarpus tenax* and *Restio complanatus*. In dry, level places, not dominated by *P. esculentum*, small shrubs and herbs predominate. These include, *Hypolaena fastigiata*, *Lomandra longifolia*, *Pattersonia fragilis*, *Dianella revoluta*, *Persoonia juniperina*, *Aotus ericoides*, *Leucopogon collinus*, *L. virgatus*, *Leptomeria drupacea*, *Ricinocarpus pinifolius*, *Goodenia lanata*, *Helichrysum scorpioides* and *Hibbertia fasciculata*.

7.4 Results and analyses

7.4.1 Stratigraphy

The Forester core is almost wholly composed of very dark brown peat. The upper 10 cm comprises a dense mat of roots and rhizomes intermeshed in a mucky cyperaceous peat. From 10 - 102 cm the sediment is very well humified dark brown *Detritus humosa* with *Lepidosperma* roots extending no further than the 50 cm level. A 16 cm basal section extending from 102 - 118 cm was composed of *Grana glareosa* (*minora*) contained in a matrix of *Substantia humosa*. The colour of the core changed from dark brown to grey brown over a depth of one centimetre at the 102 cm level and remained unchanged to 118 cm. Below 118 cm, the gravels were highly compacted and frustrated all attempts to penetrate more than 5 cm with the corer. No pollen was recovered from below 103 cm.

7.4.2 Dating

Three dates were submitted from the Forester core (sample code, MH/1). Samples were pretreated by removal of all visible roots and rootlets by wet sieving prior to a treatment with hot 10% HCl .

Sample	Depth	Date
MH/1	79 - 84 cm	3,500 +/- 130 BP (ANU-5114)
MH/2	96 -102 cm	4,430 +/- 100 BP (ANU-5115)
MH/3	112 - 118 cm	4,000 +/- 170 BP (ANU-5116)

Table 7.1. Radiocarbon dates from the Forester Marsh core.

The sequence indicates a date reversal between MH/2 and MH/3 (Table 7.1). The lower sample (MH/3, 112 - 118 cm)) consisted of peaty sands and gravels which sat directly on a very dense base of granite sands and gravels. In contrast, MH/2 was composed of very dark brown peat with no textural indications of mineral material. The base of MH/2 at 102 cm, demarcates the upper edge of a transition from peat to organic sands and gravels.

Colhoun (1986) suggests that humic acids and colloids might accumulate at the bases of the cores and therefore provide the basis for contamination of basal dates. This may be even more likely in situations where a closed basin prevents any lateral flow of groundwater. On this reasoning, it is possible that MH/3 was contaminated by younger carbon and the date should therefore be regarded as suspect. The higher stratigraphic position and greater organic content of MH/2 suggests that the sample would most likely have escaped serious contamination. The pollen samples from 102 cm are therefore confidently ascribed an age of 4,430 +/- 100 years (Table 7.1).

7.4.3 Accumulation rates

On the basis of MH/2 alone, the maximum and minumum accumulation rates at one standard deviation are 47.2 yrs.cm and 42.5 yrs.cm respectively, giving a mean rate of 44.9 yrs.cm or 0.022 cm.yr. Similarly, the 79 cm which extend from MH/1 to the surface has a mean accumulation rate of 42.1 yrs.cm or 0.024 cm.yr.

Pollen of *Pinus radiata* and *Plantago lanceolata* are restricted to the upper 3 cm which is therefore considered to represent the 160 or so years of European settlement. This gives an accumulation rate of 1 cm every 53.3 years. The differences between rates are considered to be marginal and demonstrate an approximately constant rate of accumulation over the 4,430 years represented by the organic section of core. A mean accumulation rate of 46.8 years.cm is therefore regarded as a reasonable estimate of the overall accumulation rate.

7.4.4 TWINSPAN analysis

The data were subjected to a weighted TWINSPAN analyses using the methods described in Chapter 5. The results of the weighted analysis avoided some of the problems associated with the artificial upweighting of naturally rare or poorly represented pollen taxa and was considered as the best option for developing analogues from contemporary plant communities (Figure 7.1).

Group A: This consisted of samples 1 (0 - 1 cm) and 2 (2 - 3 cm) and Trap samples FM1, FM2, FM3, BH1, BH2 and BH3. The indicator species for this group is Poaceae 3 which emphasizes the dominance by grasses in all samples. The fact that no trap was grouped

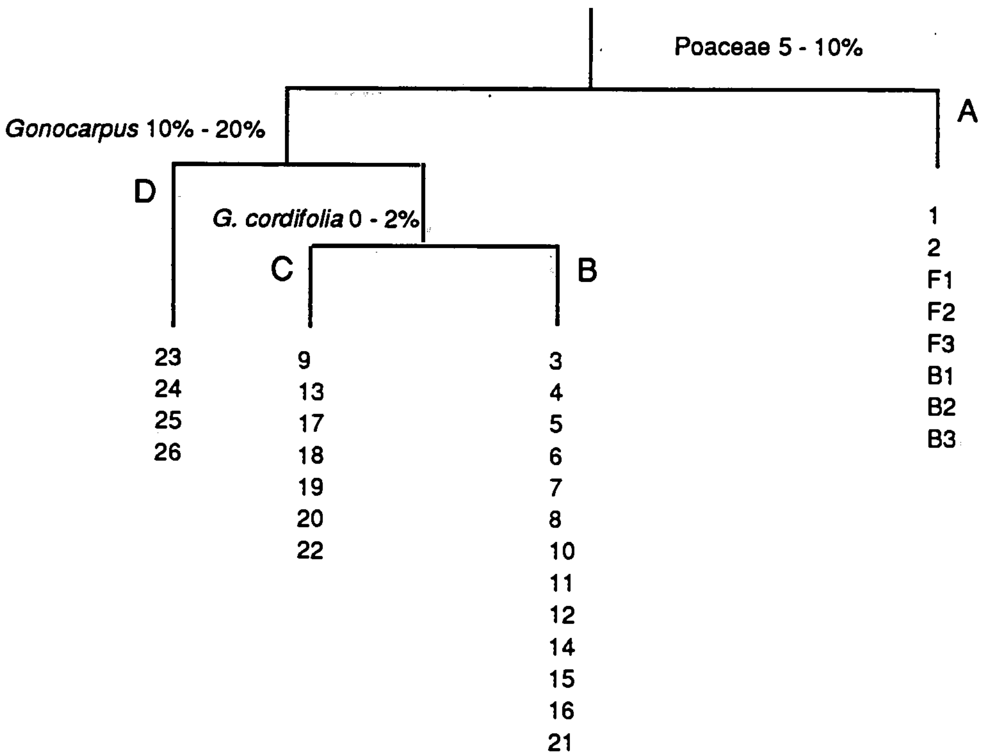


Figure 7.1. Forester Marsh. Abundance weighted TWINSPAN dendrogram for FM core samples1 - 26 (0 - 103 cm) and pollen traps FM1 - FM3, BH1 - BH3. TWINSPAN groups, indicator species and values at each major split are shown.

with samples from lower in the core indicates that other than for the past 160 years of European occupation, grasses have not formed a significant component of the plant communities around Forester Marsh for at least 4,000 years. The next dichotomy splits A into a group containing the upper samples and the Forester traps and a group composed of the Big Heathy traps. .

Group B: This is a large group containing samples 3 to 8, 10 to 12, 14 to 16 and 21. which extend from 6 cm to 43 cm and from 50 cm to 59 cm plus the 78 cm to 79 cm level. No indicator is available for the group but it is characterised by the preferentials, *Melaleuca squarrosa* 2 and 3, *Dodonaea viscosa* 1 and *Leptospermum lanigerum* 1 and 2. The group is dominated by dry sclerophyll species and by wet heaths which presumably surrounded the marsh during these times. The inclusion of the stratigraphically aberrant sample, no 21 and the exclusion of samples 9 and 13 serve to remind that the responses of vegetation to environmental changes are likely to be complex and multidirectional, rather than unidirectional.

Samples 14, 15,16 and 21 show affinities which suggest that they might be equally at home in group C described below. They have for example, relatively high proportions of rainforest taxa whilst retaining high values for *Eucalyptus*. This suggests that they may form part of a transitional sequence

Group C: In contrast to Group B, this set of samples 9 (30 -31 cm) 13 (46 -47 cm), 17 to 20 (62 - 75 cm) and 22 (82 - 83 cm) are characterised by the indicator species, *Gunnera cordifolia* and *Pittosporum bicolor*. The latter is a common element in wet eucalypt forests, while the former is presently restricted to altitudes over 700 m in the western Central Highlands (Macphail, 1986). Other preferentials include *Phebalium* spp 1, *Phyllocladus aspleniifolius* 2, *Cyathea* spp 2, *Nothofagus cunninghamii* and *Pomaderris apetala* 4, all of which mark this group as an assemblage of wet forest and rainforest species. The presence of *Gunnera* is interesting for it may indicate cooler conditions during this period.

Samples 9,-13 are stratigraphically out of place in this sequence which suggests that short lived reversals of environmental conditions occurred during this phase or that the samples represent transitions from one phase to the next. For example, sample 13 has high values for *Dicksonia* and *Cyathea* which suggest a greater affinity to humid group C than the more xeric Group B.

Group D: This is the basal stratigraphic group and comprises samples 23 (86 - 87 cm) to 26 (102 - 103 cm). By far the most characteristic taxa of this group is the indicator species, Shrubs 4 which is chiefly made up of *Gonocarpus* spp. type pollen. Preferential species include *Ricinocarpus pinifolius* 1, *Labiateae* 1 and 2, *Melaleuca squamea* 1, and *Allocasuarina* spp. 4 and 5.

7.4.5 DCA analysis

The ordination reproduces the TWINPSAN groupings although a certain amount of overlap is attributed to the multi-dimensional nature of the data, which is in turn is a reflection of natural and sampling complexities.

Included in the analysis are three trap samples from the vicinity of Forester Marsh and three trap samples from a wet forest complex at Big Heathy Swamp (see Chapter 5.). Axis 1 of the ordination describes a gradient between two complexes of shrubs one of which is dominated by *Leptospermum scoparium, Leptospermum lanigerum, Meleleuca squarrosa* and members of the Fabaceae, Poaceae and Epacridaceae, while the other complex consists of Lamiaceae, Halagoraceae, *Boronia* spp., *Cyathea* spp. and *Gunnera cordifolia.* The gradient clearly separates groups A and C but fails to distinguish between groups B and C (Figure 7.2).

The second axis highlights the close relationship between the uppermost samples and the forester pollen traps. In so doing, all other samples are placed closer to the Big Heathy traps, than to those from Forester. This gradient is characterised by a shift from a typical dry sclerophyll / wet heath complex surrounding the Forester Marsh including *Leptospermum scoparium, Sprengelia incamata,* Poaceae, *Ricinocarpus, Goodeniaceae, Calandrinia* and *Acacia* to a more mesic complex dominated by *Meleleuca squamea, Tasmannia lanceolata, Coprosma* spp., *Pittosporum bicolor, Dicksonia antarctica* and *Nothofagus cunninghamii,* which are characteristic species of the Big Heathy area.

Just as the TWINSPAN analysis highlighted variations in the data which pointed to the presence of periods of transition, so the DCA analysis overlaps samples so that no clear ordination groups emerge from the central part of the core. The analyses suggest that changes did occur in the late Holocene of the northeast, but that they were subtle, marked by changes in regional rain forest pollen percentages which were independent of local dry forest pollen representation.

7.4.6. Zonation

In order to zone the intervening samples it is necessary to stress that although samples 9, 13 and 21 are classified in the TWINSPAN and DCA into stratigraphically incoherent groups, they are nevertheless part of a stratigraphic sequence which should be adhered to when calculating mean percentage values for any particular time period.

On this basis, effective zone boundaries are described (Figure 7.3, Table 7.2) which best mediate between the dilemma posed by the need to maintain stratigraphic integrity and the desire to describe real environmental changes.

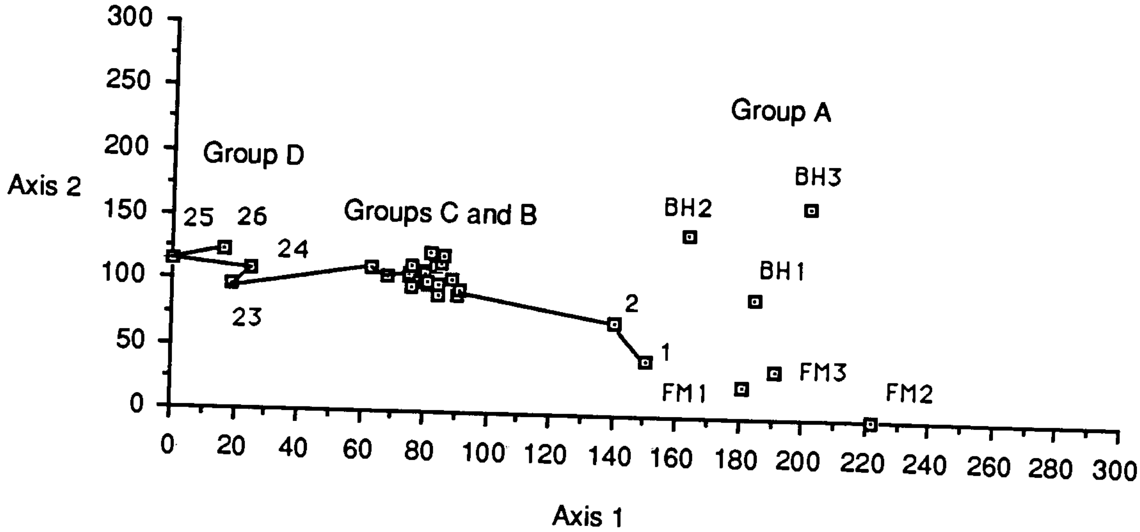


Figure 7.2. Forester Marsh. DCA axis 1 versus axis 2 for core samples 1 - 26 (0 - 103 cm) and pollen traps FM1 - FM3, BH1 - BH3. Solid lines join adjacent stratigraphic levels. TWINSPAN groups A and D are clearly differentiated from the tight cluster of groups B and C.

It is possible from the numerical analyses to see a distinct upper zone which represents the modern or European period (zone FM4: samples 1 -2). It is also possible to delineate a basal zone which characterizes the vegetation dynamics at the time of initial organic accumulation (zone FM1: samples 26 - 23). An additional zone boundary can be drawn between 43 and 46 cm which effectively marks an upper division between groups C (zone FM2: samples 21 - 17) and B (zone FM3: samples 16 - 3).

Zone	Samples	Depth (cm)	Zone Basal Age
F1	1 - 2	0 - 3	180
F2	3 - 12	6 - 43	2052
F3	13 - 22	46 - 83	3,500 +/- 130 (ANU-5114)
F4	23 - 26	86 -103	4,430 +/- 100 (ANU-5115)

Table 7.2. Basal ages of pollen zones. Ages for zones F1 and F2 are calculated from the mean rate of sediment accumulation (46.8 yrs.cm-1) as calculated in Section 7.4.3.

7.4.7 Pollen analysis: dryland taxa

The dry land percentage diagram (Figure 7.3) reveals trends which are consistent with the zones suggested by the TWINSPAN analyses. The zones are pollen assemblage zones, not climatic or successional zones.

Zone F4. From the time of initial peat accumulation at about 4,430 years BP (102 cm), F4 lasted for about 900 years. The zone is dominated by extremely high percentages of Halagoraceae pollen, most probably that of *Gonocarpus* spp. (28.9%, 10.8%). This locally over-represented taxa is, along with minor traces of *Exocarpus* sp., Euphorbiaceae and Scrophulariaceae pollen shown as 'other shrubby taxa' in Figure 7.3. *Nothofagus* percentages are low (3.2%, 2.2%) as are other regional rainforest and wet forest taxa such as *Phyllocladus* (0.6%, 0.3%), *Dicksonia* (3.4%, 1.1%), *Cyathea* (0.7%, 1.0%) and *Pomaderris* (1.2%, 1.1%). Taken together, the wet forest pollen representation suggests that rainforest was not locally well developed, and was probably restricted to favourable locations on the south slopes of Mt. Horror, 5 km from Forester Marsh.

Eucalyptus values are the lowest for the entire sequence (33.1%, 13.4%) although values do fluctuate between 19.8% and 45.3%. *Allocasuarina* spp. (16.8%, 4.6%) achieve the highest values for the entire core as do Epacridaceae tetrads (1.2%, 0.9%,

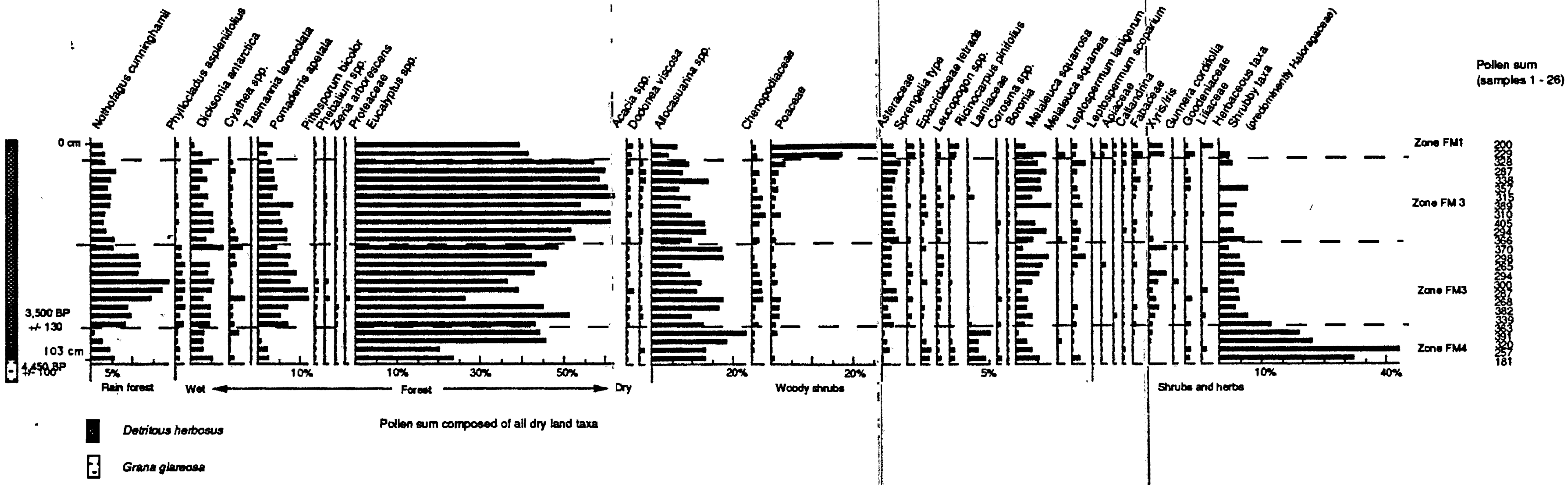


Figure 7.3. Forester Marsh. Percentage pollen diagram, dry land taxa only.

maximum of 1.9%), Lamiaceae (3.4%, 1.4%, maximum of 5.1%) and *Coprosma* spp. (0.3%, 0.4%). *Melaleuca squarrosa* (2.8%, 2.0%) pollen is well represented at the begining of the core but declines rapidly at the boundary between Zones FM4 and FM3.

Poaceae percentages are very low (0.5%, 0.6%) as are those for Chenopodiaceae (0.3%, 0.2%) and all remaining taxa. Taken overall, the assemblage seems to represent a mixed *Allocasuarina / Eucalyptus* forest or woodland with an understorey dominated by Epacridaceous heaths and a peculiar mixture of Lamiaceae shrubs (mint bushes) and *Coprosma* spp. pollen. This community mix is not represented in the surrounding vegetation today.

Zone F3: This zone covers a period of about 800 years. Like the other zones in the diagram, F3 is not uniformly represented across the spectra. Nevertheless, there is evidence that a substantial change occurred in both the local and regional pollen representation during this period.

Nothofagus (11.5%, 4.1%) reaches its peak values for the core during this phase as do *Phyllocladus* (1.6%, 0.5%), *Dicksonia* (4.3%, 1.9%), *Cyathea* spp. (1.2%, 1.1%) and *Pomaderris* (7.6%, 2.4%). Traces of wet forest types also achieve their greatest representation during this period although never suggesting a dominant presence in the local understories viz: *Pittosporum* (0.2%, 0.3%) and *Phebalium* (0.1%,0.3%). The highest value for *Nothofagus* (18.7%) some short time after 3,500 years BP, far exceeds the percentages recorded in surface samples or in the modern pollen rain (Chapter 5).

The mean values for *Nothofagus* recovered from pollen traps at Paradise Plains on the rainforest covered Mt. Maurice plateau at 900 m exceed about 13% only when traps are set closer than 500 m to a *Nothofagus* rainforest dominated forest boundary (see Chapter 5). Similarly, *Phyllocladus* values (max. 2.1%) are higher in zone F3 than in any pollen trap at Paradise Plains.

A striking rise is displayed by *Pomaderris* which reaches a peak mean value of 7.6% in this zone from a low of 1.2% in F4. It is generally accepted that rises in *Pomaderris* pollen can be explained by increases in precipitation (Colhoun *et al.*, 1990; Macphail, 1979) and in this sense the rise parallels that displayed by *Nothofagus* and *Phyllocladus*.

These trends argue for an expansion of rainforest and wet forest at about 3,500 years BP and which lasted for about 1,450 years. *Gunnera cordifolia*, attains a small but notable peak of 1.0% during this period. This low herb is presently restricted to high altitudes in central western Tasmania and may have managed to exist as a relict from Last Glacial times where ever supplies of water and cool air drainage allowed.

Taxa which have affinities with dry sclerophyll communities show some reductions consonant with increases in rainforest taxa. *Eucalyptus* (41.7%, 6.9%) falls to its lowest levels at 70 - 71 cm (19.8%) in a very marked decline as *Nothofagus* rises sharply at the same time. Modest peaks occur in Chenopodiaceae (1.1%, 0.8%), Poaceae (0.9%, 0.7%) and Asteraceae (2.0%, 0.8%).

A significant decrease in Haloragaceae type pollen from 28.9% in F4 to 5.2% in F3 points to significant changes in the local environment. This decline is difficult to explain but may be inversely related to *Sphagnum* spore counts which suggest that Haloragaceae was competitively excluded from ground surfaces surrounding Forester marsh by the expansion of *Sphagnum* moss during this period. *Xyris operculata* is a prominent component of fringing wet heath communities which surround the marsh today and seems to have been advantaged for the whole of zone F3 for it attained a significant and sustained peak during this phase when moisture availability seems to have increased.

Zone F2: From 43 cm to 6 cm, F2 occupies *ca* 1,870 years. The zone marks the decline of rainforest taxa at about 2,050 years BP and displays the full development of a sclerophyll forest in which *Eucalyptus* attained peak values (57.5%, 3.8%). *Allocasuarina* (9.7%, 2.7%) continues to decline in an irregular fashion from the levels in zone F4. The two major trends are a gradual decrease in *Pomaderris* towards the upper parts of the zone and a gradual rise in *Eucalyptus* over the same period.

Understories appear to be sparse, with little other than traces recorded from all taxa with the exceptions of *Pomaderris* (4.8%, 1.7%), Asteraceae (2.9%, 0.7%) and Myrtaceous shrubs such as *Meleleuca squarrosa* (4.9%, 2.3%) and *Leptospermum lanigerum* (1.4, 0.9%). The latter two species probably developed on the margins of the marsh, while the former two are widely dispersed taxa and most probably represent the presence of shrubby understories in wet forests nearer to Mt. Horror and the Forester River. A general decline by Xyridaceae / Iridaceae type (0.3%, 0.3%), probably indicates a general trend towards drying climates which resulted in decreases in the abundances of taxa confined to seasonally waterlogged soils.

Zone F1: The two uppermost samples are assumed on the basis of the presence of traces of *Pinus radiata* and *Plantago lanceolata* to represent the European phase which began in the area at about 1830 AD. The two samples therefore represent about 160 years of deposition. The major feature is a huge increase in Poaceae pollen (21.3%, 6.0%) from a mean of only 0.9% in zone B. This increase is attributed to the deliberate planting of exotic grasses by farmers in fields between 1 km and 5 km of the marsh. Additional features include a decline in *Eucalyptus* values to (40.0%, 1.4%) and the elimination of *Cyathea*. Declines are also seen in *Pomaderris* (2.4%, 0.9%)

Nothofagus(2.8%, 0.4%) and *Dicksonia* (1.5%, 1.4%).

Allocasuarina (5.0%, 1.5%) declined to its lowest levels for the entire sequence while *Acacia* (1.0%, 0.1%) attains a small peak. A feature of zone A is the occurrence of individually small, but collectively significant, contributions from taxa which are today well represented in the vegetation. Many of these taxa, such as *Leucopogon* spp. (0.7%, 0.5%), Goodeniaceae (0.5%, 0.1%) and Fabaceae (1.6%, 0.8%) are characteristic of heathy woodland and forest vegetation.

7.4.8: Pollen analysis: aquatic taxa

In comparison to large, relatively stable aquatic environments such as lakes or large expanses of minerotrophic bog, small closed basins can be expected to be poorly buffered against change. For this reason, aquatic taxa probably respond in a sensitive manner to even quite minor hydrological changes. The origin of the Forester Marsh basin is unclear, although its northwestern aspect and location in a belt of sandy gravels suggests that deflation of the soils by northwesterly winds may have occurred.

The Forester aquatic and Pteridophyte taxa do not conform exactly to the zonation defined by the dry land taxa and thus the spectra provide an example of the above mentioned assumption. Nevertheless, in order to provide a basis for comparisons to the dry land percentages, the following analysis confines itself to the zones developed above (Figures 7.4 - 7.9).

The only overall trend is the marked dominance of *Myriophyllum* (3.4%, 0.7%), *Gleichenia* (6.1%, 2.5%) and an unidentified, verrucate trilete spore (29.9%, 16.8%) in zone F4. *Gleichenia* species require high light levels and probably indicate the existence of low open communities on the banks of the marsh. Peaks of *Myriophyllum* pollen are in accord with the formation of a shallow aquatic system where watertables rose into a newly formed deflation surface.

The declines of *Myriophyllum* into zone F3 is associated with increases in Cyperaceae, Restionaceae, Monolete spores and *Sphagnum* spores which together seem to indicate the progressive development of community complexity, probably in response to successional and hydrological changes as water availability increased through time.

Cyperaceae pollen (1.2%, 1.6%), presumably *Lepidosperma longitudinale* has very low values in F4 followed by rises in zones F3 (14.0%, 7.9%), F2 (15.9%,6.9%) and F1 (17.1%, 6.7%). A substantial decline in Cyperaceae values at 70 to 71 cm is interpreted as a response to competition from *Sphagnum* which attains spectacular values at that level.

Restionaceae have low percentages in F4 (1.3%, 0.3%) before reaching their maximum

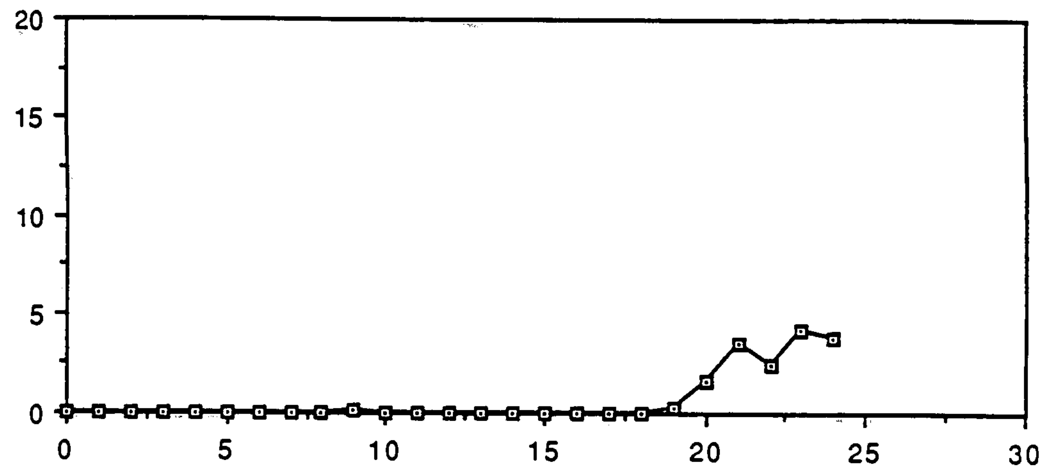


Figure 7.4. Forester Marsh. Percent *Myriophyllum* pollen (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

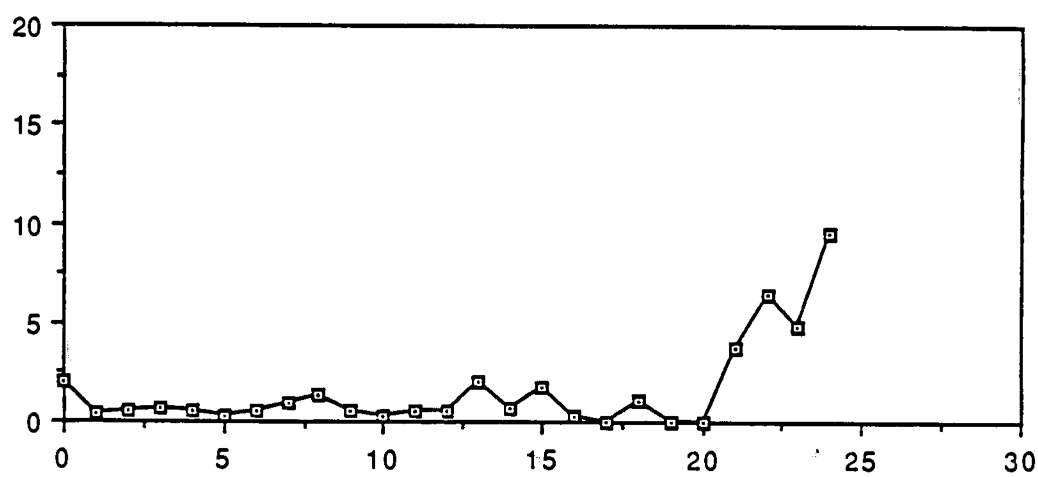


Figure 7.5. Forester Marsh. Percent *Gleichenia* spores (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

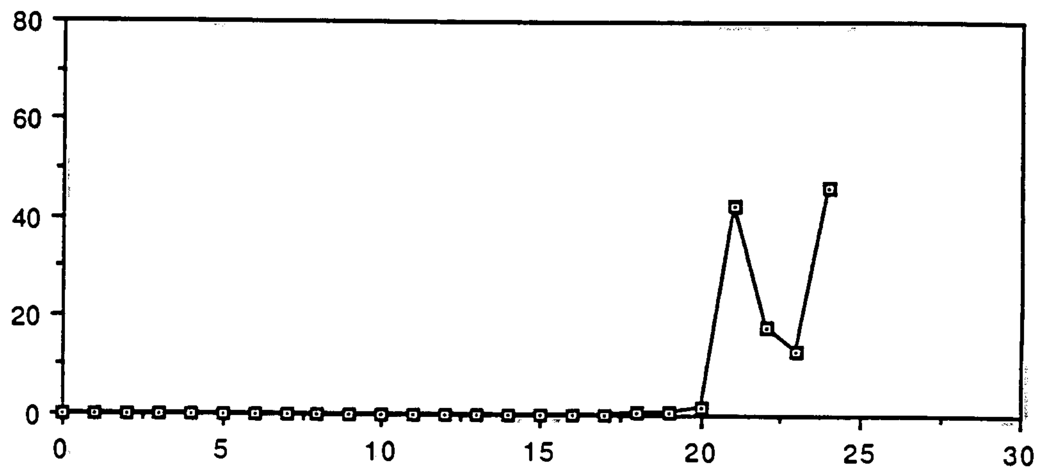


Figure 7.6. Forester Marsh. Percent trilete spores (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

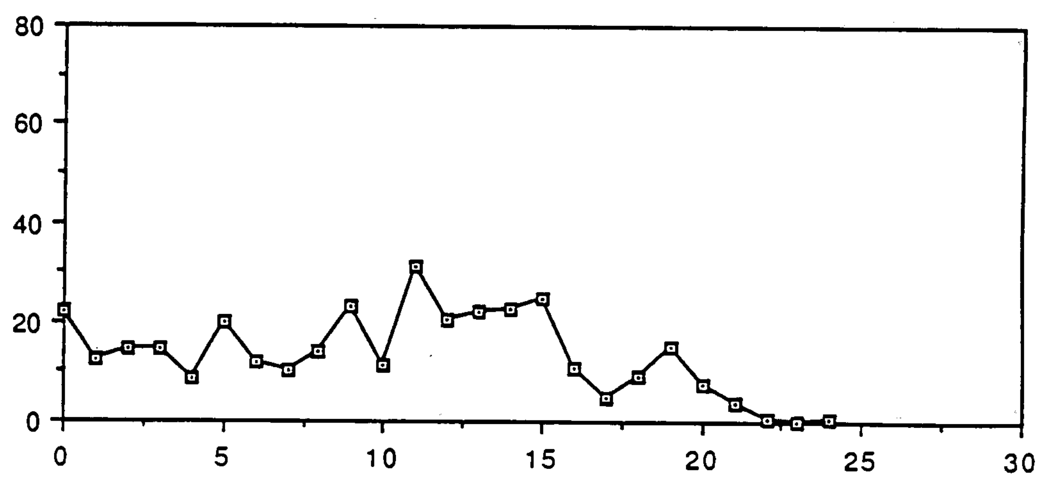


Figure 7.7. Forester Marsh. Percent Cyperaceae pollen (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

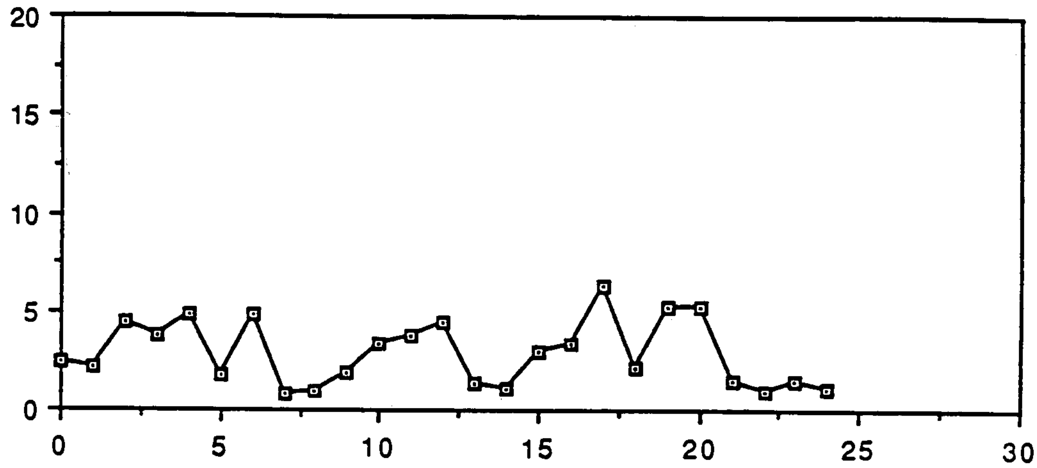


Figure 7.8. Forester Marsh. Percent Restionaceae pollen (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

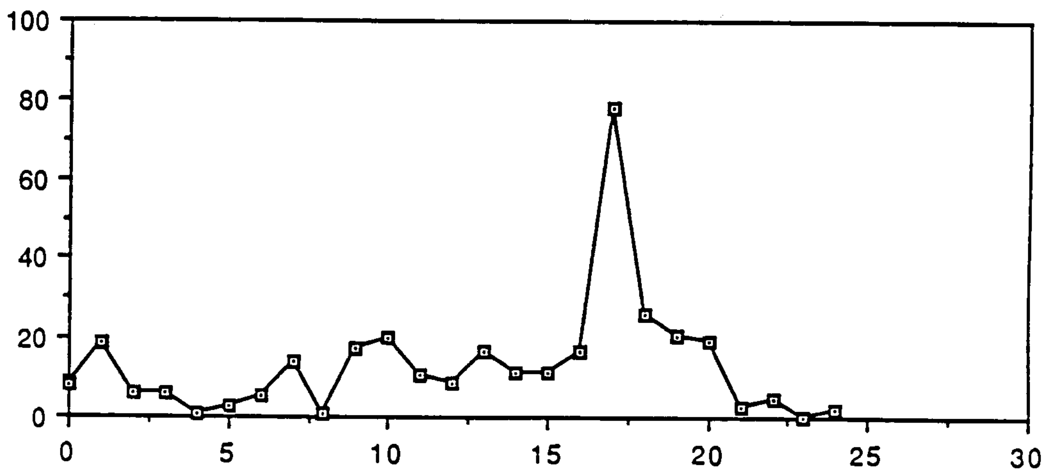


Figure 7.9. Forester Marsh. Percent *Sphagnum* spores (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

representation in F3 (3.9%, 2.0%) and thereafter varying in an irregular fashion in F2 (3.0%, 1.5%) before declining in F1 (2.3%, 0.2%).

Sphagnum spores are initially quite low in F4 (2.4%, 2.0%), before rising to high levels in F3 (27.3%, 23.5%) with an extraordinary peaks of 78% at 70 - 71 cm and 62.5% at 66 - 67 cm. *Sphagnum* is a genus which depends on constant supplies of water for its existence (Tallis, 1983; Whinam *et al.*, 1989). In the sub-humid northeastern lowlands, *Sphagnum* cannot prosper in the absence of constant supplies of groundwater. In order that *Sphagnum* could increase its representation so dramatically, it was necessary for either precipitation to increase or for ground water supplies to be charged at levels greater than exist today. Under these conditions, *Sphagnum* would most likely have expanded into sedge and rushlands and possibly even have occupied the entire outer perimeter of the marsh, leaving a central area of standing water with a sparse population of sedges.

Whereas the decline of Cyperaceae as *Sphagnum* increases points to a restriction of the space available to aquatic sedges, an increase by members of the Restionaceae probably indicates a larger area of poorly drained soils surrounding the marsh. Rushes such as *Restio australis* and *R. complanatus*, commonly grow in *Sphagnum* communities (Whinam *et al.*, 1989) and thus can be expected to co-vary positively with *Sphagnum.*

In summary, F4 represents the establishment of an aquatic / organic system on site. At this time, open conditions existed in the basin, with dominant populations of *Myriophyllum, Gleichenia* and an unidentified spore. F3 seems to reflect increases in water availability such that Cyperaceae, *Sphagnum,* Restionaceae and fern spores show increases. F2 and F1 display changes which point to variations in water availability and the eventual dominance by sedges and rushes. The decline of *Gleichenia* and the absence of *Myriophyllum* from these upper zones suggests that banks were becoming progressively drier and more shaded while the center of the marsh was being colonized by sedges.

7.4.9 Concentration analysis

Total pollen concentrations do not conform to the zones developed by the percentage analysis. The total concentration curve is marked by a major peak at 34 cm to 35 cm and a number of smaller peaks elsewhere. Pollen concentrations are likely to exhibit widely fluctuating values (Birks & Birks, 1980) and without precise chronological control are difficult to interpreted. Nevertheless, although the curves are out of synchrony with percentage derived zones, they do highlight the same general trends and are very useful, especially in regard to assessing the inputs of regional taxa which do not experience the same level of fluctuations as local taxa (Figure 7.10).

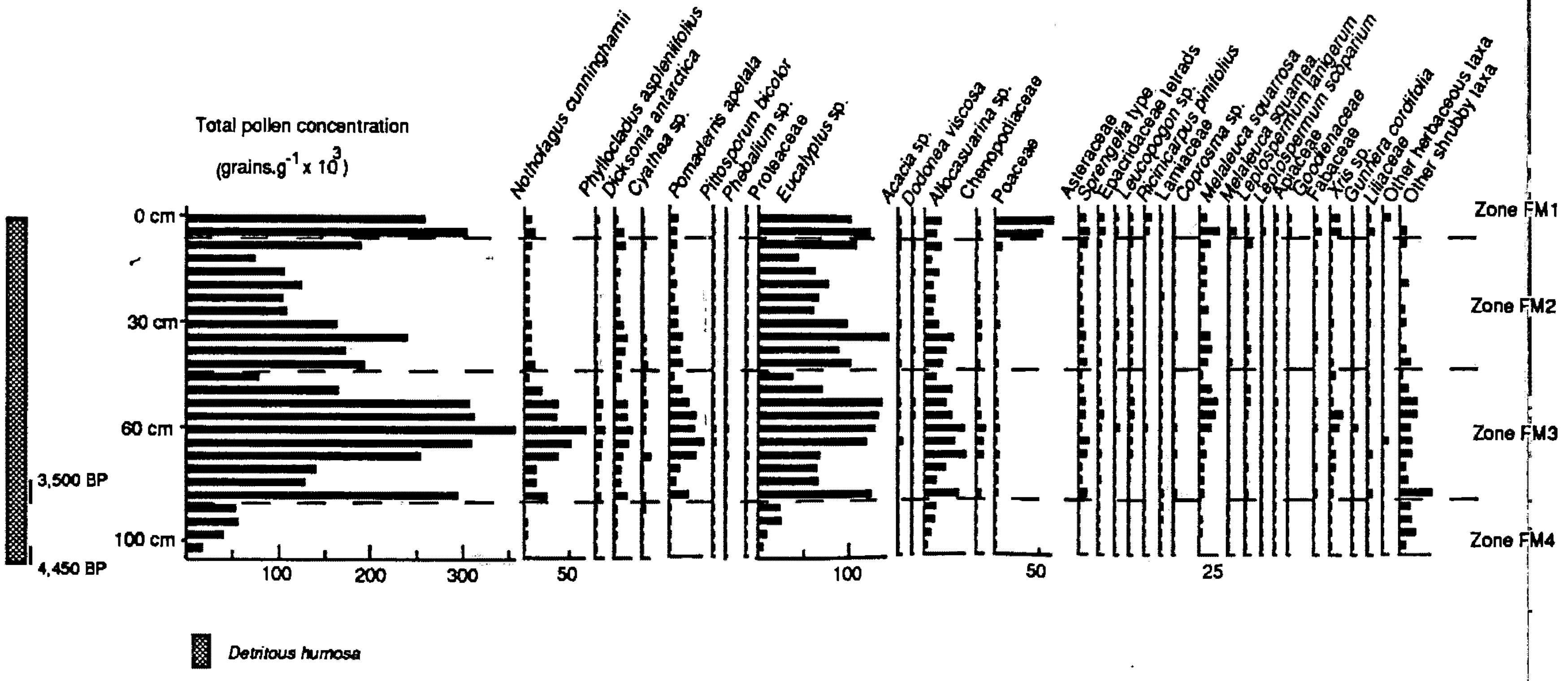


Figure 7.10. Forester Marsh. Pollen concentration diagram, dry land taxa only.

To a large degree, total pollen concentrations are dominated by *Eucalyptus* which has been the dominant genus since the beginning of organic accumulation at the site. Total values range from 15.8 x 10^3 grains.gm to 354 x10^3 grains.gm. In contrast to its percentage values, *Eucalyptus* concentrations are much more variable, ranging from 3.7 x10^3 grains.gm to 144.3 x10^3 grains.gm.

Low concentrations in zone FM4 at the base of the core might be explained by the effects of grain oxidation and degradation at a time when an anaerobic peat cover had not yet developed may also be a significant factor. In FM4, *Halagoraceae* pollen provides proportionally more pollen than any other type. Macphail (1986) has commented that the ability of certain taxa to prosper on seasonally dry surfaces may be useful in the detection of hiatuses in organic accumulation. *Gonocarpus micranthus*, a herb commonly found in wet land margins, may be the taxa involved.

Nothofagus, Phyllocladus, Dicksonia, Cyathea, Pomaderris, Zieria, Phebalium and *Pittosporum* all reach peaks between 79 cm and 46 cm or about 3,500 years BP and 2,150 years BP. *Allocasuarina* and Chenopodiaceae pollen also increase during this period. This maximum in rainforest pollen concentrations correlates well with similar trends in the percentage data. Evidence from Waterhouse Point indicated that a late period of climatic optimum occurred in the northeast which lasted until about 2,000 years BP and thus, evidence mounts that a late Holocene phase of moisture availability occurred in the northeast.

The major contributor is *Eucalyptus* which achieves its most sustained peak in the latter part of the wet forest increase from 67 - 54 cm. Even though *Eucalyptus* is seen to be quite variable in terms of absolute pollen concentrations, it is still true to state that it has always maintained its position as the community dominant. Some of the concentration fluctuations can be attributed to canopy density changes as cohorts of fire promoted seedlings grow to maturity, but this is not regarded as a full or even testable proposition. A prominent decline in percentages at 70 cm is matched by a similar decline in concentrations and may be attributed to an expansion of poorly drained ground on the margins of the marsh which disadvantaged drought adapted *Eucalyptus* species. Other fluctuations remain unexplained.

The most obvious response in the diagram is the restriction of Poaceae to the upper 3 cm where it achieves a peak of 65.2 x 10^3 grains.gm. Below 3 cm, Poaceae never rises above 6 x 10^3 grains.gm.

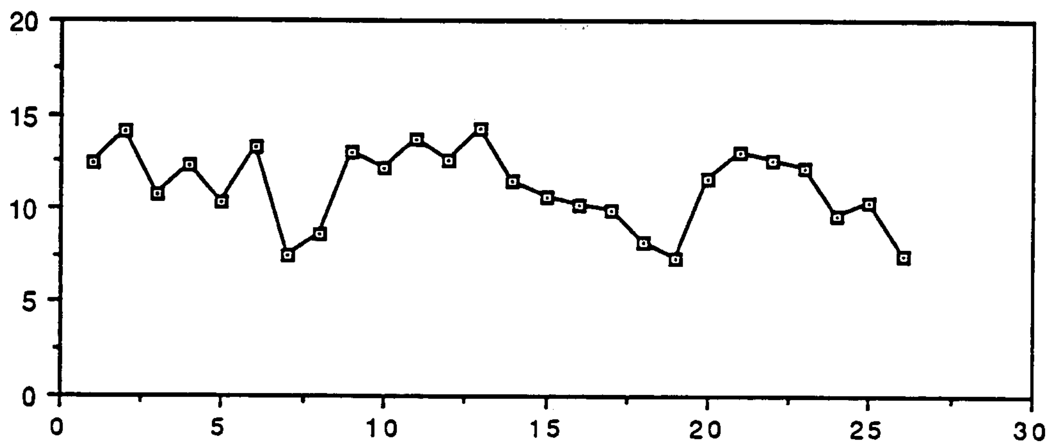


Figure 7.11. Forester Marsh. Carbon particle / pollen ratios (y axis).
Samples 1 - 26 (x axis) are in increasing order of depth from 0 cm to 103 cm.

7.4.10 Carbon particle analysis

The data are remarkably clear in that there is evidence for large inputs of carbonized particles for the entire sequence in a manner suggestive of cp histories obtained from other inland low country sites in Tasmania (eg. Colhoun *et al.*, 1990). All that can be claimed is that fire must be considered an integral part of the environment at Forester Marsh. There is little pollen or CP evidence for any initiation or cessation of fire except for a slight decline in CP representation at about 3,500 years BP and 1,000 years BP (Figure 7.11).

The pattern suggests that Aboriginal fires neither increased nor decreased over the past 4,500 years. During this period, fire frequencies were sufficient to ensure the perpetuation of *Eucalyptus* forests but insufficient to cause the thinning of forests into woodlands or open formations.

7.5 Discussion

The Forester core is particularly interesting in that for the first time, a history of a northeastern dry sclerophyll forest is available. The sequence spans the last 4,500 years of the Holocene and allows an appreciation of climate change from the perspective of a sub-humid site balanced between moisture deficit and moisture surplus. Small lowland basins such as this are expected to be more sensitive to moisture fluxes, than either highland sites or western Tasmanian sites.

In lowland northeast Tasmania where summer drought stress is considerable, even very minor positive changes to the water budget might have affected community composition. Decreases in moisture input would have heightened drought stress and possibly eliminated water sensitive taxa such as *Sphagnum* and *Lepidosperma longitudinale*. Increases in moisture inputs to such a small basin would have allowed the growth of taxa whose growth had previously been restricted by summer drought. That increases in the water budget occurred at the marsh is suggested by the responses of wet forest and aquatic taxa, both of which increase between about 3,500 and 2,900 years BP.

Increases in moisture availability can be explained by lower temperatures, rises in precipitation, or local alterations in the evapotranspiration regime. Paludification due to climate change, rising post glacial watertables and forest clearences is a well established phenomenom in Europe and North America. The European evidence points to the formation of organic deposits at any time between the present and 5,000 years BP (Frenzel, 1983.). It is difficult to disentangle the effects of these processes, but some evidence from the various analyses can be brought to bear on the conundrum.

Climate change

On a global scale, the evidence for Holocene climate change is substantial (Grove, 1988). The New Zealand evidence is most pertinent and consists chiefly of glaciological studies which demonstrate a number of glacial advances during the Holocene. Gellatly (in Grove, 1988: 349) concluded that glacial advances occurred between 11,500 and 10,500 years BP and at 8,000, 5,000, 4,5000 - 4,200, 3,700, 3,500 - 3,000, 2,700 - 2,200, 1,800 - 1,700, 1,500, 1,100 years BP and up to three times in the past 1,000 years.

Glaciated locations in Alaska, the European Alps, Scandanavia, the Himalayas, New Zealand and South America display synchrony in terms of major phases of ice expansion at about 4,600 years BP and 3,200 years BP (Grove, 1988: 351, Table 10.5). In spite of their southern latitude insularity, it is hardly possible that mainland Australia and Tasmania were insulated from global cooling trends.

On mainland Australia, dates between about 4,000 years BP and 1,500 years BP attest to slope activity during the late Holocene (Costin, 1972; Peterson, 1969 in Macphail & Hope, 1984; Hughes &Sullivan, 1981; Williams, 1978). In southern Tasmania dates of 4,435 BP, 4,360 BP, 3,850, 3,040 BP (Goede, 1965,1973); 3,840 BP, 3,575 BP (Wasson, 1977); 3,500 BP and 3,050 BP (Caine, 1968) point to the formation of alluvial fans and river terraces due to an increased availability of sediment supplies.

Caine (1978, 1983) has obtained dates of 3,940 +/- 110 BP (Beta-2109), 3,520 +/- 100 BP (Gak 668) and 2,340 +/- 90 BP (Gak 669) from slope deposits in northeastern Tasmania. He points out that these results represent localized episodes of hillslope instability. The combined data set strongly suggests an increase in moisture availability during the late Holocene. Whether this was due to increased precipitation or a lowering of temperatures leading to increased moisture effectiveness is difficult to ascertain. Williams (1978:96) suggests that the slope activity at this time can be explained by"a combination of lowered temperatures, less rainfall, more wind, more frost, and episodic fires".

In a convincing demonstration of climate change, Goede & Hitchman (1983) and Goede *et al.*, (1990) have shown from carbon dating and oxygen isotope analyses of speleothem sequences that mean annual temperatures in northern Tasmania were depressed some 2^0 -3^0 C compared to today between about 4,100 years BP and 3,000 years BP. This evidence suggests that the previously mentioned slope deposits may have been aided by increases in effective ground water moisture consequent upon a lowering of temperatures.

Useful data from Tasmanian mires comes from Macphail & Hope (1985) who, after a consideration of rates of accumulation of peats from highland sites in southeastern Australia, suggested that cooler conditions sometime soon after 3,500 years BP may have stimulated the accumulation of organic material by creating effectively wetter conditions due to a 'substantial' decrease in evaporative losses (Macphail & Hope, 1985: 348).

Despite this substantial body of evidence, there has been to date, little convincing pollen evidence for episodes of Holocene cooling. Pollen evidence from sites around Tasmania show little indication of temperature declines during the last 4,000 years of the Holocene. Macphail (1979, 1980, 1986, 1988) indicated that trends towards sclerophylly in the vegetation of eastern Tasmania probably indicated regional trends towards drier and cooler climates during the late Holocene, but he was unable to convincingly differentiate between climatic effects and those caused by burning of the bush by Aborigines. Similarly, other pollen based vegetation reconstructions (Colhoun,1975; Colhoun & van de Geer,1986; Hill *et al.*, 1988) display no substantive pollen changes which can be linked to temperature decreases at about 4,000 years BP.

In an assessment of Macphail's pollen evidence, Markgraf *et al.*, (1986:379) emphasise that effective moisture is a function of temperature and precipitation so that moisture availability at sites with relatively high temperatures and high rainfall may have the same effective moisture experienced at sites with lower temperatures and lower rainfall. The mutability of such parameters provides evidence, in their opinion, of synchronous regional changes in major pollen taxa across the western part of the state. Their position has been severely criticized by Colhoun *et al.*, 1990), but is useful in that local site parameters are considered a significant influence on plant dynamics along with climate.

The distance between geomorphological and palynological evidence in regard to late Holocene cooling can be resolved if due consideration is given to the types of evidence, the location of pollen core sites and the physical characteristics of pollen sites.

The humid environment of western Tasmania is well suited to resolving major changes such as the transition from Pleistocene to Holocene, but is singularly ill equipped to respond to small variations in precipitation, the effects of which may have gone unnoticed in pollen records from sites with a surfeit of water.

In the northeast, climates are less humid than in the west. Plant communities are ordered according to position along moisture gradients (see Chapter 5). In the lowlands, wet forests are only found where watercourses or southerly aspects increase moisture availability. In situations such as these, plant communities occupy a finely balanced position between precipitation inputs and evaporative losses with many distributions dependent on aspect and between precipitation inputs and evaporative losses. Even small fluctuations in temperature or precipitation would have major effects on distributions. A similar situation is expected to have occurred in the past, especially during the Pleistocene when precipitation gradients across Tasmania were even steeper than those experienced today, and during the latter part of the Holocene when statewide climates were drying (Bowden, 1983; Colhoun, 1978; Macphail, 1979). temperature declines would have greatly affected small closed basins, by allowing more effective surface water flow consequent upon reductions in evaporation and evapotranspirational losses (Ingram, 1983).

A decrease in temperature of 2^0 to 3^0 as suggested by Goede *et al.*, (1990) would have increased the effectiveness of moisture into the closed basin of Forester Marsh and contributed to the instigation of mire formation at *ca* 4,500 years BP. By 3,500 years BP a threshold seems to have been crossed which enabled regional wet forests to expand and local aquatic communities to become dominated by *Sphagnum* spp. and associated graminoids.

Increased run-off from steep hill country around Mt. Horror would have altered the flow regime of the nearby Forester River. Summer flows might have been higher and more regular than at present, while spring flows were possibly swollen by increased winter snow falls. Two results of temperature decline and consequent enhanced moisture availability might have been an expansion of rainforest along the Forester River corridor and an expansion of mesophytic taxa onto open slopes from drought and fire protected gullies.

High values for *Nothofagus, Phyllocladus, Phebalium, Pittosporum, Zieria, Pomaderris* and Proteaceae types in zone F3 support the interpretation that both rainforest and wet eucalypt forest taxa expanded during this phase. The expansion is more likely to have had origins on the damp southern slopes of Mt. Horror to east of the marsh than from the undulating plains to the west.

This interpretation is also consistent with the evidence from the Waterhouse Point area which points to regional rainforest increases in the northeast during the mid to recent Holocene period. Although it is possible that purely local hydrological factors caused a rise in *Sphagnum* percentages at Forester Marsh, this is not a sufficient explanation for concomitant rises seen in the regional wet forest taxa *viz. Nothofagus cunninghamii, Phyllocladus aspleniifolius* and *Pomaderris apetala.*

Higher river and creek discharges would have increased the extent of fringing swamp forests and probably allowed outlying rainforest pockets to expand out of drought and fire protected refuges (where they exist today).

The implications of mid Holocene climate change for human settlement

Climate changes have the potential to alter settlement patterns on a number of scales. At a very local level, an increase in precipitation over a decade or so could easily sway decisions concerning the siting of settlements. Likewise, a sustained period of temperature decline might convince people to seek more sheltered places to live and work. Associated with basic climatic oscillations are environmental changes which may alter resource availability or security.

Cosgrove *et al.*, (1990) and Jones (1977, 1984) have suggested that a general expansion of forests in southwest Tasmania at about 12,000 years BP forced people out of previously open grasslands. Although the mode and scale of the change can be challenged (Chapter 8), the hypothesis is an example of how global warming may effect settlement patterns. During the Holocene, climatic and vegetation changes have been of a lesser magnitude than those at the transition from Pleistocene to Holocene (Macphail, 1979; Colhoun *et al.*, 1988) but this should not be taken to indicate that people did not make settlement decisions during the Holocene which were either insignificant or detached from the influences of climate change.

For example, in the Forester area, it is possible that an expansion of rainforest at about 4,000 years BP caused a shift in the local economic fabric so that site placements were altered in order to keep campsites located on wet forest / dry forest transitions. This might be considered a dynamic version of the hypothesis suggested by Cosgrove (1984). Likewise, people may have moved their entire settlement focus from river banks to northwestern slopes in order to take advantage of sunny aspects during the cool climates which prevailed. Places which were once dry underfoot, may have become boggy due to rising watertables with a consequent re-alignment of preferred paths and work places.

Additionally, it is possible that an expansion of rainforest resulted in a more equable distribution of food resources, so that *Cyathea* and *Dicksonia* for example, were more easily accessible. The cool shaded habitats of the giant crustacean *Astacopsis gouldii* Clark (an example of invertebrate megafauna?) and various edible fruits and fungi would also have expanded, leading to increases of formerly restricted resources.

In the northeast generally, campsites formed during the period 4,000 to 2,500 years BP might be expected to be significantly more dispersed throughout drier parts of the landscape, owing to greater availability of moisture in places which previously suffered from deficits. Additionally, sea surface temperatures may have lowered sufficiently to cause changes in the availability of marine resources.

Effects of this kind are well documented in the northern hemisphere, with the most famous episode being the 'Little Ice Age' which caused massive crop failures during the 14th and 15th centuries (Grove, 1988). Many examples exist which describe harvest failure, grass growth and insect and avian migrations. More interesting are the documented effects of temperature declines on the availability of marine availabilities. The kidneys of the European cod for example (*Gadus morhuna*) are sensitive to low temperatures so that their distribution varies according to sea water temperatures. Fluctuations of as little as 2^0C cause the migration of whole fisheries. Failures of the cod fishery around Iceland and the Faroe Islands caused widespread hardship for many decades of the 17th and 18th centuries (Grove,1988:392). Plots of fish distributions against sea surface temperatures in the north Atlantic demonstrate the sensitivity of marine organisms to temperature fluctuations (Table 12.6 in Grove, 1988:393).

The well known Tasmanian controversy concerning the rejection of fish as a dietry item at about 3,500 years BP has been a subject of debate for over two decades. Some people argue that environmental factors led to a decision to stop eating fish (Allen, 1979), while others see cultural practices, such as taboos, as being more efficient at explaining the phenomenon (Jones, 1966, 1971a, 1975, 1977, 1978). The evidence presented in this chapter suggests that the timing of the initial cessation coincided with a mid Holocene cool, humid phase, perhaps resulting in lowered sea surface temperatures. Changes in the representation of various species of *Mytilus* spp. (mussels) during the mid-Holocene have been attributed to salinity fluxes in the Derwent estuary in southern Tasmania (Stockton, 1982) and these may also relate to precipitation changes.

Archaeological evidence from Rocky Cape Jones (1966, 1971a, 1977, 1978) suggests that terrestrial resources replaced fish as a food resource. This implies a greater use rate of terrestrial resources and possibly an expansion by some coastal tribes into under-utilized inland forests. This hypothesis can be tested by research directed to examining the physiology of fish species represented in archaeological sites and by investigations of the diachronic changes within non-coastal Aboriginal sites.

Fire history

The Forester core does not detail changes in pollen stratigraphy which can be attributed to changes in cp input. High levels of cp occur throughout the core thus demonstrating that fires have been an integral part of the dynamics of dry eucalypt forests for at least the past 4,000 years. An expansion by rainforests from about 4,000 years BP to 2,500 years BP took place in spite of a continual history of burning at the site. Rainforest pollen taxa are likely to be recruited from regional rather than local sources and from this it is deduced that fires lit by Aborigines did not normally burn areas of rainforest. Fires were likely to have been restricted to dry *Eucalyptus* communities.

The classic line of reasoning followed by adherents of the firestick farming hypothesis (Jones, 1969, 1975) is that people burnt to improve the growth of grass in order to attract game. The Forester core shows no evidence at all of grasslands or grassy woodlands having existed in the dry forests surrounding the marsh for at least 4,500 years. Burning seems to have favoured the growth of heathy rather than grassy understories, in particular, those dominated by *Allocasuarina*, Myrtaceous shrubs and members of the Epacridaceae. It is possible therefore, that Aborigines preferred, in certain circumstances, to utilize the resources of heathy forests in preference to grassy communities. Certainly the heathy forests of the northeast have large complements of marsupials including kangaroos, small wallabies, possums and echidnas despite a lack of grassland.

The berry and tuber resources of heathlands are considerable, and unlike grasslands, provide a convenient set of food resources which are palatable to marsupials, avians and humans alike. Aborigines are today fond of eating berries and fruits from species of *Acacia*, *Exocarpus*, *Leucopogon*, *Astroloma*, *Cyathodes* and *Epacris*. People are also keen to consume the immature fruits of *Allocasuarina* (R. Summers & D. Shaw, Tasmanian Aboriginal Centre Inc). Rhizomes of *Pteridium esculentum* and the central pith of *Xanthorrhoea* spp. would also have formed easily obtainable energy sources. From this it is possible to envisage a burning regime which was designed to encourage heaths and heathy dry forests.

An assessment of the Waterhouse pollen results indicated that burning of forests on the coast led to a decline of *Eucalyptus* which resulted in the formation of a heathland. However, burning was not solely responsible, for oceanic salt spray effects and progressive podsolization of dune sands are likely to be equally as significant. At Forester Marsh, 4,500 years of burning did not remove or even reduce forest cover. Dry sclerophyll forests appear to have undergone a number of minor changes in understories, the most prominent being a change from Lamiaceae shrubs to heaths at about 3,500 years BP.

Much more significant changes occurred in the local aquatic and regional wet forest vegetation. Here, the effects of fire were not sufficient to stop the advance of rainforest on surrounding hills or the development of *Sphagnum* at the marsh. It is not clear if people deliberately allowed rainforest to advance by not raising fire frequencies or by keeping fire intensities under control, but it seems possible that increases in wet forests may have been welcomed by people who were surrounded by large tracts of dry forest. This suggests that in a region with a limited area of rainforest compared to dry forest, Aborigines might have been careful not to allow fires to escape into wet forests.

In the following chapter, this proposition is tested in relation to high altitude areas which are dominated by wet forests, rainforests and buttongrass moorlands. Pollen analyses from those places should allow comparisons with lowland vegetation trends as well as provide a forum for the exploration of a number of controversial issues, pre-eminent being the extent of Aboriginal burning in forested highlands and an examination of vegetation dynamics in buttongrass moors from a longer term perspective than is obtainable from phytosociological vegetation surveys.

Chapter 8

Late Holocene pollen changes in the northeastern highlands

8.1 Introduction

This chapter describes and interprets pollen data derived from two peat deposits and one archaeological site in the central mountains of the northeast. The questions adressed by the chapter are:

1) What is the regional vegetation history of the montane plateaux of the northeast?

2) What processes led to the formation of mires on substrates which commonly carry a mosaic of rainforest and *Eucalyptus* forest and which appear to be little different in terms of ground slope and aspect to adjacent forested sites?

3) How old are the moorland and bog peats of the northeastern highlands?

4) What evidence, if any, exists to demonstrate the effects of fires lit by Aborigines on the forests of the highlands?

8.2. Methods

Two mire sites were selected as good examples of shallow blanket bogs which commonly occur in the highlands. The first site, Big Heathy Swamp, is dominated by Restionaceae and Liliaceae species and is presently surrounded by tall wet eucalypt forest. The second site, Una Plain, is a cyperaceous moorland dominated by *Gymnoschoenus sphaerocephalus* which is fringed by a mosaic of rainforest and eucalypt forest. The location of both bogs on slopes and substrates which seem in no way unusual from surrounding ground and which presently support full forest vegetation suggested that both sites would be suitable to address the above questions.

In addition, pollen was analysed from a small number of soil samples extracted from the excavation of a rockshelter located in a rainforest gully on the margins of Una Plain. A comparison of basal dates and pollen from this site with those obtained from the two bogs allowed strong arguments to be developed concerning the effects of Aboriginal burning practices on highland vegetation.

Field methods follow those described in Chapters 5 and 6.

8.3 Big Heathy Swamp

Big Heathy Swamp is a shallow bog situated at 900 m, which stradles the interfluve between the North and South Esk Rivers (Plate 8). The bedrock geology of the site is granite with deep forest soils developed on Devonian granite and Permian sandstone colluvial slope deposits. Big Heathy provides an opportunity to investigate the development of a mire located in an environment which is more fertile than the blanket bogs of the Mathinna Plains (see Section 8.6).

The vegetation of the area is mostly *Eucalyptus* regrowth forest with isolated large examples of *E. delegatensis* and *E. dalrympleana*. Rainforest species such as *Nothofagus* and *Atherosperma* are commonly found in deep fire protected gullies. The transition from open bog communities to forest is marked by up to 100 m of *E. rodwayi* woodland (Plate 8). Sparse understories on the western margin of the bog include *Coprosma nitida*, *Persoonia gunnii*, *Tasmannia lanceolata* and *Cyathodes glauca*. A ground layer of *Poa* spp. and ferns has established with *Poa* tussocks dominant in open locations. On the eastern margins of the bog, a dense understorey of *Oxylobium ellipticum* and *Leptospermum lanigerum* grows under a forest of *E. rodwayi*.

The surface of Big Heathy Swamp consists of a dense mat of *Empodisma minus* with low mounds of *Astelia alpina*, *Callistemon viridiflorus*, *Leptospermum lanigerum* and *Melaleuca squarrosa* up to 2m high, grow on hummocks consisting of decayed *Astelia alpina*. A series of disconnected open water depressions up to 5 m in diameter are distributed across the bog. The origin of these depressions is not clear.

8.4 Results and analyses

8.4.1 Stratigraphy

Turfa herbacea (peat with roots and humic substances) extends down to 20 cm which grades into very dark brown *Detritus granosus* (peat with fragments of herbaceous and ligneous plants). Between 51 - 55 cm is a horizon of *Grana suburralia* (coarse sands and fine gravel) which overlies 60 cm of *Argilla steatodes* (fine clay) which is very heavily gleyed. This, in turn, overlies hard packed gravels which are derived from Devonian granite basement rocks.

8.4.2 Dating

A basal peat sample from 47 - 50.5 cm was dated to 5,050+/-210 BP (ANU-5112). A second sample from 20 - 25 cm returned a date of 1,900+/-80 BP (Beta-25272). In such a short core, there is a chance that contamination of the lower levels by younger carbon could have occurred; (Colhoun, 1986), but a comparison with dates obtained from similar depths in cores from other parts of the state suggests that the date is acceptable (Colhoun, 1985).

In western and central Tasmania, at similar altitudes to Big Heathy Swamp, it is often possible to correlate pollen shifts with lithological changes at the Pleistocene / Holocene transition. For example a change from herb to forest dominated assemblages at that time would be accompanied by a change from minerogenic to organic sediments (eg. Colhoun & van de Geer, 1986; Macphail, 1979). This core shows an analogous pollen change that is located well above a lithological break from sandy clays to peat, and thus, the change is highly likely on stratigraphic grounds alone, to represent a time more recent than the Pleistocene / Holocene transition. This puts the pollen change out of synchrony with Tasmanian regional climatic trends and supports a proposition that the basal date is a reasonable estimate for the age of the organic section of core. A date of 1,900+/- 80 BP obtained from the 20 - 25 cm level argues that the basal date is of the correct order of magnitude.

Colhoun's reservations should be heeded but not taken to indicate that the dating of shallow cores is a fruitless or misleading enterprise, neither should it be taken as a general prescription which applies to all cores.In fact it is considered crucial to heed and act upon Macphail's (1981) exhortation to date and categorize the shallow blanket bogs which make up such a large proportion of the Tasmanian landscape.

8.4.3 Accumulation rates

The section of the core from 0 cm to 25 cm has a maximum age at one standard deviation of 1,980 years and a minimum of 1820 years. The average accumulation rate is therefore 76 yr.cm-1 (0.01 cm.yr). The average rate in the lower section between 25 cm and 50 cm is 126 yrs.cm^{-1} (0.008 cm.yr).

8.4.4 Zonation

The diagram was divided into two zones based on visual changes in the pollen stratigraphy (Figure 8.1). The lower 4 samples extending from 47 - 32 cm are placed in zone B1, while the upper 10 samples from 29 - 0 cm are placed in zone B2. The division is based chiefly on the distribution of *Eucalyptus* percentages which have means and standard deviations of 12.8% and 2.5% in zone B1 and 32.7% and 7.2% in zone B2.

8.4.5 Pollen analysis: dry land taxa

Regionally dispersed taxa show interesting trends which are consistent with the removal of rainforest and its replacement by grassland or open woodland (Figure 8.1). Initial low values for *Nothofagus* were short lived, for by 37 cm, *Nothofagus* achieved its highest values for the sequence. However, this high level was ephemeral. In B1, *Nothofagus* values (5.8%, 2.2%) fluctuate markedly. *Phyllocladus aspleniifolius* is initially absent but then increases before declining again at the base of B2. The tree-like fern, *Dicksonia antarctica*, maintains consistently high values (10.4%, 2.0%) for the entire period represented by B2. *Dicksonia* is known to survive the burning of rainforest and with the removal of major canopy species can achieve dominance. Towards the top of B1, *Pomaderris* increases to its maximum values (3.8%, 2.8%).

At the commencement of B1, Poaceae, with a value of 22.2%, was dominant in the vegetation surrounding the swamp. The same sample contained high percentages for Asteraceae (10.0%), Epacridaceae tetrads (7.0%) and *Astelia alpina* (4.9%). *Nothofagus* (1.2%) and *Eucalyptus* (13.6%), have low values at the same level. This suggests that the vegetation at the time of initiation of organic accumulation was open forest or woodland.

The major local and extra local trends in B1 are a decline in Poaceae (12.0%, 8.1%) from high initial values to quite low values at the top of the zone, continual low percentages for *Eucalyptus* (12.5%, 2.6%) and consistently high percentages for Asteraceae and Epacridaceae tetrads. Taken together, these could indicate a woodland with a shrub rich grassy understorey. The wet heath species, *Sprengelia incarnata* rises sharply (7.8%, 5.8%) from quite low values at the base (4.1%). Likewise, *Leptospermum* (5.6%, 2.4%) has initial low values followed by significant increases which terminate at the base of B2. *Astelia alpina* , a lily characteristic of open, cold and wet environments, almost drops out of the record from 43 - 36 cm, but makes a marked recovery at 32 - 33 cm (3.9%, 3.6%).

Herbaceous taxa are poorly represented throughout the entire sequence. In B1, an assemblage of herbs (1.3%, 1.6%) comprising *Ranunculus, Asperula* and *Euphrasia* and *Acaena novae-zelandiae* are present throughout (including the lower part of B2), before declining in the central part of B2. Traces of *Boronia, Tetratheca, Hibbertia* and *Pimelea* form a composite group along with the greatly over-represented *Halagoraceae* type pollen (*Gonocarpus*?). Fabaceae pollen (0.8%, 0.8%), possibly the open forest and woodland shrub *Oxylobium ellipticum*, is consistently represented in B1

Although none of these taxa are restricted to open situations, their occurrence, as an assemblage, with moderate to high Poaceae values and low *Eucalyptus* percentages is consistent with the presence of a montane shrubby grassland or woodland.

Zone B1 lasted for about 2,300 years. The consistent appearence of *Dicksonia antarctica* with low *Eucalyptus* values and high Poaceae and Asteraceae percentages, suggests that the formation of the bog may have its origins in the destruction by burning, of rainforest or wet eucalypt forest. Although structural details are difficult to reconstruct,

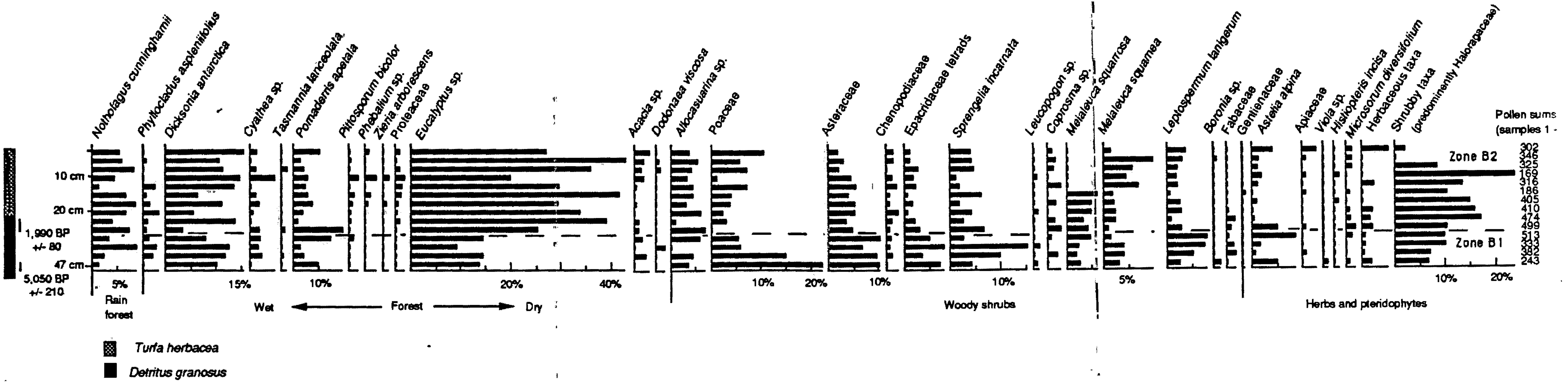


Figure 8.1. Big Heathy Swamp. Percentage pollen diagram, dry land taxa only.

it is probable that *Dicksonia* existed in a shrubby grassland, with *Eucalyptus* wet forest and rainforest surviving in fire protected copses and gullies.

The lower part of B2 between 32 - 25 cm is calculated to have lasted about 880 years. The upper section of B2 from 25 cm to the surface represents about 1,900 years. In contrast to B1, this section displays changes which eventually led to full forest conditions. *Eucalyptus* percentages attain their highest values (42.8%) but remain fairly consistent throughout (32.7%, 7.2%). By the start of B2, Poaceae had dropped out of the record but thereafter staged a slow recovery, eventually reaching a maximum value of 10.3% in the surface centimeter. This peak is nonetheless only half the value attained in the basal sample of B1.

Regional taxa display fluctuating responses which are difficult to attribute solely to climatic change. *Nothofagus* (5.8%, 2.2%) continued to fluctuate throughout, pointing to continuing disturbances in rainforests across the extent of the Maurice Plateau. *Phyllocladus* (0.9%, 1.0%) is reasonably prominent as a minor rainforest species today, but is very poorly represented in the upper 10 cm. *Dicksonia* (10.3%, 4.2%) has initially low values at the commencement of the zone, before quickly climbing to a significant peak (13.5%) and then dropping out of the record at 20 - 21 cm. After this low point, *Dicksonia* displays relatively high values and appears to have achieved a stable position in the makeup of the plateau's forests. An unexplained peak is displayed by *Cyathea* (4.8%) at 10 - 11cm. The abrubtness of the peak suggests that *Cyathea* became locally dominant for a short period in the forests adjacent to the swamp. *Allocasuarina* (4.3%, 1.8%) maintains a constant level which reinforces its presence as a distant source.

An interesting phenomenon is discerned in the 800 year period which represents the lower part of B2. This section marks a transition from an open grassy formation, to a *Eucalyptus* forest. If this was the case, and accepting the assumption that the core contains a complete record, then it might be expected that some evidence of the floristic succession from grassland to forest might be discerned. Wet forest shrubs such as *Zieria arborescens* (0.7%, 0.4%) *Phebalium* spp. (0.5%,0.8%), *Pittosporum bicolor* (0.4%, 0.6%) and Proteaceae (0.7%, 0.6%) including *Telopea truncata* and *Persoonia*, increase at the top of B1 before attaining maximum percentages in B2. *Coprosma* spp. (2.5%) is a common element in contemporary wet forest understories and may be linked with this assemblage . These trends are reasonably interpreted as evidence for succession from grassland or woodland to wet eucalypt forest (Ellis & Thomas, 1988).

Pomaderris apetala (3.0%, 2.7%) reaches a surprisingly high peak (9.6%) between 28 - 33 cm before declining and rising again. According to the accumulation rates discussed in Section 8.4.3, sample 11 (32 - 33 cm) has minumum and maximum ages of 2,128 and 4,158 years BP respectively. The variation is because samples 10 and 11 straddle the boundary between B1 and B2, with each zone having its own accumulation rate.

Pomaderris apetala is a regionally dispersed pollen type which is abundant at altitudes below 500 m and which does not grow on the plateau. Variations in *Pomaderris* values are traditionally attributed to climatic changes with high values representing humid phases and low values representing drying periods (Macphail, 1979 1981; Hill *et al.*, 1988). *Pomaderris* pollen can also be expected to be over represented in highland assemblages owing to the upslope movement of regional forest pollen (Macphail, 1979). It is possible therefore for lowland *Pomaderris* communities to be represented in the Big Heathy core regardless of what plant communities existed near to the core site.

The peak is therefore likely to represent a short lived phase which resulted in the development of mesic understories in the catchments of the Esk Rivers. Although the rainfall of the plateau is high enough at present to suggest that small increases in moisture availability would not cause changes in arboreal communities, it might result in changes to drier lowland forests and highland bogs. These communities are considered to be more sensitive to moisture fluxes than highland forests . Such a trend towards excess moisture is reflected by synchronous expansions in regional *Pomaderris* / *Coprosma* understories and *Astelia alpina* bogs. *Astelia* prefers cool poorly drained sites so an increase might indicate either cooler or wetter conditions, or both.

Additionally, peaks in *Nothofagus* and *Sprengelia* might indicate the development of rainforest understories and wet heaths respectively. A marked decline in *Leptospermum lanigerum* is difficult to explain by this hypothesis as this species is well adapted to life in cool waterlogged soils. It may simply have been outcompeted by the development of a *Meleleuca* / *Sprengelia* wet heath, or was perhaps shaded by *Eucalyptus* growth. This pattern is ecologically and temporally in accord with the hypothesis developed in Chapters 6 and 7 which argued for a short lived late Holocene phase of lowered temperature. This would have resulted in more effective moisture being available at ground level through savings in evaporative losses (Macphail & Hope, 1985). *Acacia* spp.(1.0%, 1.0%) declines during the transitional phase before rising again in the uppermost levels.

8.4.6 Pollen analysis: aquatic taxa

The most striking aspect of this analysis is the sustained dominance by members of the Restionaceae (Figures 8.2 - 8.5). The rushes *Restio australis* and *Empodisma minus* are extremely significant in the present day vegetation of the bog and probably make up a great proportion of the fossil pollen. The local dominance of these taxa is reflected in the extremely high percentages found in the uppermost samples. The curve for Restionaceae shows little change throughout the entire sequence which indicates that

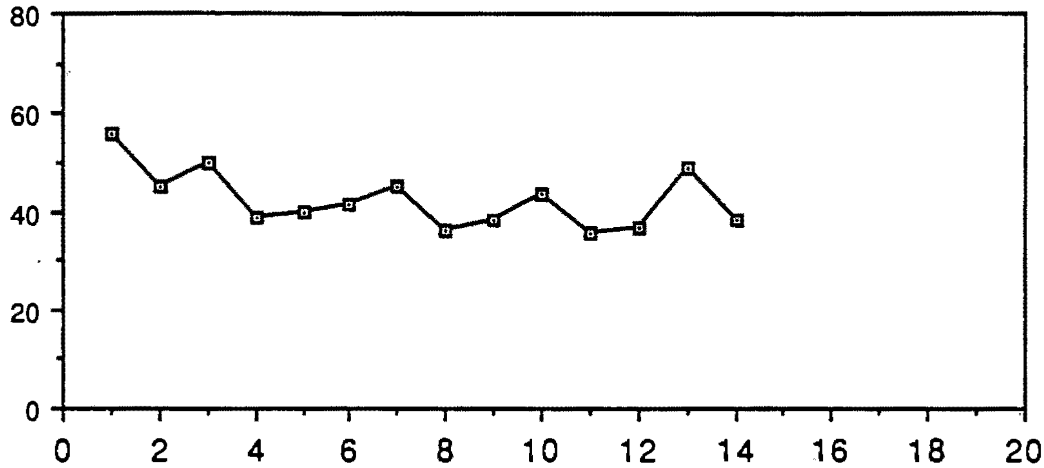


Figure 8.2. Big Heathy Swamp. Percent Restionaceae pollen (y axis). Samples 1 - 14 (x axis) are in increasing order of depth from 0 cm to 51 cm.

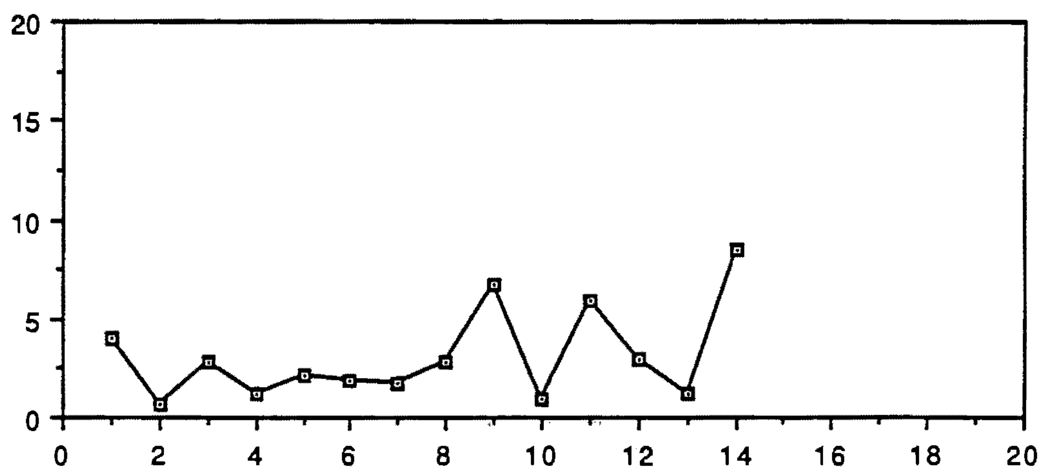


Figure 8.3. Big Heathy Swamp. Percent Cyperaceae pollen (y axis). Samples 1 - 14 (x axis) are in increasing order of depth from 0 cm to 51 cm.

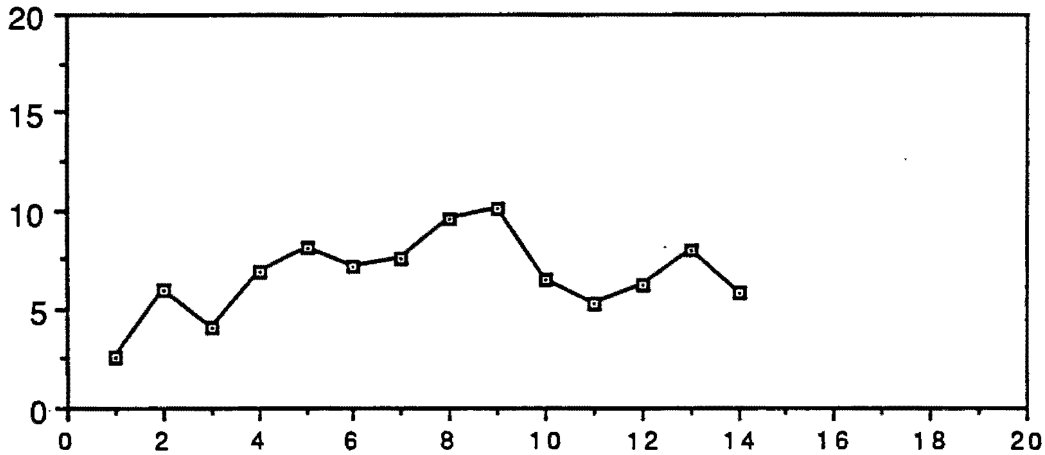


Figure 8.4. Big Heathy Swamp. Percent Haloragaceae pollen (y axis). Samples 1 - 14 (x axis) are in increasing order of depth from 0 cm to 51 cm.

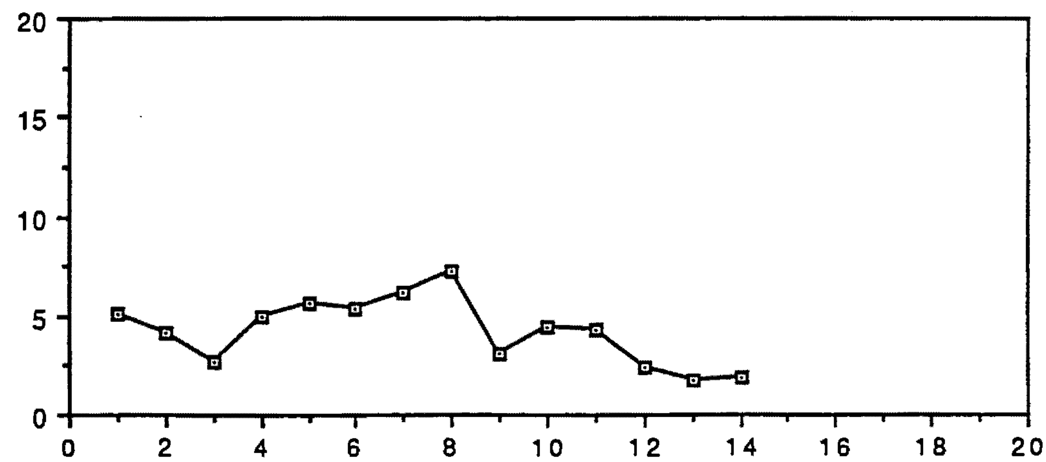


Figure 8.5. Big Heathy Swamp. Percent *Sphagnum* spores (y axis). Samples 1 - 14 (x axis) are in increasing order of depth from 0 cm to 51 cm.

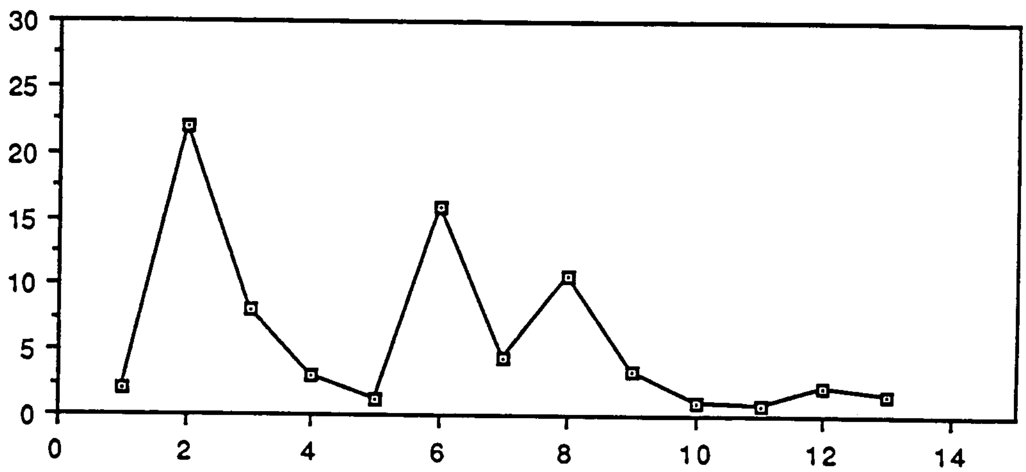


Figure 8.6. Big Heathy Swamp. Carbon particle / pollen ratios (y axis). Samples 1 - 14 (x axis) are in increasing order of depth from 0 cm to 51 cm.

suitably waterlogged conditions have existed on site for the past 5,000 years.

Cyperaceae pollen does not form a significant proportion of the analysis and except for initial and final peaks seems not to have been a phytosociological important component of the vegetation at Big Heathy Swamp. Likewise *Sphagnum* seems to have been constantly present

Haloragaceae pollen, excluding *Myriophyllum* spp. form a significant proportion of the assemblage until the final few levels. Halagaceae developed from moderate percentages in B1 to higher values in the lower part of B2. Its presence may be explained as a response to the development of a mat of deepening organic material over the local watertable. This may have enabled *Gonocarpus* spp. to survive on a perched surface where hypoxic rather than anoxic conditions existed in the root zone.

8.4.7 Concentration analysis

Total pollen concentrations vary markedly from a surprisingly low 18.2 x 10^3 grains.gm in the surface $1cm^3$ to 408 x10^3 grains.g at 16 - 17 cm. The concentration diagram (Fig. 8.7) reproduces the essential pattern displayed in the percentage diagram but with a number of significant differences which are attributed to the peformance of individual taxa through time. Concentrations for taxa are given in Appendix 4.

Generally, lower concentrations for all spectra in B1 support the interpretation that the assemblage represents a formation in which pollen productivity was low. This is not necessarily the case for open grasslands, but where grasslands are associated with higher altitudes, pollen production is usually lower than in surrounding forests or communities at lower altitude (Chapter 5; Birks & Birks, 1980). Higher total concentrations at the base of B2 show that pollen production increased during this period, probably because a regenerating phase of *Eucalyptus* forest development allowed the establishment and growth of vigourous young eucalypts and wet forest shrub understories.

The most striking difference is seen in the *Eucalyptus* curve where concentrations follow a gradual transition through B1 into B2, with fluctuating values thereafter. This is interpreted as indicating a forest which regenerated without major disturbances for about 1,000 years between the open grassy phase of B1 and the full forest conditions of B2. Fluctations in concentrations which occurred after about 2,000 years BP are attributed to the effects of occasional intense fires which raised pollen productivity by stimulating the growth of even aged forest regeneration.

Low total pollen concentrations between 1 - 0 cm support the contention developed in Chapter 4 that *Eucalyptus* pollen is not a regionally dispersed taxa. This is further

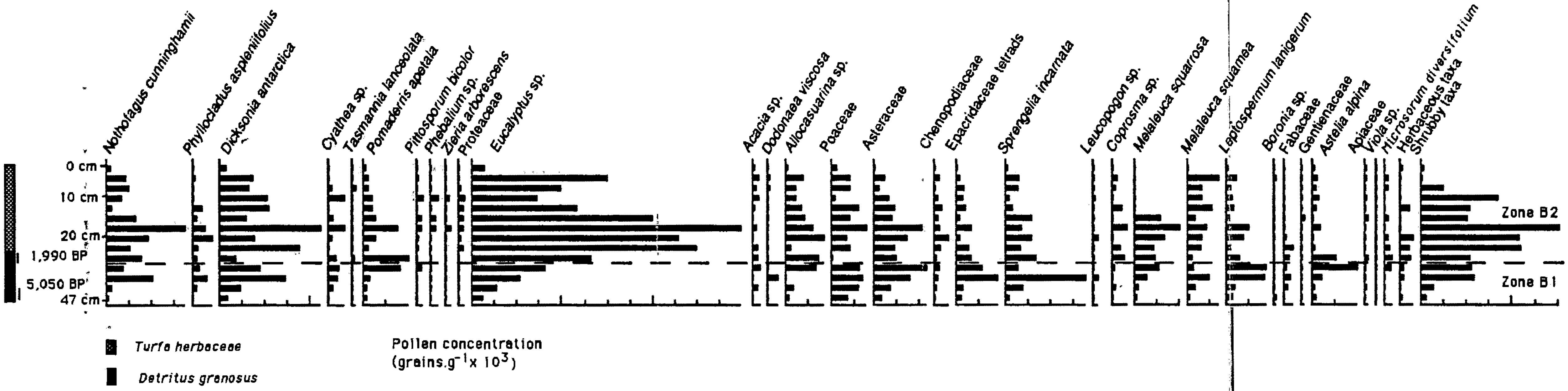


Figure 8.7. Big Heathy Swamp. Pollen concentration diagram, dry land taxa only.

suggested because it is known that wet eucalypt forests have existed in the area since early last century (see Chapter 2, in Jennings, 1983) and yet, in spite of this, pollen concentrations at the surface are the lowest for the past 2,000 years. In consideration of this, it is suggested that high concentrations in the lower part of B2 represents a denser forest formation than exist today. Similarly, the low concentrations in B1, in conjunction with relatively high herbaceous percentages, suggests that the local vegetation at that time was more open and herb rich than today.

Poaceae concentration levels in B1 are more consistent than percentage values which indicates that grasses maintained their local presence in the face of increases by Asteraceae, heath and scrub taxa such as *Sprengelia incarnata, Leptospermum lanigerum, Melaleuca squarrosa* and *M. squamea*. The latter species probably formed fringing scrub communities on the margins of a central waterlogged area.

8.4.8 Carbon particle analysis

There is a distinct increase in cp size classes following the lower more open structured vegetation phase in the core. The lower section of core has significantly higher cp/pollen ratios than the upper section (Figure 8.6). This is to be expected because that section has a higher rate of organic accumulation than the upper 20 cm. In spite of this, cp's have higher concentrations in the upper forest section thus indicating a real increase in the production of cp's independent of organic accumulation rates.

At about 2,000 years BP, *Eucalyptus* attained its highest values following a period apparently free from catastrophic fires. From 2,000 years BP to the present, the forest was associated with fires characterised by the production of abundant, large (>50 mu) carbonized particles. The previous open phase was associated with the constant production (or dissemination through the core), of an abundance of fine particles (<5 um), a moderate input of medium particles (5 - 50 um) but very few large particles.

8.5 Discussion

The main feature of the diagram is a change at about 30 cm from low to high values of *Eucalyptus* pollen. There are generally inverse relationships between *Eucalyptus* on one hand, and Poaceae, *Leptospermum* Epacridaceae, Asteraceae and herbaceous taxa on the other. Positive relationships exist between *Eucalyptus* and and wet forest shrubs such as *Coprosma, Zieria, Pittosporum, Pomaderris apetala*, Pteridophyte spores and *Sphagnum* spores. Other taxa such as, *Allocasuarina* and *Dicksonia antarctica* behave in less predictable ways.

Initially, Poaceae and members of the Asteraceae were dominant, with increases through time in the percentages of Epacridaceae and myrtaceous shrubs. *Acacia* has highest values in the lower third of the diagram, as do spores of *Dicksonia antarctica*. The dominance by Poaceae was curtailed by shrubs which invaded the open environment. The full sequence beginning with Poaceae and proceeding through herbs, myrtaceaous shrubs, wet forest shrubs to forest, is a successional path that has been documented in the highlands (Ellis, 1985) following the removal of Aborigines from the northeast in the 1830's (Plomley, 1966).

The development of the forest phase at about 2,000 years BP was accompanied by first appearances of wet forest shrubs such as *Zieria*, *Phebalium*, *Coprosma* and *Pomaderris apetala*. Increases by *Nothofagus*, *Pomaderris*, *Coprosma* and *Astelia* are compatible with a hypothesis developed in chapters 6 and 7 that a short lived cool climatic phase took place between about 4,000 and 3,000 years BP.

In general terms, an earlier herb dominated open phase was succeeded by a rise in in the local dominance of eucalypts and shrubs, culminating in full forest conditions. The transition from open structured vegetation to full forest took place over approximately 800 years from about 2,800 years BP to 2,000 years BP.

Fire history

Once eucalypt forest was established on the site it could have been maintained, provided that a fire occurred every 100 - 200 years (Jackson, 1978). Given the carbonized particle evidence and the demonstrated fact of over 30,000 years of human occupance in Tasmania (Cosgrove, 1989), it is likely that that such a fire regime could have been maintained. The evidence from Una Plains and Mt. Victoria rockshelter (Section 8.6) leaves no doubt that this was almost certainly the case.

On this high altitude plateau, under conditions of few or no fires, a eucalypt forest would likely maintain shrubby understories as it drifts towards rainforest. The increasing presence of Poaceae over the last 1,000 years provides corroborative evidence for the frequent use of fire .

It is unclear what the vegetation of the Big Heathy area was like prior to 5,000 BP. One possibility is that grassland or woodland may have survived since the Last Glacial. Noble (1984) has demonstrated that at a similar altitude, but in a drier environment on Ben Lomond, eucalypt forests were extant at about 10,000 years BP. Considering that post glacial forests expanded on a statewide basis (Macphail, 1979, 1986; Colhoun, 1978) and that the climax vegetation of the Big Heathy area under present day conditions is *Nothofagus* rainforest (Ellis, 1985), it is probable that in the warmer and more equable climates of the early to mid Holocene the vegetation would have been rainforest or wet eucalypt forest.

Assuming that surrounding forests were eliminated by fire, some consequences would have been lowered rates of rainfall interception by tree canopies, generally reduced evapotranspiration and a diminished capacity for the soil to cope with runoff. Watertables would have risen to produce waterlogged conditions on the broad interfluve. This process is evident today on Paradise Plains where *Sphagnum* mounds are invading onto hillslopes cleared of forest by fire about 200 years ago. The location of the bog on a broadly convex slope leaves no room for doubt that the site was never a lake impoundment. Except for the presence of mottles, the lower 60 cm of clays and gravels resemble the B horizons of present day forest soils and thus, the minerogenic sequence probably represents a previous forest soil which has been degraded by oxidation / reduction cycles. The presence of a former soil is further circumstantial evidence that forests formerly existed on site.

The sequence of events at Big Heathy is remarkably similar to one successional pathway which is seen to be occurring on Paradise Plains at the present time (Ellis, 1985; Ellis and Thomas, 1988). An estimate for the time required for *Eucalyptus* forest to completely coalesce over Paradise Plains is about 1,000 years (*pers comm.* R. C. Ellis). This compares with the 880 years taken by the grassland of Big Heathy Swamp to convert to forest. Considering that the bedrock geology and altitude are similar, it seems reasonable to assume that the areas of both grasslands were roughly equivalent at their respective times of origin.

The best explanation for the beginning of organic accumulation at Big Heathy Swamp is that fire removed a previous forest formation, thus allowing the development of water tolerant vegetation consequent with rises in the local watertable. There is no pollen or other evidence from any part of Tasmania for climate changes at about 5,000 years BP which could account for the development of mires in the highlands. The argument developed in this chapter assumes that fires lit by Aboriginal people were responsible for the creation of the Big Heathy Swamp environment. This runs counter to previous notions concerning the Aboriginal settlement history of the northeast (Jones, 1971a, 1974; Kee, 1987; Plomley, 1966) and allows further speculation in relation the longer term history of the area.

The lack of glacial ice in the eastern highlands during the Last Glacial period (Caine, 1983) suggests that regardless of the type of vegetation present during the late Pleistocene, there existed the potential for human settlement. The presence of fire dependent eucalypt forests at 12,000 years BP at Waterhouse Point and at 10,000 years BP on the slopes of Ben Lomond points to the possibility of at least 10,000 years of Aboriginal burning in the forests of the northeastern highlands. The full occupation span may extend much further back than the Holocene if the 30,000 year dates obtained by Cosgrove (1989,1990) for the lower Central Plateau are any indication.

8.6 Mathinna Plains (Una Plain East)

Buttongrass moorland in the east of the state is characterized by *Gymnoschoenus, Lepidosperma filiforme, Restio australis, Melaleuca squamea* and members of the Epacridaceae and Myrtaceae (Jarman *et al.*, 1988a) In the northeast, *Gymnoschoenus sphaerocephalus* occurs from near sea-level to about 900 m with the most largest stands found on Mathinna Plains, an extensive and generally level area located in the heart of the northeastern highlands at an altitude of 800 m. The plains are underlain by Silurian sequences of shales, quartzwackes and Permian sandstone (Figure 4.2) on which are developed infertile mineral soils and extensive beds of shallow blanket peats.

The plains are divided into various expanses of buttongrass separated by belts of *Nothofagus* rainforest, *E. delegatensis* forest and *E. rodwayi* woodland. In many places, especially near rainforest, the transition from forest to plain occurs over ecotones of less than 50 m. In other locations associated with *E. rodwayi*, the transition is often effected over much greater distances. Isolated individuals of *E. rodwayi* are found dotted across the open expanses of the plains as are many patches of burnt eucalypts (Plate 17).

Although the buttongrass sedgelands are restricted to sandstones and shales, this should not be taken to indicate that rainforest is restricted to non-sedimentary substrates. In many places in the northeast and throughout Tasmania, rainforest can be found growing on sandstone (Jarman *et al.*, 1984) and from this it can be reasonably assumed that factors other than nutrient differentials are responsible for the existence of buttongrass plains on sandstone.

To the south west of the main extent of Mathinna Plains are extended fingers of plateau capped by Permian sandstones. Each finger represents a watershed between deeply incised valleys which eventually unite in the valley of the South Esk River. Una Plain is an isolated buttongrass moorland which occupies one of these divides.

8.7 Methods

A 45 cm deep sediment core was extracted from the center of the 0.4 km^2 Una Plain at 800 m. Field methods follow those described in Chapters 5, 6 and 7. In the following discussion, *Gymnoschoenus* moorland, buttongrass plain and buttongrass moorland are synonymous.

Plate 16. *Gymnoschoenus sphaerocephalus* (buttongrass) moorland at Una Plain near Mt. Victoria in the northeastern highlands. In the foreground is a healthy population of *Melaleuca squamea*. In the background are a number of isolated eucalypts growing over an understorey of pure rainforest. A sediment core (Una 1) was retrieved from the centre of the moorland.

Plate 17. *Gymnoschoenus sphaerocephalus* moorland at Mathinna Plains in the northeastern highlands. Mt. Vctoria and Mt. Albert in the distance. The effects of fire are everywhere apparent. Recent fires have destroyed patches of forest to the evident advantage of *G. sphaerocephalus*.

8.8 Results and analyses

The importance of the plain is its critical location near to an extensive series of sandstone rockshelters, some of which contain evidence of former occupation by Aborigines (see Chapter 4).

The present day vegetation surrounding Una Plain include *Nothofagus* and *Atherosperma* rainforest up to 30 m high with a very open understorey of *Dicksonia antarctica* and *Polystichum proliferum*; mixed forest (*sensu*, Jackson, 1978), consisting of old individuals of *Eucalyptus delegatensis* greater than 40 m high growing over rainforest understories; *Acacia dealbata* forest approximately 15 m high with fern or grassy understories and *Leptospermum lanigerum* and *L. scoparium* scrub.

The core was taken from a position at the center of an expanse of *Gymnoschoenus* and *Melaleuca squamea* moorland, 100 m from a transition from buttongrass plain to rainforest (Plate 16). The transition is a common feature on Mathinna Plains with many places displaying obvious fire damage (Plate 17). The transition changes in character from forest to open plain with *Leptospermum* scrub decreasing in height from approximately 3 m in height at the forest edge to less than 1 m at a distance of 50 m. Large decaying mounds of *Gymnoschoenus* can be found within the forest surrounding the plain. Jarman *et al.*, (1988a: 89-90) have described similar occurrences from western Tasmania.

8.8.1 Stratigraphy

The upper 8 cm of the 45 cm core consisted of coarse rootlets and partly decomposed plant remains in a finer matrix of *Detritus herbosus.* The remaining 12 cm of peat consists of *Detritus herbosus* with only a few penetrating roots. Below 25 cm, a 2 cm thick horizon of *Grana glareosa* (*minora*), overlies orange and grey, gleyed *Argilla granosa* which presumeably extends to sandstone bedrock. Mottling in the clay indicated that seasonal dry / waterlogged cycles may have had a significant effect on pollen preservation. This proved to be the case, with no pollen preserved below 26 cm. Considering that the peats are located on clays developed over sandstone, and that there is no stream influx onto the plains or possibility of former impoundment, it seems likely that the clays represent the remnants of a former mineral soil. The shallowness of the peat section is considered typical for blanket bogs in Tasmania (Jarman *et al.*, 1988a: 83; Pemberton, 1989).

8.8.2 Dating

A basal organic date from 20 - 25 cm returned a date of 1,660+/- 90 BP (Beta-4144). Prior to dating, roots and rootlets were picked out in preparation for further pretreatment consisting of acid/alkali/acid baths. Similar reservations to those advanced for the Big Heathy Swamp core can be advanced regarding the degree of contamination by younger carbon in such a shallow profile (Colhoun, 1986).

8.8.3 Accumulation rates

The basal date indicates maximum and minimum ages at one standard deviation of 1,750 years and 1,570 years BP. Accumulation rates therefore vary between 70 yrs.cm^{-1} and 62.8 years.cm. The mean rate of accumulation is 66.4 yrs.cm^{-1} or 0.02 cm.yr.

8.8.4 Zonation

The diagram is divided into two zones based on a visual inspection of spectra. Zone M1 is composed of samples 13 and 12 between 25 cm and 22 cm; M2 comprises the remaining samples (Figure 8.8). It is possible to delineate a further zone composed of the upper two samples but this was not pursued because the changes in these spectra are restricted to a small number of taxa. A numerical annalysis was not undertaken because the small sample size makes it unlikely that multivariate methods would confer any significant advantage.

8.8.5 Pollen analysis: dry land taxa

The percentage diagram reveals rather subtle changes in the major pollen taxa (Fig 8.8). Of these, the most visible are a gradual increase in *Eucalyptus* from the base of the core and a marked change from low to high *Nothofagus* percentages. Isolated basal peaks in *Leptospermum lanigerum*, *Astelia alpina*, and Chenopodiaceae are also significant. Other noticable changes occur in the uppermost samples where *Astelia alpina*, *Melaleuca squamea*, *Boronia* spp., Fabaceae and Gentianaceae show significant increases. A single grain of *Pinus radiata* was counted at 2 cm -3 cm in zone M2.

Zone M1 (25 - 22cm) is characterised by relatively low mean values for *Nothofagus* (12.7%, 0.3%) and *Eucalyptus* (7.0%, 0.7%). This is in contrast to Poaceae (12.9%, 2.2%), Chenopodiaceae (5.6%, 7.0%), *Leptospermum lanigerum* (13%, 1.2%) and *Astelia alpina* (8.4%, 6.4%) which show maximum values. Carbonized particles of all size classes are extremely high throughout the core with slightly lower values in zone M1 (Figure 8.13).

Low percentages for *Eucalyptus* (7.0%, 0.7%) in the basal levels suggests that it was

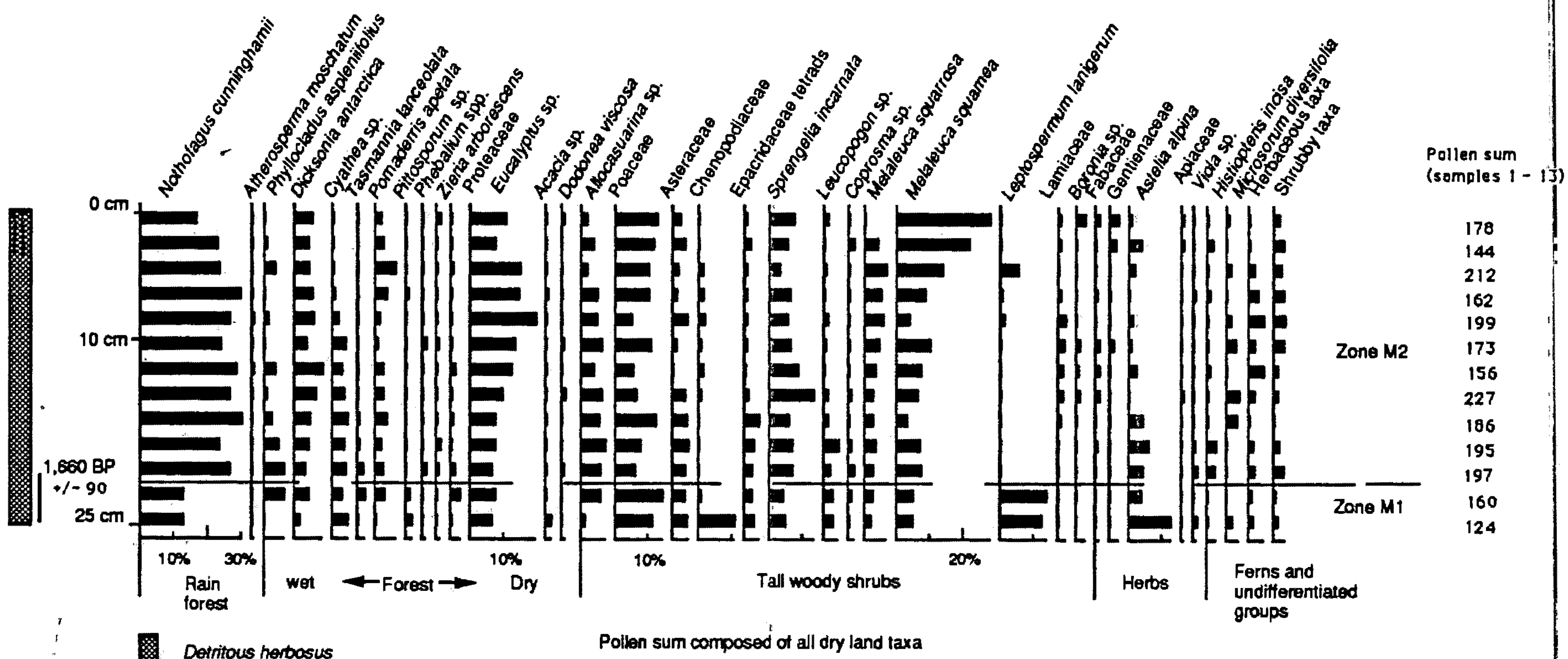


Figure 8.8. Una Plain. Percentage pollen diagram, dry land taxa only.

not a particularly dominant member of the vegetation prior to 1,600 years BP and thus it is more likely that the vegetation prior to the commencement of organic accumulation was rainforest, perhaps with a few emergent *Eucalyptus*.

High values for *Leptospermum lanigerum* and *Astelia alpina* are interesting in that both species appreciate damp and sunny conditions. *Astelia* has a prominent berry fruit and may be dispersed by birds into cleared areas. *Leptospermum* is known to be adapted to fire (Specht, 1979) and in northeast Tasmania the taxa commonly invades recently burnt areas by expanding along creek banks and watercourses (Ellis, 1985). The presence of these taxa indicates the existence of open waterlogged conditions at about 1,600 years BP. The absence of fire sensitive *Phyllocladus* and the abundance of fire tolerant *Dicksonia* and *Leptospermum* at the same time indicates the possibility that fire may be implicated in the creation of this assemblage.

Anomolously high values obtained for the Chenopodiaceae at the base of the core are also evident at the same time at Big Heathy Swamp, Forester Marsh and Waterhouse Marsh. The significance of this is unknown, although Macphail (1979) suggests that Chenopodiaceae pollen blown from the Australian mainland may contribute to the Tasmanian pollen rain. However, it seems just as likely that zones of coastal plant communities found on the northern coast of Tasmania may have been the source.

The transition from M1 to M2 is marked by increases in *Pittosporum bicolor*, *Zieria arborescens* and *Persoonia* spp. As in the Big Heathy core, these taxa are regarded as transition wet forest shrubs, capable of expansions following fire but incapable of surviving under fully shaded rainforest conditions.

Zone M2 is substantially different to the preceding zone M1. The most significant trends are those displayed by *Eucalyptus* (11.5%, 3.4%) and *Melaleuca squamea*.(10.6%, 7.7%). The eucalypts rose gradually to a peak at about 550 years BP and maintained relatively high levels for the next 265 years. The maximum value for *Eucalyptus* in the core is 19.6% at 8 - 9 cm. This value indicates that *Eucalyptus* was present either as widespread but isolated copses in a predominantly rainforest formation, or as scattered individuals on the open expanse of the moor. In the forests surrounding Una Plain today, many eucalypts greater than 60 m in height exist. It is possible that some of these mature survivors established during the period of eucalypt expansion between 265 and 500 years ago.

8.8.6 Pollen analysis: aquatic taxa

In many regards this analysis is crucial to questions concerned with secondary plant successions and possible interactions between Aborigines and community dynamics. It is often quite reasonably assumed, that *Gymnoschoenus* moorlands are a result of

Aboriginal burning practices (Colhoun, 1978; Jackson, 1965, 1968, 1978; Jones, 1969, 1975; Macphail & Colhoun, 1985). Implicit in these arguments are the related assumptions that buttongrass moorlands were an immediate product of the burning of forests and that Aborigines desired to create and then maintain moorlands, either for hunting or travel purposes.

This analysis demonstrates that on Una Plains, the first response of vegetation at time of bog formation was not an expansion by Cyperaceae, including *Gymnoschoenus*, but rather, the immediate dominance by Restionaceous plants and *Sphagnum* moss.

Cyperaceae (Figure 8.9) have very low values at the base of the core in zone M1 (1.3%, 0.4%) prior to a sharp increase at the transition from M1 to M2, followed by relatively consistent values (8.8%, 4.9%) until the surface 3 cm where percentages rise rapidly to a peak of 20.8%. This suggests that *Gymnoschoenus* was not a community dominant for at least 200 years. After an initial phase of establishment, Cyperaceae expanded somewhat but failed to attain the very dominant position that it holds today. A comparison of the 60% projective foliage cover exhibited by *Gymnoschoenus* on Una Plain, with its 20% pollen representation in the surface sample, suggests that for most of zone M2, indeed for the core as a whole, Cyperaceae pollen has been under-represented in the pollen record. If one assumes a linear relationship between plant cover and rate of pollen deposition, Cyperaceae never occupied more than about 30% of the area around the pollen site.

Sphagnum (4.9%, 0.1%) is well represented in M1 before peaking at 20-21 cm (11.2%). This value is likely to represent a substantial ground cover of moss and the beginnings of a raised or blanket bog (Figure 8.11). Above 20 cm, *Sphagnum* gradually declines, before vanishing completely from the record above 6 cm.

The major pollen producers on the plain have always been members of the Restionaceae (Figure 8.10). This family, which include *Restio australis* and *Empodisma minus* are locally prolific pollen producers and are obviously over represented in the diagram. The Restionaceae are consistently represented in both M1 (78.6%, 29.1%) and M2 (64.9%, 13.0%) with a peak of 99.2% in the basal level.

Gleichenia (Figure 8.12) varies throughout the profile from low values in M1 (1.1%, 0.4%) to slightly higher mean values in M2 (2.0%, 1.2%). Five levels in M2 exhibit substantially higher percentages than the mean, ranging from 2.8% - 3.9%. Jarman *et al.*, (1988: 82) observe that after fire in *Sphagnum* communities: "There is a proliferation of more fire tolerant species such as *Empodisma minus* and *Gleichenia alpina*, and the vegetation may change rapidly from a moss-dominated community to one that is dominated by sedges and ferns."

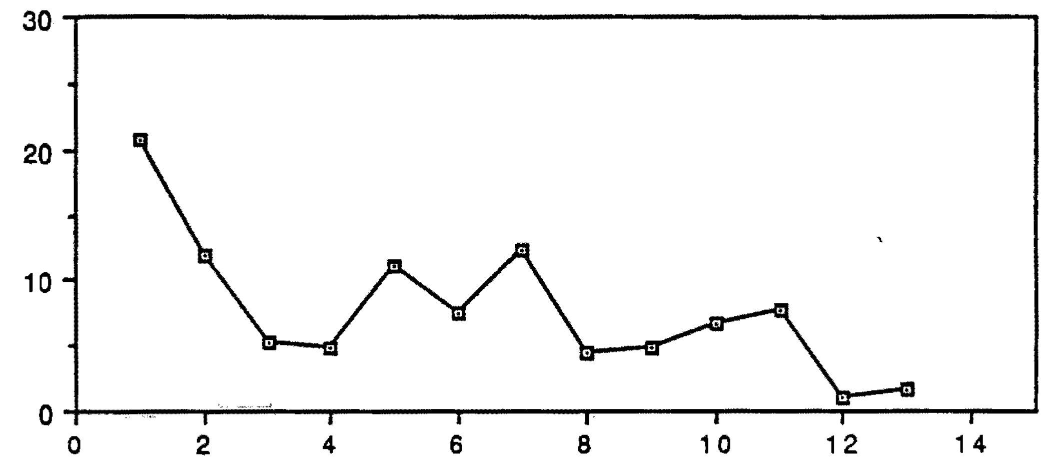


Figure 8.9. Una Plain. Percent Cyperaceae pollen (y axis).
Samples 1 - 13 (x axis) are in increasing order of depth from 0 cm to 25 cm.

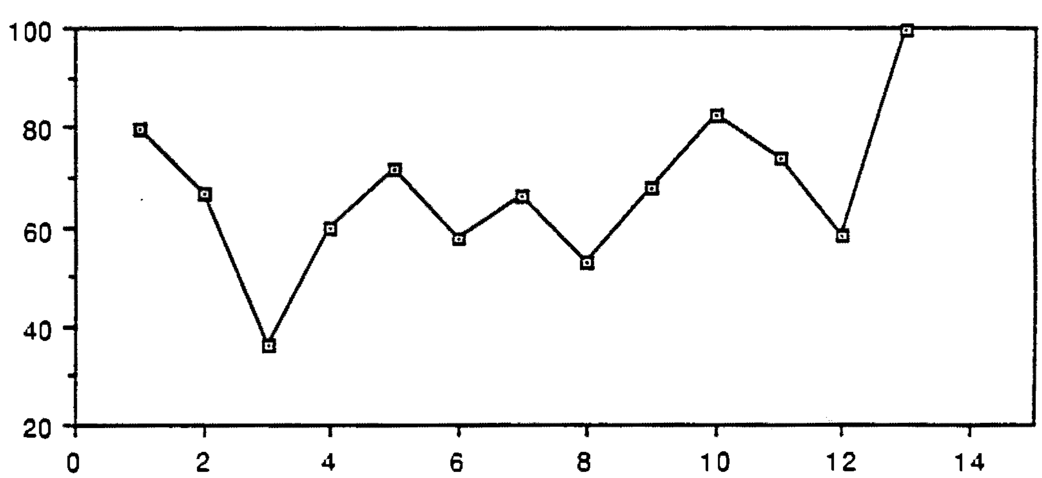


Figure 8.10. Una Plain. Percent Restionaceae pollen (y axis).
Samples 1 - 13 (x axis) are in increasing order of depth from 0 cm to 25 cm.

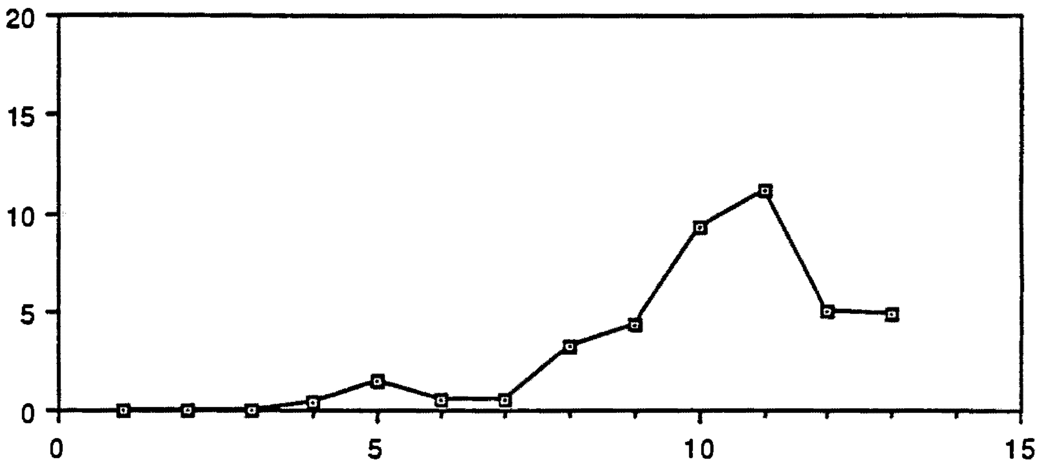


Figure 8.11. Una Plain Percent *Sphagnum* spores (y axis).
Samples 1 - 13 (x axis) are in increasing order of depth from 0 cm to 25 cm.

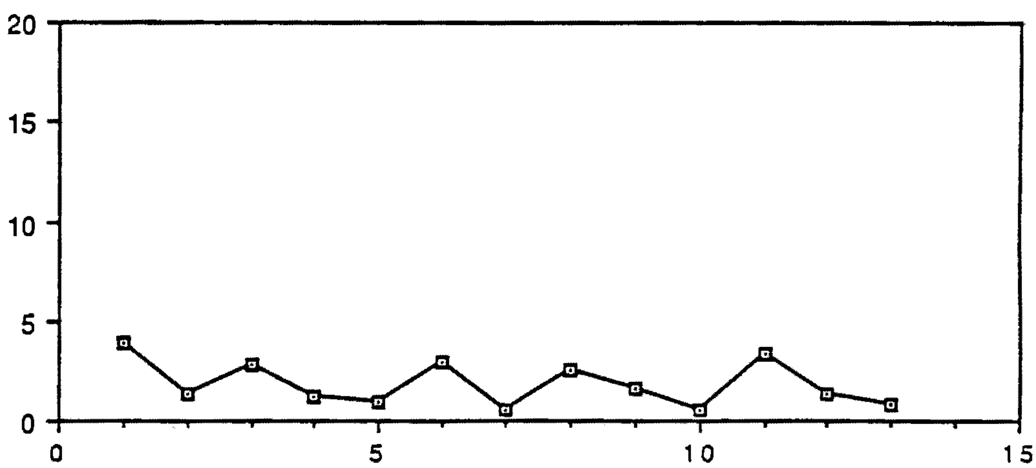


Figure 8.12. Una Plain Percent *Gleichenia* spores (y axis).
Samples 1 - 13 (x axis) are in increasing order of depth from 0 cm to 25 cm.

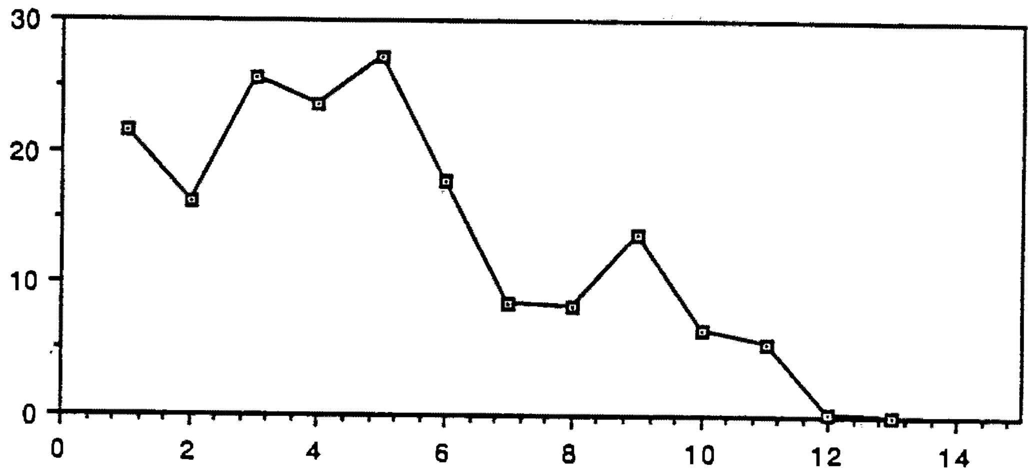


Figure 8.13. Una Plain. Carbon particle / pollen ratios (y axis).
Samples 1 - 13 (x axis) are in increasing order of depth from 0 cm to 25 cm.

The *Gleichenia* and Restionaceae curves suggest that these observations have applied for the 1,600 years represented by the core. A comparison with the dry land analysis shows no obvious competitor which might have periodically outcompeted *Gleichenia*, and thus, it is possible that exogenic forces were at work. Fires are the obvious agent, and although no peaks in cp's correlate with increases in the fern, this is probably because an abundance of cp's throughout the core masks any variations in the fire regime. It is entirely possible that against a background of small highly localized burns, larger fires occurred every 200 years or so, resulting in periodic increases in the cover of *Gleichenia*.

Pteridophyte spores have lower values in M1 (2.9%, 0.5%) than in M2 (3.4%, 2.2%) with a strong peak between 21 - 18 cm where 7.7% maximum values were attained at the same time as *Sphagnum* and *Gleichenia*. The monolete spores which typify the pteridophyte counts are likely to comprise a mixture of *Blechnum penna-marina* and *Blechnum wattsii* (Whinam *et al.*, 1989).

8.8.7 Concentration analysis

The average rate of accumulation at Una plain is 0.02 $cm.yr^{-1}$. In general total pollen concentrations rise from initially low levels to maxima at about halfway through the sequence, *ca* 800 years BP. This period coincides with the greatest development of surrounding rainforest and is just prior to the maximum extent of *Eucalyptus* expansion.

Nothofagus concentrations are low in M1 (5.8×10^3 grains.gm) prior to a sharp increase into M2 ($x = 24.5 \times 10^3$ grains.gm, sd = 10.33×10^3 grains.gm). The trend is substantially different to the percentage curve for instead of maintaining consistent levels the concentration gradually drops from a maximum of 39.2×10^3 grains.gm at10-11 cm (730 years BP) to values at the surface which resemble those in M1 (Figure 8.14).

The trend of increasing, followed by decreasing concentrations is general for all of the major taxa with the exception of *Astelia alpina*, *Meleleuca squamea* and *Leptospermum lanigerum*. *Leptospermum* spreads rapidly following fire, while *Astelia* is favoured in poorly drained open aspected locations. An early local plant community, dominated by *Astelia* (3.5% , 2.1%) and *Leptospermum* (6.%, 2.0%), was apparently well suited to waterlogged conditions following a period of fires. The association lasted for *ca* 200 years before *Leptospermum* declined. *Astelia* continued as an important member for another 400 years before it too, dropped out of the record. This was accompanied by the gradual expansion of regional vegetation including *Nothofagus* and *Eucalyptus* forest.

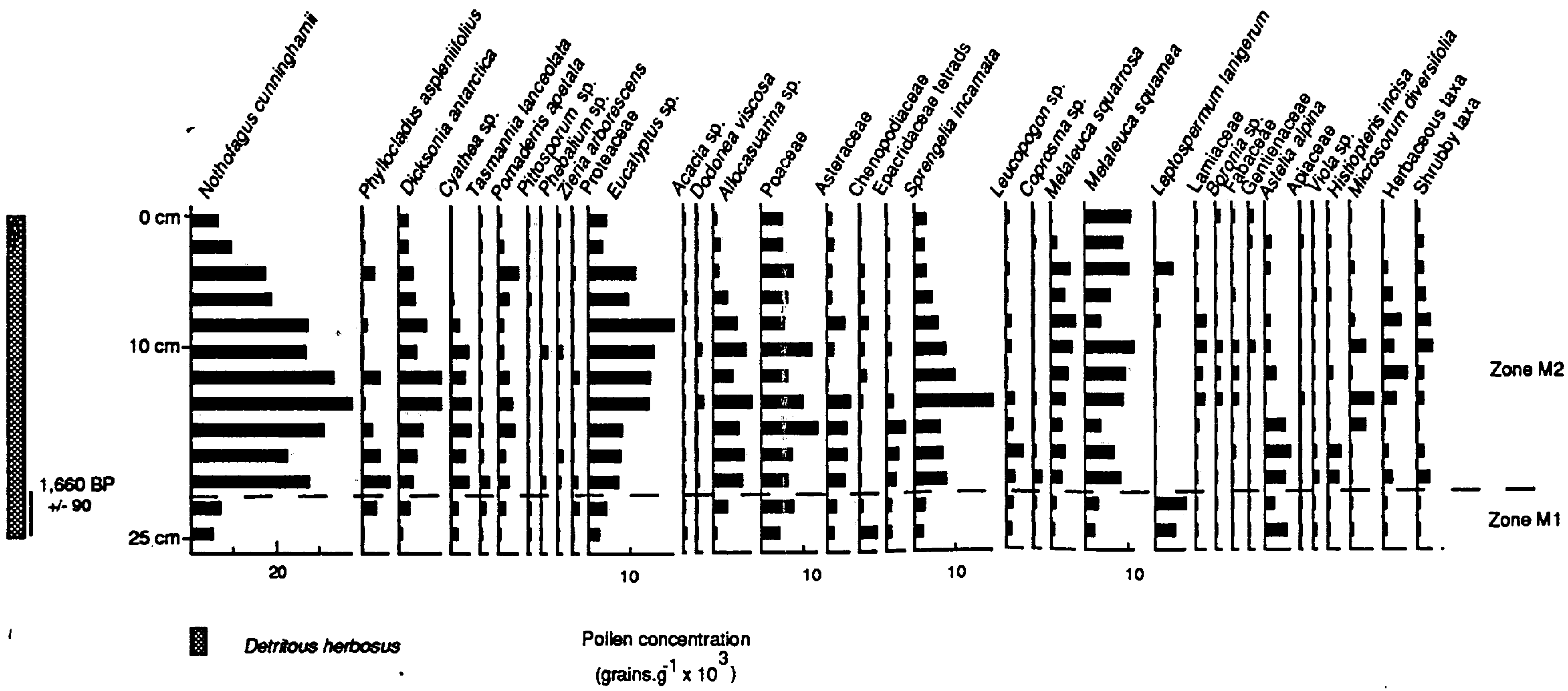


Figure 8.14. Una Plain. Pollen concentration diagram, dry land taxa only.

8.9 Discussion

The *Gymnoschoenus* peat from the Mathinna Plains provides results which can be profitably compared to those obtained from the restionaceous peat of Big Heathy Swamp. Both sites are at the same altitude and on similar geological substrates. The average rate of accumulation at Una is 0.2 cm.yr which compares to 0.009 cm.yr at Big Heathy. From this it seems that moorlands at the same altitude which follow the successional path of *Sphagnum* to buttongrass, are more productive in terms of sediment accumulation than those dominated by *Astelia alpina* and Restionaceae.

Jarman *et al.*, (1988a:86) suggested that the pan northern hemispherical estimate of 0.06 cm.yr presented by Tallis (1983) might be valid for peatlands in Tasmania. Although this figure may apply to cool and humid locations in western parts of the state, it is clearly an overestimate for parts of the east where higher temperatures and generally lower precipitation levels present conditions may not favour the accumulation of peat.

Jarman *et al.*, (1988: 86) suggest that climatic controls on the rate of organic accumulation indicate that: "It seems likely, therefore, that the age of Tasmanian blanket bogs is in the order of several thousands of years". This point of view fails to take into account the possible effects of culturally induced soil and hydrological changes which can lead to the initiation of bog formation. Pollen spectra from Una Plain suggest that burning of rainforest created open conditions which led to waterlogging and the development of organic accumulation. If critical climates were the sole determinant of bog formation then most blanket bogs should have basal dates from either the period 10,000 to 6,000 years BP, which defines a period of heightened precipitation (Macphail, 1979, 1980), or from about 3,500 years BP when cooler conditions may have caused an acceleration in bog growth (Macphail and Hope, 1985).

This is demonstrably not the case in the northeastern highlands where organic accumulation began at Big Heathy Swamp at 5,000 years BP; Una Plain at 1,600 years BP and on Paradise Plains about 200 years BP.

The only other plausible method by which people could alter vegetation sufficiently to alter the hydrology is with the use of fire. Humans provide the only regular source of ignitions in wet Tasmanian forests and therefore, Aboriginal burning can be directly implicated in the formation of at least some buttongrass moorlands and mires in the highlands.

Regional forest changes

In the forests surrounding Una Plain from 1,660 years BP to about 1,300 years BP, *Phyllocladus* (2.8%, 4.0%), *Dicksonia*(3.0%, 2.0%) and *Cyathea* (3.3%, 1.1%) increased prior to an expansion by *Nothofagus* (25.2%, 3.9%) in M2. This is interpreted as a secondary successional change very similar to contemporary successions in western Tasmania (Jackson,1965,1977) and to classic palaeo-successions at the Pleistocene/Holocene boundary (Hill *et al.*, 1988a; Macphail, 1979, 1980, 1986, 1988). The absence of *Phyllocladus* from the basal sample, prior to a significant rise in M2, is unusual considering its local co-occurrence with *Nothofagus*.

This can be parsimoniously explained if burning eliminated the extremely fire sensitive conifer (Kirkpatrick, 1977a; Barker, 1990) from rainforests, which probably covered the plains before 1,660 years BP. Early occurrences of *Dicksonia* and *Cyathea* and low basal values for *Nothofagus* and *Eucalyptus* suggest that before the initiation of moor peat formation, a vegetation type was in existence which contained populations of treeferns which survived fire (s). These might have been either mixed forests (*sensu*, Jackson, 1978) or callidendrous rainforest (*sensu*, Jarman *et al.*, 1984). It is difficult to envisage a situation in which bog or moorland vegetation existed on site prior to 1,600 years BP, however, it is likely that many elements of the moorland vegetation existed within the prior forests (Jarman *et al.*, 1988a; Whinam *et al.*, 1989).

Jarman *et al.*, (1988a, 1988b) have commented on the inability of*Gymnoschoenus* to quickly colonize newly available niches. This observation is in agreement with the Una Plain evidence where the creation of a *Gymnoschoenus* dominated moorland from what was probably a *Nothofagus* rainforest took place over a period of at least 200 years. The successional pathway led from a *Sphagnum* / Restionacaeae / *Leptospermum* community to one in which *Sphagnum* dropped out, probably following the continued use of fire. These taxa probably existed on site prior to the instigation of peat accumulation, perhaps in poorly drained locations within rainforest (Jarman *et al.*, 1984, 1988a; Whinam *et al.*, 1989).

Even as fire pressure continued to mount over the period 1,300 years BP to 200 years BP, surrounding forests managed to expand, suggesting that fires were not eroding into rainforest margins. Depressed arboreal pollen concentrations in the upper part of the sequence may be due to the gradual senescence of forests during the past 500 years.

Local moorland changes

The most significant aspect of the analysis is that *Sphagnum* and Restionaceae initially dominated the vegetation, well before Cyperaceae asserted its presence. The curves suggest that as *Sphagnum* decreased, space became available for colonization by buttongrass, as well as by herbs and small shrubs, such as *Boronia*, Fabaceae, Lamiaceae and Gentianaceae. It is important to note that the lily, *Astelia alpina*, was an important constituent of the basal levels where a Restionaceae / *Sphagnum* / *Astelia* community dominated. This almost certainly means that a constant source of ground water was available with high light levels. As peat depth developed, decreases in overall fertility would have also acted to promote the growth of buttongrass.

Considering the high cp/pollen ratio throughout the sequence, the decline of *Sphagnum* and increase in Cyperaceae can be attributed to fire. Jarman *et al.*, (1988a:74-75) point out that: "*Sphagnum* bogs seem to be very vulnerable to fire disturbance ---. The open conditions in these burnt, waterlogged situations are very suitable for the establishment of of *Gymnoschoenus*. The introduction or expansion of this species accelerates the demise of the bog vegetation because *Gymnoschoenus* is a fire promoting species and acts as an ignition point within the community. --- Its prominence in the vegetation is strengthened with subsequent fires". These observations are validated by the pollen sequence from Una plain.

An examination of air photographs and of the vegetation surrounding Una Plains East suggested that the plain might provide a good example of Jackson's theory of ecological drift (Jackson, 1968) in which buttongrass moorlands are hypothesised to drift towards increasing woodiness in the absence of fire, eventually to culminate in the dominance of either *Eucalyptus* forest or rainforest, depending on the availability of seed sources. Although ecological drift is specifically directed towards nutrient poor environments in the southwest of the state, it was thought that the reasonably infertile Permian sandstones which underlie Una Plain East provided a reasonable analogy for the conditions demanded by Jackson's theory.

In this regard, the observations that buttongrass clumps existed in a degradation sequence from healthy clumps in open moorland to dead decaying mounds 20 m into the forest canopy suggested that the moorland was being invaded by forest. However, on the moor proper, occassional clumps of fire scarred trees and shrubs suggested that fires have caused either some degree of attrition to invading forest species or that survivors from an original forest managed to exist in the face of considerable fire pressure. Bowman and Jackson (1981:361) pointed out that long intervals between fires on sedgelands allow nutrients to accumulate in infertile peat, thus allowing expansions of heath and scrub species. An increase by *Melaleuca squamea* pollen in the upper samples may be indicative of this process and points to a lower fire frequency on this site during the European period. This interpretation is supported by the above mentioned occurrence of decayed buttongrass clumps found within the forest margins and the presence of a healthy *Melaleuca squamea* population on the moorlands (Plate 16).

These observations suggest that in this case, the stable boundary model of moorland forest interactions (Mount (1965, 1979) does not apply. Rather Jackson's model (1968) seems more appropriate. At Bathurst Harbour in western Tasmania, Brown and Podger (1982a) have demonstrated from floristic surveys that ecological drift applies in that location. Similarly. Jarman *et al.*, (1988a, 1988b) provide examples of moorland which are apparently drifting towards rainforest in the absence of fire. However, the latter also detail instances where stable moorland / forest boundaries seem to exist. They stress that the many communities which make up the Tasmanian buttongrass complex probably have individualistic responses to fire and climate changes and that there is probably no general successional path taken by all communities. They feel that differtences between buttongrass moorlands seem to be a reflection of environmental differences rather than an expression of age. However, they conclude that their data are incomplete and that much more information needs to be gathered before any firm conclusions can be made (Jarman *et al.*, 1988 b).

Jarman *et al.*, (1988b: 6-7) sampled the age distributions of shrubs growing on buttongrass moorland and concluded that 95% of all communities were less than 50 years old. The oldest moorland was at high altitude and had a maximum age of 131 years. Vegetation at lowland sites was frequently less tham 20 years in age. These figures relate to the time of the last fire, not to the long term stability of the community. Neither do the data give any indication of pre - European age distributions. This sort of data are only available by the study of fossils, especially pollen. At Una Plain it is clear that buttongrass plains have existed for over a thousand years, over which time, changes have occurred in both local and regional plant abundances. The Una Plain evidence indicates the value of a long term approach in defining the parameters within which present day ecological observations can be assumed to hold true. Without this type of data, it would be impossible for instance, to have any idea of when Una Plain was formed or what changes had occurred during its existence.

Historical records (Ellis, 1985) and contemporary observations of the vegetation suggest that ecological drift can operate in different directions at the same site over timescale of about 300 years. This stands in contrast to medium time scales of about 1,500 years, where pollen analysis shows that open moorland has existed with reasonably stable boundaries for the past 1,600 years. However, this degree of stability is illusionary, for major compositional changes were taking place in the local moor vegetation while minor adjustments continued in the regional forest composition. Finally, the fact that Una Plain has a basal date of 1,600 years BP indicates that major changes were taking place during a period when burning rather than climate can be implicated in vegetational changes.

The analysis demonstrates that some buttongrass moorland communities are themselves the product of successional changes. Following the burning of forests, the vegetation at some sites, especially those on free draining, fertile substrates, such as granite, may follow a successional path which leads from forest to grassland (Ellis, 1985).

In poorly drained forests, where buttongrass never existed or had been excluded, post fire communities are likely to be dominated by Restionaceae. Forests on infertile, poorly drained sites may eventually become dominated by buttongrass after initial increases by *Sphagnum*, *Gleichenia*, and *Astelia alpina* and Restionaceae, depending on the frequency of fire.

Considering the total absence of pollen evidence from buttongrass plains in western Tasmania, it is considered premature to formally extrapolate these results to other sites with different plant communities, different climates or places with different cultural histories. However, because of longstanding controversies concerning moorland dynamics, it is reasonable to tentatively suggest that linkages will exist between cultural and vegetation histories in other parts of the state and southeastern Australia (see chapter 9).

8.10 Mt. Victoria rockshelters

In an exceptionally clear example of concordance between cultural and pollen evidence, the onset of Aboriginal occupation in a sandstone rockshelter coincided exactly with the onset of organic peat accumulation in the adjacent *Gymnoschoenus* moorland of Una Plain. This represents a crucial piece of evidence in an ongoing debate concerning the dynamics of fire in wet Tasmanian forests and is tendered as an example of moorland created and subsequently maintained by Aboriginal burning.

8.11 Methods

Four sediment samples were taken from the wall of a shallow archaeological excavation conducted in a dry and commodious sandstone cave on the northeast bank of Dans Rivulet near Mt. Victoria at 800 m in the northeastern highlands. Four samples of sediment were taken for pollen analysis; a surface sample and 3 further samples at 5 cm intervals. Laboratory methods have been described previously. The excavation was conducted during the winter of 1989 at a time when fierce winds, snowfalls and below zero temperatures were recorded for periods of up to one week at a time. During these periods, no water entered the trench, which bears testimony to the excellent camping facilities provided by the site.

8.12 The study area

The shelter (MV2) is located at the base of a short escarpment of Permian sandstones (Figures 4.1 & 4.2), has a level floor and appears not to be subject to poor drainage or seasonal dampness.

The local vegetation within 10 m of the front of the shelter is wet eucalypt forest

Plate 18. Mixed forest of *Eucalyptus delegatensis* and *Nothofagus cunninghamii* in front of a set of rockshelters below Mt. Victoria. The shelters contain Aboriginal sites.

Plate 19. Rockshelter MV/2 at Dan's Rivulet. Aboriginal artefacts litter the surface of this shelter. A basal date of 1,490 +/- 70 BP (Beta-32573) was obtained from charcoal recovered from an excavation conducted on the level ground to the left of the figure in the photograph.

composed of *E. delegatensis* over a dense shrubby understorey of *Banksia marginata* and *Leptospermum lanigerum* with a ground layer of ferns. Situated between the eucalypt forest community and Dans Rivulet 40 m distant is a gallery rainforest consisting of *Nothofagus cunninghamii*, *Atherosperma moschatum* and *Dicksonia antarctica* (Plates 18 & 19). On the opposite bank of the rivulet, on the shady western side, an elongated community of *Sphagnum* spp. grows under the drip line of a second set of cliffs. Shelters under these cliffs are larger and damper than MV2 and contain cliff dwelling communities of ferns and wet forest shrubs.

Although the steep nature of Dans Rivulet has protected vegetation from damage by forestry activities, the effects of fire are manifest in the forests above the shelters, by an abundance of burnt trees and the presence of fire tolerant vegetation such as *Banksia* and *Gymnoschoenus*. Above the rockshelters are a series of buttongrass plains, including Una Plain, which appear to have a much drier aspect than would have been the case before logging and burning took place. The present regeneration of wet forest shrubs indicates that in the absence of fire, the entire area may eventually follow a successional path to rainforest. Mediating against this is the low fertility staus of the underlying Permian sandstones and the development of areas of impeded drainage on level ground wherever forest has been overcut.

8.13 Results and analysis

8.13.1 Dating

A C^{14} date was obtained from charcoal excavated from an Aboriginal site in shelter MV/2 (Plate 19). The determinations were made on hard black charcoal fragments greater than 5 mm in diameter. Pretreatment consisted of acid / alkali / acid baths prior to dating.

A sample from the lowest spit from which artefacts were excavated (15 cm) was dated to 1,590 +/-80 BP (Beta-2521). The sandy sediments at this level were acid with a PH of 6.5. The site provided no evidence to show that waterlogging or that post depositional disturbances had affected the integrity of the sediments. All sediments were derived from sandstones which form the shelter.

8.13.2 Pollen analysis: dry land taxa

The excavation recovered 101 artefacts from a 1m x 0.5 m trench which attained a maximum depth of 50 cm. Artefacts were not recovered from depths greater than 15 cm. This level marked a sharp colour and texture change in the sediments from brown, fine coarse sands which overlay bright orange coarse sands and gravels.

Figure 8.15 shows that *Eucalyptus* is never strongly represented but that its position

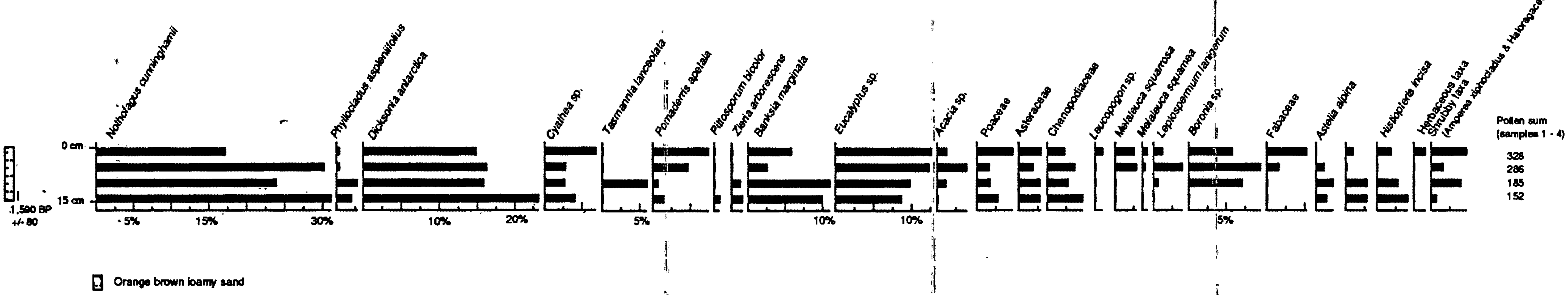


Figure 8.15. Mt. Victoria rockshelter (MV/2), dry land taxa only.

strengthens as time progressed (8.6% to 12.5%). In contrast, *Nothofagus*, declines towards the surface but retains relatively high values throughout (17% to 30%). *Dicksonia antarctica*, *Banksia marginata* and the mesophytes, *Zieria*, *Pittosporum*, *Microsorium diversifolium* and *Astelia alpina* follow the trend established by *Nothofagus* as do representatives of the Fabaceae, probably *Oxylobium ellipticum*. Heathy taxa such as *Melaleuca squamea*, *Leptospermum* spp., Epacridaceae and *Leucopogon* all show increases in the upper part of the profile.

Poaceae and Asteraceae show little variation and from their low values (< 5%) and are assumed to represent regional pollen rain. *Pomaderris apetala* pollen reaches a significant peak in the surface sample and may represent increased disturbance regimes over the past 100 years in the vegetation of the South Esk River valley.

8.14 Discussion

Hope (1978) has demonstrated how pollen is usually filtered and intercepted by the physical nature of caves and rockshelters as well as by cave mouth vegetation. This process leads to an over-representation by local plants at the expense of regional and extralocal elements. At present the entrance to the shelter is obscured by a sparse scrub of *Banksia* growing as an understorey to a tall *Eucalyptus* forest, which in turn borders a *Nothofagus* gallery rainforest. In the past, only the understorey vegetation has changed significantly, although *Eucalyptus* declines as *Nothofagus* increases towards the surface.

The major understorey changes are from a prominent *Banksia* and fern association to understories dominated by myrtaceous scrubs and heathy species. The former asociation may have been quite open, for the presence of herbs such as *Astelia* and shrubs such as *Boronia* and *Oxylobium* and *Pultenaea* suggests that reasonably high light levels existed at that time. Changes in understories from wet forest shrubs to heathy shrubs are consistent with the climate changing to drier conditions during the late Holocene. However, this explanation is considered unlikely because the canyon like valley of Dans Rivulet would have maintained a constantly humid microclimate even in the face of considerable drought stress. This attribute allows the continued existence of rainforest within the valley.

On the balance, and in consideration of the demonstrated human occupance within the shelter for the past 1,600 years, the understorey changes are likely to have been a response to the presence of people. The most obvious effects of people on vegetation would have been the continual use of fire leading to an erosion of wet forest understories, and the impacts of people collecting material for economic reasons.

The effects of Aboriginal burning practices on the vegetation of highland northeastern Tasmania

Until now no evidence existed which plausibly demonstrated a direct link between local Aboriginal burning practices and the formation of buttongrass moorlands. The synchrony between the basal date at Una Plain (1,600 years BP) and the settlement of rockshelters adjacent to the plain (1,590 years BP) suggests that a link exists.

It is possible that earlier evidence for human occupance might exist in other places or at far deeper levels. It is also possible that sediment growth might be cyclical ans unrelated to any particular set of events. However, any explanation should take into account the available archaeological and ethnohistoric data, and in consideration of that body of evidence, it is thought that the coincidence of sediment growth with human occupation is causally related.

This evidence does not beg the question of the role of Aboriginal fires in the rest of Tasmania. Rather the debate is expanded with the realization that organic deposition can occur at any point in time as long as local hydrological and vegetational thresholds coincide. The temporal link between people and the creation of Una Plain seems secure, and with due consideration to the dates of initial organic accumulation at Paradise Plains (200 years BP) and Big Heathy Swamp (5,500 years BP) it is expected that the mosaic of moorland and forest so evident in wet parts of Tasmania will prove to consist of a temporal mosaic, equally as spectacular as the present day spatial mosaic.

On the western edge of the plateau which encompasses Mt. Victoria to Ben Nevis, there are examples of rainforest greater than 200 years in age which have remains of older *Eucalyptus* logs lying on the forest floor. Ellis & Thomas (1988) have pointed out that the presence of open crown trees in stands of tall pole form eucalypts to the west of Paradise Plains and Big Heathy Swamp points to the existence of still other areas which were once more open and grassy than they appear today. They suggest that as existing grassland became impoverished or overgrown with fire resistant vegetation, people may have abandoned areas and generated new grassland by burning adjacent rainforest. A similar complex and historically determined pattern probably also accounts for the distribution of many buttongrass moorlands in the northeast and northwest.

Much of the debate concerning the effects of Aboriginal burning regimes has revolved about the extent of boundary interactions between moorland and forest with little attention paid to the processes of formation and initial colonization. This is of paramount importance if the scope of the argument is widened to include the involvement of people in vegetation dynamics and their reasons for burning.

Ecological research has concentrated on boundary dynamics between moorland and forest (Brown & Podger, 1982a, Podger *et al.*, 1988; Jackson, 1965, 1968; Bowman & Jackson, 1981; Jarman *et al.*, 1988a, 1988b; Mount, 1979, 1982). The evidence presented above suggests that internal dynamics may be equally as important in the development of moorlands. The initiation of moorlands has been considered of secondary importance to subsequent successional processes, and yet, if as most suppose (Jackson, 1965, 1978; Jones, 1969, 1984; Macphail and Colhoun, 1985), Aboriginal burning of forests created buttongrass moorlands in the first instance, then the questions must be asked: what were the initial expectations of Aborigines and what degree of foresight was involved in the burning of wet forests.?

For instance, the Una Plains core shows that buttongrass moorland in the form that it exists today is a modem association of species which has no counterpart in any other level of the core. To argue that people created buttongrass moorlands for the purposes of hunting or ease of travel is to assume that moorlands as we know them have been relatively unchanged since their creation. Considering the vegetation on Una Plain as it existed 1,600 years ago, it is hard to imagine that travel or camping would have been advantaged by the creation of a boggy complex which would have remain wet through the summer period and which would take at least another 300 years to transform into drier moorland. On the other hand, the herbs associated with *Sphagum* communities may well have attracted game, acting in much the same fashion as freshly bumt grassland patches (Whinam *et al.*, 1989). It is also highly likely that people created open bog complexes for reasons which we do not apprehend. For example, changes wrought in this fashion might have had the desirable result of reinforcing social obligations or ownership priorities. Bumt patches may have acted as signals to band members or warnings / greetings to others.

If the complex mosaics of plant communities which exist today, had counterparts in the past, then it is likely that the people were as familiar with the burning characteristics of various plant communities as we are with the performance of various automobiles. In such a case, people might burn an area of rain forest, knowing full well that changes to either grassland or moorland would not occur immediately. Oral traditions are perfectly well suited to the retention of socially crucial information and there is no reason why ecologically crucial information should not also be the object of an oral tradition. The fact that any good Irish person (Hyde, 1899) or Maori (Bellwood, 1979) can recount a genealogy extending back for 1,000 years is sufficient proof of the ability of people to store complex data in the absence of writing materials. Certainly, the ethnohistoric data points to a knowledge which allowed fire to be used for domestic, ritual, defensive, signalling and economic reasons. There seems to be no valid reason why people who used fire in so many sophisticated ways would not have been fully cognizant of the results and implications of their endeavours.

According to peoples needs and inclinations, patches of forest in the montane and sub alpine zones were probably burnt as other patches regenerated. People could have exploited an enormous range of botanically based resources based on grassland, sedgeland, open forest and closed forest plant communities. Unlike the drier low country, with its easy access to both coast and hinterland and its abundance of food resources, the mountain forest economy depended on very careful manipulation of the environment in order to maximize returns. One way to achieve resource security in the face of slow plant growth and unpredictable weather conditions may have been the establishment and maintainence of a dynamic spatial and temporal mosaic of plant communities, ranging from bog to eucalypt forest and from grassland to rainforest.

Pollen analysis and ethnographic information suggest that the fire stick farming was very probably in operation at places at moderate to high altitudes in the northeast and northwest. It remains for future research to flesh out the possibilities offered by other regional and local variations. The theories of Ecological Drift (Jackson, 1965, 1978) and StableFire Cycles (Mount, 1972) do not fare so well because insufficient data exists in regard to the long term dynamics of sedgelands. This study suggests that a more comprehensive theory will have to take serious account of how historical factors interact with soils, climate and cultural influences.

That Holocene climatic oscillations led in many cases to increases in rates of organic accumulation is highly probable (Macphail & Hope, 1985). That climatic variations caused the initiation of accumulation in many places is equally likely, but any theory that asserts the primacy of climate in determing Holocene vegetation change may severely under-estimate the effects of people, especially in the montane zone. The evidence in this chapter points to changes in hydrological regimes caused by human activities as being at least equally responsible for such phenomena.

Chapter 9

Firestick farming, environment and Aboriginal settlement patterns

9.1 Introduction

The previous chapters have emphasised the proposition that Aborigines lived in a more intimate relationship with forests that has hitherto been generally accepted. In this respect, Jones's (1969) theory of firestick farming has proved to be seminal, even though a degree of modification is necessary in order to account for regional variations in environment. Tasmania is the most forested state in Australia and yet only recently has the archaeological focus shifted decisively away from coastal economies to those based on inland resources. At the same time there has been little evidence of any extension of pollen analysis to complement archaeological research programmes. With few exceptions, palynology has been restricted to describing broad scale vegetational trends, and climatic reconstructions derived from sites with the capability of providing long glacial and interglacial sequences.

Taken together, both disciplines have neglected the research value presented by the simultaneous study of Aboriginal sites within a context of locally derived pollen sequences; a notable exception being the work of Bowdler (1984) and Hope (1978). In this thesis, Aboriginal / environment interactions during the Holocene have been investigated by detailed analyses of ethnohistorical records, archaeological site distributions and local pollen histories. This multidiciplinary approach has been advocated by Brown & Podger (1988) and successfully executed in Victoria by Head (1983, 1986 1988) and Gell & Stuart (1989).

This chapter examines aspects of the important theories of ecological drift (Jackson, 1968) and firestick farming (Jones, 1969) in the light of the ethnohistorical and palynological investigations described in the preceding chapters.

The fact that many grasslands and sedgelands are considered to be pyrogenic disclimaxes provides the botanical clue which links vegetation change with cultural traditions. Jones (1968, 1971, 1975) recognized the relationship, and in a brilliant example of synthesis, banished forever the notion that Aborigines were children of nature, incapable of affecting the environment. He introduced to Australia the concept that cultural traditions are inevitably interwoven with ecological processes by way of his famous theory of firestick farming. This advance was accomplished with reference to the equally spectacular botanical work of Jackson (1965, 1968) who proposed the first, and so far, the only model, to explain the nature of the general processes which have acted on Tasmanian vegetation during the Holocene.

Alternative theories have attracted attention, but failed to win widespread support. Horton (1982) attempted to downplay the effects of Aboriginal fires on the Australian vegetation, but his alternative does not explain the pyrogenic disclimax formations found in Tasmania (Bowman & Brown, 1986). Likewise, the static vegetation model of Mount (1979, 1982) does not explain vegetation dynamics on a scale of centuries, much less the longer term changes determined by pollen analysis (Macphail, 1980, 1984, 1988).

The following discussion links the foregoing chapters by suggesting some modifications to the theories of Jones and Jackson, before critically analysing a recent attempt to explain cultural change which uses a palaeo-environmental framework (Cosgrove *et al.*, 1990).

9.2 An analysis of the firestick farming hypothesis in Tasmania

The theory takes the positive view that Aborigines had the will and the means to alter their environment. Jones (1969) argues pursuasively for the careful fire management of vegetation by Aborigines living in the Northern Territory, and by Aborigines in Tasmania during the first quarter of the 19th century. A central element of the theory is that the Surrey Hills area of northern Tasmania experienced a rapid invasion by rainforest following the removal of Aborigines in the period 1830 to 1840 (Jones, 1965, 1971, 1973). Much of the evidence comes from descriptions recorded by the Van Diemen's Land Company. surveyor, Henry Hellyer (see Chapter 3)

In order to demonstrate this proposition , it is necessary to prove beyond reasonable doubt that:

1) Hellyer's original description of the Surrey Hills area was accurate

2) A rapid advance of rainforest across the hills did in fact occur.

Hellyer's description

The primary historic sources used by Jones (1969, 1971, 1973) appear to have been Hellyer (1828), Walker (1897 and 1898, in 1973) and possibly, Meston (1954:51). Oddly enough, Gunn (1860) is not cited by any authority, and yet his observations are, perhaps, the most reliable of all.

In a series of footnotes to a copy of Hellyers account, published as a Survey office

Report (Hellyer,1861), Surveyor General, James Calder felt compelled to bring to the readers attention the tendency of Hellyer to exaggerate. Binks (1980) points out that Hellyer's suicide was related to the fact that he suffered a 'personality crisis' following the revelation that his assessment of the Surrey Hills was overly optimistic.

Meston (1954) and Binks (1980) point out that the company injudiciously expended massive funds into developing the Surrey Hills area based on Hellyer's opinion. The director of the company, Edmund Curr (already peeved that another company surveyor, J. H. Wedge, had failed to locate much grassland in the northwest) was bitterly disapointed when he first viewed the Surrey Hills. He berated the efforts of his surveyors by writing: "What Hellyer and Fossey had extolled as magnificent park like country, In the Surrey HIlls was not even second rate sheep pasture" (Curr in Binks, 1980:79).

The companys agricultural expert, Alexander Goldie, gave Curr a description of the Surrey Hills severely at odds with that of Hellyer. Goldie reported that the hills were: "very high, cold and bleak, the feed very bad with a great deal of stoney rocky ground, the grass being very wirey and the tussocks far apart" (Goldie, in Meston:28). Curr responded to Hellyer's report with sarcasm: "Climate cannot be judged in a days walk, but stoney rocky ground with tussocks far apart no person ought to have converted into the most magnificent grass hill he had seen in the country" (Curr, in Meston:28). Later, Curr mockingly declared that for Hellyer: "His geese are all swans" (Curr, in Meston:50).

Hellyer's description of the Surrey Hills is inherently flawed. In spite of this, it is not argued that the place did not form a focus for Aboriginal settlement, or that Aboriginal burning did not maintain certain areas in an anthropogenic pyric disclimax. Rather, the revelation that Hellyer's idyll was so far from the mark, raises the question of what was the real vegetation structure and comunity composition of the Surrey Hills in 1827?

Invasion by rainforest?

Following the lead offered by Jackson's ecological research into rainforest succession, Jones (1973) utilized Hellyers descriptions to claim that grass at the Surrey Hills turned 'sour' because of a lack of burning in the decade or so following the removal of Aborigines: "With the lifting of the old Aboriginal fire pressure, the flora have been returning to the edaphic climax which here is wet scub and *Nothofagus* rainforest" (Jones,1973:26).

The assertion that the Surrey Hills was rapidly invaded by scrub and rainforest following the lifting of a traditional Aboriginal fire regime forms the central element in the fire stick farming notion in respect to Tasmania. A close reading of Walker (Walker, 1898 in 1973:272) suggests that the situation may not have been so clear cut. He wrote:

"Most of the hinterland was covered with dense, almost impenetrable forest, but the high downs of the Hampshire and Surrey Hills and Middlesex Plains were favourite resorts. Other patches of open country at intervals would probably afford to these tribes the means of inland communication with their kinsmen on the west coast. These open spaces were formally more numerous, being kept clear by buming. Many of them have become overgrown with timber since the removal of the natives"

It seems possible that Walker was referring not to the high downs, but to smaller clear patches in lowland forests which led across to the west coast. Meston (1954:57) states that these openings varied from five to six hundred acres.

Meston (1954:51) further states that: "much of the land at both Surrey Hills and Hampshire Hills the scrub had been kept down by the annual bumings of the Aborigines who hunted there and reappeared quite rapidly after the land had been taken from them" (Meston:51). Presumably Meston derived his information from Walker, Gunn and the records of the VDL Co.

Good information comes from the noted botanical collector, Ronald Gunn, who gave details of trips made by him to the northwest in January and April, 1860. At that time, 35 years after the removal of Aborigines from the region, he described the country surrounding St. Valentines Peak as: "rough and unpromising for travelling, not having being burned, I presume, since the times of the Aborigines" (Gunn,1860). Yet a few short months later he was to describe the Surrey Hills as: "a series of thinly wooded, grassy open forests and plains, forming a sort of plateau, some 14 miles from e. to w. and about the same from n. to s. --- I believe therefore that the Surrey Hills may be estimated as at least 2,500 feet above the sea level. This would, in a great measure, account for the character of the vegetation and the severity of the climate" (Gunn, 1860).

He went on to state that: "There is much open, grassy country south and west of Middlesex Plains, equal in quality to Middlesex Plains themselves". In regard to the Surrey Hills he is most definite that: "A very considerable extent of the Surrey Hills is also becoming rapidly covered with forests of young *Eucalypti*, so as to render it probable that they will also in time become useless for pasture purposes. The want of the usual and regular Aboriginal fires to clear the country seems to be the cause" (Gunn, 1860). This then, is the primary historical evidence that the Surrey Hills area was once more open than it is today.

Ecological considerations

Jackson (1965) pointed out that *Poa* grasslands occur on fertile soils where fire incidence and frost activity limit forests. He goes on to state that these types of grasslands: "occur on basaltic and granitic soils at between 2,000 and 3,000 feet in high rainfalls as openings in rainforest. They were more extensive in the past climate and show capture by forest. In the last 130 years the advance of forest has been rapid and can be attributed to the lower incidence of fire in these regions following the extinction of the aboriginals" (Jackson, 1965:33).

In this suggestion Jackson proposed a complex system in which altitude, fertility, rainfall and burning all contributed to the maintainence of the grasslands. He asserts that in regard to savannah grasslands in Tasmania: "There seems no doubt that this condition was again produced by a long history of firing by the Tasmanian natives" (Jackson:30). However, in this case he was arguing for the Midlands Valley , not the northwestern plateaux country.

Bowman & Jackson (1982:358) look to the supporting evidence of Cremer (1960) and Jackson (1965) in order to bolster the argument that changes in fire regimes in high rainfall areas were consequent upon: "the resulting decline or extinction of Aboriginal populations", which supposedly allowed rainforest to advance in sclerophyll forests.

Cremer (1960:123) felt that even though: "Rainforest advance into eucalypt areas is reported to have been actually observed over the past century in an area of N.W. Tasmania", he attributed the expansion to recent increases in rainfall.

Cremer relies on anecdotal evidence, probably that provided by Walker and Meston referred to earlier. However, he does cite Needham (1959) who, in an investigation of problems associated with the regeneration of *Eucalytus gigantea* (*E. delegatensis*) on the Surrey Hills, noted that: "The myrtle is advancing out of the gullies and invading the peppertree area. It competes strongly with the native *E. gigantea* slows up its growth rate and prevents the regeneration of the eucalypt."

Only Needham provides actual evidence of a rainforest advance. However, the rainforest is advancing out of fire protected gullies onto *Eucalyptus* covered slopes. Cremer's evidence relates to sclerophyll forest areas and not grassy plains. Likewise, Bowman & Jackson (1982) restrict their argument to sclerophyll forests in spite of Jackson's earlier work (1965) which refered to grasslands.

The botanical data do not support the commonly held notion that the Surrey Hills reverted back to rainforest following the removal of Aborigines. If the process did in fact occur, then it was taking place over centuries rather than decades.

Grasslands at medium to high altitudes in Tasmania are remarkable stable communities in which invasion by tree species takes a considerable amount of time. High altitude grasslands are maintained by a combination of frost effects, drainage and soil fertility which together, favour the development of a thick grass sward which in turn provides conditions inimical to arboreal invasion (Ellis,1985; Hill & Read,1983; Kirkpatrick, 1984;

Thomas,1984).

On Paradise Plains in northeastern, Tasmania, Ellis has calculated that the advance of *Eucalyptus* forest onto adjacent grassland occurs at appoximately 0.25 m per year. The conditions at Surrey Hills are comparable. Soils are more fertile than on the granite soils of Paradise Plains, but this advantage may be mitigated by generally colder winters and a greater incidence of frosts.

Hellyer recorded that in some places on the Surrey Hills, grassy plains extended without a tree for up to 6 kilometres. If Ellis's forest expansion rate is generously doubled in order to allow for possible fertility effects, it would still take 6,000 years for a forest to advance 3 km on all fronts to coalesce into a continuous forest!

Botanical and pollen evidence (Ellis,1985; Ellis & Thomas,1988) have shown that small patches of grassland within wet forests can be produced by Aboriginal burning. Meston estimated that the area of grasslands created by Aboriginal burning were five or six hundred acres in extent. This is approximately the area of Paradise Plains, which is known from ecological (not ethnohistorical) research, to have been created by Aborigines (Ellis, 1985).

The fact that Hellyer reports decaying trees on the open downs of Paradise Plains suggests that at least part of the area was only recently converted from forest. Read & Hill (1983) have emphasised the important place that fallen tree trunks have in providing suitable regeneration niches for rainforest propagules. Their work on the Surrey Hills suggests that approximately 300 m of grassland can be invaded by rainforest shrubs in 50 to 70 years. Even so, the invasion is not uniform and depends on the local availability of seed sources such as a rainforest filled gully. The species involved are chiefly small shrubs dispersed by birds. At this rate the complete invasion of Hellyer's open downs by climax rainforests taxa would take in excess of 700 years.

In contrast, Kirkpatrick & Duncan (1986:75) consider that the northwestern high altitude tussock grasslands such as those on the Surrey Hills: "may have been enlarged since that time as a result of eucalypt senesence, or the removal and the prevention of seedling regrowth by cattle and marsupial grazing". These authors also suggest that the formation of these grasslands may have been more recent than those on the Central Plateau where palynological investigations have demonstrated a great antiquity (Thomas, 1984).

Today there are numerous grassy patches in the forests and woodlands which cover the Surrey Hills. Considering the extent of the present day vegetation, the slow rates of tree growth for eucalypts at high altitudes and the distortions contained in Hellyer's account, it seems likely that the extent of grassy plains at Surrey Hills in the 1820's has been greatly overestimated. A more likely vegetation structure would have been an extensive woodland, with smaller patches of grassland interdigitated by rainforest patches on south facing slopes and along watercourses.

This conclusion in no way falsifies the firestick farming hypothesis, for the Paradise Plains and Mathinna Plains evidence point clearly towards Aboriginal burning as the agent which created them. However, the ecological considerations force a reappraisal of the rate or frequency of fires at high altitudes. It seems likely that the vegetation structure of the Surrey Hills could have been produced by relatively infrequent intense fires rather than the accepted notion of frequent low intensity burns. The important point to note is that firestick farming is not a formula to be applied uncritically over all of the state. In places like the Surrey Hills, ecological processes provides the necessary base within which burning was probably used to maintain a naturally grassy environment. On the balance, the theory is generally correct, but will need substantial modification in order to account for regional environmental differences and local vegetational and cultural traditions.

9.3 Aborigines and environment in southwestern Tasmania

Ethnographic evidence demonstrates the widespread nature of Aboriginal occupation in western and southwestern Tasmania. The data suggested that fires on buttongrass plains were of limited extent, resulting in mosaics of uneven aged communities. Flanagan (1983, 1985) and Thomas (1984, 1991) have pointed out that information derived from historical records do not support Jone's thesis that the southwest was a wilderness at the time of the European invasion. Jones does however, concede that infrequent visits to the southwest probably occurred (1974).

It is important to appreciate Flanagans argument that, contrary to being the vertebrate desert portrayed by Jones (1984), Bowdler (1983), Kiernan *et al* (1982) and Cosgrove *et al.*, (1990), the southwest *ca* 150 years ago was a rich environment, with ample populations of kangaroo and wombat.

Flanagan emphasises that the explorers, surveyors and piners all had access to fine hunting grounds (Flannagan, 1985:12). The accounts of Hellyer, Frankland, Goodwin, Darke and others reiterate this view. Certainly, as Binks (1980) and Flanagan hypothesise, and the above analysis demonstrates, the use of fire in the southwest was not simply a result of infrequent visits by Aborigines. Rather, the ethnohistorical evidence indicates a long term human presence in the area. Pollen analysis in multiple, appropriately sited locations should throw light on the extent and timing of burning, and thus, Aboriginal occupation.

Brown & Podger (1982b) have pointed out that over 45% of the southwest is covered by fire promoted *Gymnoschoenus* moorlands. This figure stands in stark contrast to the image of the southwest presented by recent archaeological literature in which the emphasis is on dark, dank, impenetrable forests, devoid of economic resources and inimical to human settlement (Cosgrove, *et al.*,1990; Bowdler, 1983; Jones, 1974, 1977, 1984, 1988; Kiernan *et al.*, 1982). From this emerges a paradox which has haunted both ecologists and archaeologists: if people had never occupied the southwest during the Holocene, how could so great an area of fire dependent vegetation exist?

It is clear that forests became established across Tasmania following the transition to warmer and more humid climates at the Pleistocene / Holocene boundary *ca* 14,000 to 10,000 years BP (Macphail, 1979, 1980, 1986; Colhoun and van de Geer, 1986; Hill *et al.*, (1988). The arguments regarding cultural change proposed by Cosgrove *et al.*, (1990), Kiernan *et al.*, (1982) and Jones (1984,1988) depend on the post-glacial expansion of forests as a key element in their explanations of cultural change. The question therefore becomes: how can the existence of extensive areas of fire sensitive buttongrass be reconciled with the hypothesis that expanding forests forced people out of the southwest?

Four possibilities suggest the range within which the contradiction between fire dependent and fire sensitive plant communities might be explained.

A) People may have lived in the southwest for the entire course of the Holocene, with their abandonment of cave occupation at about 12,000 BP being a response to changing environmental circumstances. This proposition has been suggested, but not pursued by Cosgrove *et al.*, (1990). The carbonate films which seal many of the cave floors may well represent a period of increased precipitation and groundwater activity (Macphail, 1979, 1980, 1986, 1988; Colhoun and van de Geer, 1986; Colhoun and van de Geer, 1988). Increasing humidity levels could have altered cave environments from being dry and comfortable during glacial times to damp and uncomfortable during the early Holocene.

In those circumstances, a reasonable response by people might have been to vacate damp caves in favour of a life in forests. Of course, as has be shown in Chapter 3, there is every reason to believe that even during the Pleistocene, use would have been made of open sites between caves, surrounding caves and in places where caves do not exist. The move from cave to forest would not have been such a dramatic transition, for no new technology would have been needed. Hut building techniques would have already existed, perhaps since people had arrived in southeastern Australia from the wet tropics.

An extremely interesting development in recent years has been the discovery and dating of rock art to ca 11,000 BP. The loss of the caves as a favourable environment for ritual or artistic expression may have been balanced by the development or extension of mobile artworks or the internal decoration of huts, similar to those described by Hellyer in the northwest and Calder in the southwest.

If the development of buttongrass plains was a response to increasing fire pressure on vegetation over the 10,000 year span of the Holocene, pollen evidence should show the expansion of buttongrass formations, with some deposits dating to at least 10,000 BP. In fact, pollen profiles from all known sites in western Tasmania show maximum values for Cyperaceae before 11,000 BP followed by rapid declines. A similar but even more marked trend is displayed by Poaceae.

B) A second possibility depends on the extent of drying trends in southern and western Tasmanian climates from roughly 5,000 BP to the present. Pollen evidence from central Tasmania suggests an opening of forests, a reduction in the rate of expansion of rainforest taxa and gains by drought tolerant eucalypts (Macphail, 1979, 1980, 1986; Markgraf *et al.*, 1986). From a consideration of these trends, Gellie (1980) hypothesised that an increase in coastal utilization by Aborigines led to the establishment of inland routes into more accessible parts of the west thereby increasing the frequency of ignitions. If such were the case, many inland buttongrass mires should date to about 5,000 BP. Such a finding would confirm predictions concerning the age of moorland peats made by Jarman *et al.*, (1988).

C) A third possibility is that the occupation of the southwest may be a relatively recent phenomenon. Aborigines may have only invaded into the southwest during the late Holocene or even as recently as the culture contact period, perhaps as a result of pressure by European settlement. The historical records demonstrate that by 1827, buttongrass expanses were already well established. The fact that roughly 45% of the southwest is covered in buttongrass communities suggests that regular burning of buttongrass plains has occurred over a long period of time. The removal of forests from tens of thousands of hectares of the state is difficult to sustain if Aborigines had been burning for only a few hundred years. In this case buttongrass mires should have relatively recent basal dates.

D) The final possibility is that a significant proportion of buttongrass communities are edaphic climaxes, limited by combinations of low soil nutrient status and waterlogged environments (Jarman *et al.*, 1988a, 1988b; Pemberton, 1989). If this is the case, some moorlands may have existed unchanged for tens of thousands of years. A range of basal ages could be expected, ranging from late Pleistocene to recent, depending on various local combinations of fire / vegetation / soil interactions.

A resolution to the problem of what effect Aborigines had on the vegetation of the southwest cannot be obtained until many more cores have been analysed for pollen and many more Holocene Aboriginal sites have been excavated. Vegetation analysis alone is inadequate over the .5,000 to 11,000 year timescales required. Pollen analysis is perfectly suited for the task, but in Tasmania specific anthropgenic indicators to distinguish between natural and cultural processes are lacking.

Ethnographic evidence, when combined with an appreciation of contemporary vegetation dynamics points to the fact that Aborigines have had a considerable effect on plant distributions. The problem is to ascertain for how long has this been the case. The extent of buttongrass moorlands, and the slow rate of organic accumulation, suggests that blanket bogs have been accumulating for a considerable period of time, perhaps for thousands of years. (Jarman *et al.*, 1988a). This in itself is an argument against buttongrass plains being recent artefacts.

9.4 Vegetation changes in the northeast as an aid to understanding the southwestern Tasmanian problem

If there is no evidence of synchroneity between the establishment of vegetation types and the occupation of Aboriginal sites in the west, the initial indications from the northeast suggest the opposite. At Waterhouse Point burning of forests by Aborigines acted synergistically with decreasing soil fertility and salt spray effects to replace *Eucalyptus* dominated forests with *Allocasuarina* / *Eucalyptus* formation and finally, a treeless heath. In dry forests at low altitudes, forests were not appreciably altered by burning.

It is often thought that Aboriginal burning was directed to promoting the growth of grassy understories in preference to heath understories, especially on fertile soils (Fensham, l989), but the evidence from the Forester Marsh shows that heathy understories have existed relatively unchanged for at least 4,500 years in the continual presence of fire. Aborigines had certainly lived in the northeast for at least 9,000 years (Cosgrove, 1985) and thus, it is likely that forests with heathy understories fomed just one part of an economic matrix which utilized varying proportions of grass, wet heath, dry heath, wet forest, dry forest and rainforest.

At higher altitudes, Jones's (1969) theory has proved a reasonable basis for explaining vegetation changes during periods of the Holocene which are not thought to have experienced significant climatic changes. At Big Heathy Swamp, grassy formations gave way to wet eucalypt forests at about 3,000 years BP, after about 2,000 years of dominance; whereas at Una Plain, a buttongrass moorland was created about 1,600 years ago. Finally, at Paradise Plains (Ellis & Thomas, 1988), grasslands and *Sphagnum* bogs were created from rainforest about 200 or 250 years ago.

The variation in the basal dates and the differences between the locations, strongly suggests that much peat formation occurred in response to local factors rather than regional climatic trends. The absence of any obvious climatic reasons for the initiation of peat accumulation suggests that hydrological changes wrought by Aborigines were responsible for the development of blanket bogs. During the Holocene, climate is seen to be important in determining the rate of peat accumulation rather than acting as a formation factor.

The most significant finding is the synchroneity between initiation of peat production at Una Plain and the commencement of human occupation at Mt. Victoria rockshelters at 1,600 years BP. This result is the first evidence from Tasmania which firmly links the presence of people with the creation rather than the simple maintainance of buttongrass plains. In consideration of this result, it is possible to speculate about the possibility of similar links in other places.

Although the Mathinna Plains buttongrass communities are geographical outliers to the major areas of buttongrass in the state, they are floristically and structurally similar to many more widespread communities (Jarman *et al.*,1988) and may have similar developmental histories. Also, the location of the elevated plains on a highly infertile substrate, adds to the similarities between communities in the northeast and northwest in particular.

Buttongrass communities are variable in their floristics and geographic locations. Many contain evidence of a prior forested state (Podger *et al.*, 1988) and many are located on slopes which indicate that waterlogging cannot be held responsible for their origins (Jarman *et al.*, 1988a; Permberton, 1989). However, equally as many are located in poorly drained river valleys and on the margins of lakes and lagoons. Clearly, the origin of moorlands will not be covered by a single explanation, although the Mathinna Plains evidence strongly implicates Aboriginal burning practices in the formation of certain buttongrass plains.

9.5 Pleistocene settlement patterns

A recent settlement model proposed by Cosgrove *et al.*, (1990) proposes a simple Pleistocene environment in southeastern Tasmania in which resources were scattered and distributed sparsely across a landscape, with a high probability of drought conditions, and in a generally unstable ecosystem. In contrast, western Tasmania is modelled as a stable ecosystem in which the discontinuous extent of fertile soils led to the development of patches of moist grassy habitat in a vegetation type composed of low trees and shrubs.

A reconsideration of their pollen evidence shows that Poaceae and Asteraceae in association with alpine coniferous heath pollen was dominant over the period in question in western Tasmania. Poaceae has been shown in Chapter 5 to be primarily a locally derived element and thus high values might indicate limited areas of grass, as suggested by Cosgrove *et al.*, (1990). On the other hand, the fact that every core so far analysed from western Tasmania shows similar trends, suggests that the putative patches must have been so numerous as to be ubiquituous features rather than isolated occurrences.

Considering that many of the core sites are developed on highly infertile rocktypes, it must be assumed that grasses were growing on those substrates during the Pleistocene and if that were the case then grasses might have grown anywhere and everywhere. Although it is recognized that the majority of the southwest is comprised of poor soils on infertile substrates, it is also the case that quite large areas support soils of varying quality. Grasses are perfectly capable of colonizing infertile soils (Anderson, 1982) and their absence from the southwest today may result, in part, from their exclusion by forests and sedges during the course of the Holocene.

Also, it is probable that higher levels of rainfall during the Holocene, in combination with the loss of nutrients occassioned by burning buttongrass (see Chapter 3, this thesis; Bowman & Jackson, 1981) acted to accelerate soil leaching effects to produce present day soils which are likely to be more acidic and markedly infertile compared to those of 15,000 years ago.

In addition, the authors, conclude that Bennet's wallabies (*Macropus rufogriseus*), which form the dominant element in faunal assemblages, has sedentary habits and a diet in which grasses predominate. The evidence cited in support of this contention comes from northern New South Wales, in sub-tropical cattle grazing country, and in no way can be considered as indicating the Tasmanian situation. Wallabies may indeed have those attributes in a grassy paddock, but the evidence must be carefully considerered before applying it to such a different environment as western Tasmania, of 15,000 years ago. Additionally, Bennet's wallaby in Tasmania are known to consume buttongrass shoots and the soft bases of restiads (M. Driessen, *pers comm.* Tasmanian Department of Parks Wildlife and Heritage). The evidence cited of abundant wallaby scats found in an alpine herbfield (Gibson & Kirkpatrick, 1985) further suggests that wallabies feed on sedges and sclerophyllous herbs and shrubs, for at that site (Mt. Field), the local vegetation is dominated by the sedge *Carex gaudichaudiana* and the cushion plant *Abrotanella forsteroides.*

Finally, there is no pollen evidence from anywhere near the cave sites of the southwest to suggest just what was the local vegetation. It is incumbent on the authors to provide evidence in the form of pollen diagrams which can demonstrate a grassland / rainforest assemblage similar in many respects to that which exists at Paradise Plains in the northeast.

Their evidence in support of a uniform and unpredictable southeastern Tasmanian environment rests on the scant pollen evidence from an undated core from the eastern highlands (Sigeo & Colhoun, 1981), and a single radio carbon date from an inland sandune (Sigleo & Colhoun, 1985). The presence of lunette sands dated to 8,300 years BP in the northeast is taken to indicate unstable conditions which lasted from near the Last Glacial maximum to well into the warmest and most humid phase of the Holocene. In regard to the lunette date, it is more likely to represent dune formation consequent with lake full and developing strand conditions than the deflation of a dry lake surface. The evidence from Leedway lagoon in the same area (Chapter 6), demonstrates that lake full conditions and forests were developed by at least 12,000 BP, and there is no good reason to think that the situation at Rushy Lagoon would be any different.

The archaeological evidence presented by Cosgrove *et al.*, (1990) is not in question. Their conclusion that simple unidirectional models of culture change are untenable in the face of the unique southwestern Tasmanian sites is to be applauded. Their conviction that 'multidirectional trajectories' apply to their data is a major advance in Tasmanian archaeological research. However, their model is in urgent need of explicit palaeoenvironmental data derived from local sediment deposits. In this way the model could be developed without recourse to 'limited sets of value laden data and assumptions' (Cosgrove *et al.*, 1990:59).

Today we find an environment of great variety and it would be unusual if the Pleistocene was any different in this regard. Distributions were certainly different, as were community compositions, but complexity would have been maintained. Just as todays the alpine and subalpine areas exhibit great floral and geographic diversity (Kirkpatrick, 1984), so the alpine and subalpine associations in the Pleistocene were almost certainly just as varied. Aboriginal settlement models based on simple environmental distinctions will inevitably fail because there is no evidence for regional environmental simplicity during the Pleistocene and there never will be.

Neyland (1990) considers that rainforest patches in eastern Tasmania are relicts from a formerly more widespread distribution. One of the rainforest patches discoverd by Neyland (*pers comm*) is located in a dry part of the lower midlands valley, far outside of the normal precipitation range of the taxa. These patches, plus a larger core area in the northeastern highlands could not possibly have expanded from western glacial refugia during the Holocene, because *Nothofagus* has a particularly slow rate of dispersal (Noble, 1984). The rainforest must therefore have been extant in the east for the whole of the Holocene and probably since the last interglacial at least.

In consideration of the present distributions of plant formations, it must be admitted that representatives of all present formations were present in the east during the Pleistocene. The diversity of physiographic features from lowland plains to alpine plateaux and including a substantial area of dissected hills with attendant river valleys suggests that sufficient habitats would have always existed to support a complex pattern of plant communities.

As Aboriginal people lived in the southwest during the late Pleistocene, it seems inconcievable that they did not make use of other parts of the state. Glaciers and ice sheets were probably shunned, but many areas must have been as botanically varied as the Central Plateau is today. The lack of Pleistocene sites in eastern Tasmania may well be because the most likely sites have not yet been investigated. Rather than concentrating on lunette and sandsheet deposits, many of which were probably formed during the Holocene (Cosgrove, 1985, Kee, 1990), it might be more productive, though admittedly more difficult, to seek sites in the river terrace deposits of steams such as the South Esk, St Pauls, Swan, Prosser and Georges Rivers.

Recent evidence from a rockshelter on the hillslopes in central Tasmania demonstrates the Pleistocene occupation of the upper Derwent river catchment (Cosgrove, 1989; Cosgrove *et al.*, 1990) and it would be most surprising if sites of a similar age were not to be found furthur east. Rather than conditioning an specific archaeological problem with a limited selection of palaeo-environmental data, it may be wiser to admit that :-

1) The few inland excavations so far conducted in the east and southeast do not form a reliable sample

2) That until surveys and excavations focus on Pleistocene landforms, instead of Holocene sand sheets and coastal middens, Pleistocene sites will not be located.

3) The lack of limestone rockshelters in the eastern parts of the state means that sites will be difficult to locate and that settlement patterns will be radically different from those in the southwest

It is clear that a great deal of research will have to be initiated with the aim of elucidating local vegetation changes in an effort to understand Aboriginal / environment relationships.

Chapter 10

Paleaoecological and archaeological perspectives

10.1 Introduction

This chapter summarizes the data presented in the foregoing chapters in response to the questions posed in Chapter 1. It is recognized that any answers to palaeoecological and archaeological investigations are merely approximations that best fit the available data. This should be obvious from the fact that even the most simple of modern natural environments are poorly understood. In this sense all research is merely a precursor to future work.

10.2 Does the ethnographic record provide useful data in relation to settlement patterns and the use of fire by Tasmanian Aborigines?

Tasmanian ethnohistorical sources have usually been interpreted to demonstrate that Aborigines burning techniques were based on large fires, creating enormous areas of destruction. However, a close reading of the sources shows that many large fires were largely a response to the European presence and not a normal pattern of fire use. Extensive fires were also lit by European explorers and settlers.

In the northeast, a paucity of ethnohistoric data meant that many rather obscure records were examined. In spite of a distinct lack of material of interest to archaeologists, there was sufficient information to justify some generalisations concerning past vegetation patterns and the effects of Aboriginal burning practices. Notable in this regard are the papers and journals of G. A. Robinson which, although usually considered to be repositories of socially relevant data, were found to be more productive and reliable for the environmental data which they contain.

Elsewhere in the state, a number of very good sources exist which provide observations independent of the ubiquitous G. A. Robinson . The best of these include the reports of early Tasmanian land surveyors, especially H. Hellyer, R. Gunn, J. H. Wedge, W. S. Sharland and J. C. Darke. Good localized accounts are available from the early mariners. However, many of these suffer because their authors were so unfamiliar with the Tasmanian flora and landscape that many observations must be regared with suspicion.

The sources are fairly easily divided into those which apply to the coast and coastal plains and those which relate to the mountainous interior. Relatively few records apply to the extensive forested regions behind the eastern and northern coasts. Records are also scanty for alpine areas, although in these places the modern distributions of fire sensitive vegetation provides invaluable data (Cullen, 1987).

The coastal observations can be subdivided into those which relate to infertile and sandy substrates and those which refer to more fertile areas. A further division can be made based on precipitation levels. In general, observations from the more humid and fertile southeast coast indicate that in spite of the large number of smokes sighted by the mariners, a great deal of forest existed which had not been burnt for a substantial period of time. The records from the D'Entrecasteax and Baudin expeditions are clear on this count.

The journals of Bligh and Cook show that on Bruny Island, dense forest extended down to the waters edge in places which are underlain by fertile dolerite derived soils. On infertile sandy substrates, coastal heaths existed. Fire blackened trees were seen by all observers, especially in sandy areas. Tracks or beaten paths were often observed which led from the waters edge back into dense forest. An ecological argument to explain these patterns is that frequent fires in heathlands tends to maintain heaths and gramminoids, while in forests, frequent fires can eliminate many trees and replace them with grassy or heathy understories

The location of large campsites in coastal forests suggests that people preferentially sited many settlements in places which were subject to a relatively low frequency of fires. Such places were often adjacent to frequently burnt heaths and open woodlands. The infrequent burning of forests around campsites would have encouraged the growth of *E. obliqua*, *Dicksonia antarctica* and other plants suitable for hut building. Additionally, forests close to fresh water supplies generally have abundant faunal resources which may have been utilized by people close to the campsite. Women and children for example might be well provided for by small marsupials and shellfish, especially if men carried out stereotypic hunting roles on open grasslands and heaths.

On the extensive coastal plains of the northeast, fires were extensive, sometimes extending, according to Robinson, for one days march, or about 10 to 20 km. However, even these fires did not remove or even damage all trees. The most common formation on these plains was an open woodland of *Allocasuarina*, *Banksia* and peppermint eucalypts, with grassy or heathy understories. This suggests a reasonably high fire frequency, perhaps as much as one major fire every 15 or more years with a series of less intensive fires at closer intervals. Any one point on true heathlands such as those at Waterhouse Point and Musselroe Bay was probably burnt at least once every 10 years.

The large areas of low to moderate altitude country between the coastal plains and the mountains in northeastern Tasmania do not appear to have been extensively burnt. G. A. Robinson recorded the presence of small open plains within these dense and gloomy forests. These open places may have been regularly burnt, as they seemed to support a cover of heaths. He saw little evidence of Aboriginal occupance, but was told of the former presence of a group of people who lived almost exclusively in these deep forests. The nature of the forests, with their interdigitation of eucalypt and rainforests, points to a generally very low fire frequency with very occasional large wildfires.

In the northwest, Hellyer intersected a number of Aboriginal encampments located in forests which had previously been burnt. The contrast between this reasonably populated country and the northeast may be because of the greater number of social contacts between the people of central and northwestern Tasmania. Alternatively, the differences may be a function of the greater attention paid to this country by the early European settlers.

In the southwest, there is good correspondence between the presence of buttongrass / forest mosaics and sightings of Aborigines. The records of Goodwin and Darke are particularly good in this respect. Both Hellyer and Sharland provide good descriptions of uneven aged stands of buttongrass in valley bottoms. Many places were seen to be recently burnt, and both huts and pathways were recorded. Robinson never entered this country and was told that it was uninhabited. This is regarded as a deliberate piece of misinformation by the Aborigines to Robinson.

At higher altitudes in the northeast, patches of rainforest were burnt to create grasslands and sedgelands. This data is not available from the ethnohistoric sources for the simple reason that Europeans rarely ventured into those remote parts. Elsewhere in the state, Gould recorded huts and the marks of fire in the Eldon range in the central Highlands. Jorgenson and Robinson noted the presence of numerous huts in the grassy eucalypt forests of the lower Central Plateau. These forests, like those on the coastal plains might have been subject to complex fire regimes involving well spaced intense fires and more frequent localised blazes.

In regard to fire and the effects of Aboriginal burning of bushland, it is considered that the available ethnohistoric information is both more informative and more complex than hitherto suspected. It is however, strongly suggested that a degree of circumspection be employed when analysing and using such records. For example, the notion that Aborigines burnt bush at yearly intervals is a myth that is widely accepted by a large percentage of the general population. The myth has its origins in the reports of the early maritime expeditions from which descriptions of intense and extensive fires have been well publicized (Jones, 1975; Plomley, 1983). The fact that these descriptions refer to summer fires has added to a perception that Aborigines were reckless with their use of fire.

The analysis contained in chapters 2 and 3 points to a situation where Aborigines may have deliberately used fire as an aid in the defense of their land. Additionally, many of the smokes and fires recorded by G. A. Robinson appear to have been deliberately lit to misguide or confuse Robinson while at the same time allowing the Aborigines with Robinson to gently subvert his mission.

Furthermore, the scale of burning carried out by the early surveyors and explorers should not be underestimated. The effects of these fires have altered and obscured the vegetation patterns caused by Aboriginal burning to a major extent. Some plant communities which appear to have disjunct or perplexing distributions, such as certain areas of dry forest in high rainfall areas, or extensive areas of scrubby rainforest may be explained in this way.

10.3 What are the links between Holocene vegetation distributions and Aboriginal settlement patterns in Tasmania?

10.3.1 Holocene vegetation and settlement patterns in northeastern Tasmania

Between 18,000 years BP and about 8,500 years BP there is little evidence for occupation in the north, unless a number of large cores and flakes found on deflated podsol soil surfaces represent the remains of a technocomplex similar in some respects to the enigmatic Kartan industries (Lampert, 1981) from southern Australia.

At Rocky Cape (Jones, 1977) in the northwest and Rushy Lagoon (Cosgrove, 1985) in the northeast, occupation is found again at about 8,500 years BP. These sites represent the coastal and inland facies respectively of a second, more visible phase of settlement. The physical environment at Rushy Lagoon was likely to be directly analogous to that found at Leedway Lagoon (see Chapter 6). Both places were wetlands with lunettes on their eastern shores. At Leedway at about 12,500 years BP, a *Eucalyptus* forest grew on the sandy shores and there is every reason to suppose that Rushy Lagoon was similarly endowed. This is fairly surprising because in western Tasmania at the same time forests were just beginning to expand, and yet the east, on infertile sandunes, forests were already well established. Either the post glacial expansion of forests was earlier in the northeast or pockets of forest / woodlands had existed since much earlier times, perhaps for the whole of the Last Glacial.

The evidence from Waterhouse Marsh shows that a sparsely timbered salt marsh habitat gave way to fresh water and forest cover at about 9,000 years BP. Why a 3,000 year timelag should occur between Leedway and Waterhouse in terms of the establishment of local forests is not clear. Nevertheless, it is apparent that the timing of the occupation at Waterhouse dated to about 6,000 years BP is related to the demise of eucalypt forests. The relationship is not simple. The seeds of change were probably planted some thousand or so years earlier as rising sea levels caused salt spray to penetrate inland forests. Perhaps the process of change was inevitable given the inherent infertility of the deep siliceous sands and their proclivity to leach under humid early Holocene conditions. Whatever the initial cause, the final contributory factor was probably the burning of bush by Aborigines who focussed their settlement objectives on the coast as ocean levels stabilized at 6,000 years BP.

The dating of shell middens on the present northeastern coast show a range of ages from modern to 4,000 BP. The people and environment at Waterhouse seemed to have established some sort of equilibrium, for few significant changes in the local vegetation occurred over that period. But even so, life was not static, for although the coast was a focus for settlement, changes were occurring; changes which were beyond the control of people and which may have caused people to look to their memories and recall stories of when it was so cold that shelter had to sought in caves and when winds blew sand across the landscape.

These changes were climatic in nature, resulting in lowered temperatures. increased erosion in the highlands (Caine, 1978). Places which were once dry, filled up with water. Rainforests advanced down rivers valleys. The changes were gradual but lasted for about 1,000 years, from 4,000 to 3,000 years BP. During this time, mean annual temperatures may have declined by up to 2^{0}- 3^{0} C (Goede *et al.*, 1990). What this meant in terms of economic or social patterns is highly speculative, but it is tempting to agree with Allen (1979) and suggest that cooler climates caused a shift in economic activities. Depressed air and water temperatures may have been a major factor in the decision of people to stop eating scaled fish at about 3,500 years BP.

Other effects of temperature are likely to be more subtle. People may have opted to abandon some of their more exposed campsites in favour of those in more sheltered locations. An expansion of rainforest may have allowed people in the northeast to exploit a wider variety of plant foods, *Cyathea* for example. It is also possible that people may have dispersed into places where water availability had previously restricted their occupance. These speculations need to be addressed by more research in order that inland economies can be more closely linked to coastal settlement patters and so that the intensification hypothesis can be tested

10.3.2 Holocene vegetation and settlement patterns elsewhere in Tasmania

The analysis of ethnographic and archaeological records in chapters 2 - 4 supplements the early work of Bowdler (1979, 1984), Jones (1971, 1974), Lourandos (1972, 1977) and the more recent surveys of Brown (1986), Cosgrove (1984, 1990) and Vanderwal & Horton (1984). Prior to the discovery of large numbers of Aboriginal sites on the alpine Central Plateau (Cosgrove, 1984), the general pattern of settlement was thought to consist of a tightly exploited coastal economy in western and southern Tasmania and a less intensive and more extensive economy in the drier eastern parts of the state. Inland locations in the southwest and west, as well as the northeastern highlands were assumed not to have been systematically exploited. Subsequent research has shown that with few exceptions, all major parts of the state were occupied at the time of settlement.

The archaeological data suggests that Holocene settlement models for coasts and coastal plains might include a provision for large complex sites, comprising hut sites and domestic activity areas, to be found near freshwater, in places which were well forested at the time of observation. Scattered smaller sites, not related to camping or domestic activities will be found in places which were grassland or heathland at the time of observation. Coastal shell middens will be associated with often used camping areas in places near to freshwater and which had forest or heavy scrub cover almost to the waters edge. Shell middens on heathy or grassy coasts will be simple, small and show no evidence of longterm camping. The latter site type will contain few stone artefacts.

10.4 What are the links between Pleistocene vegetation distributions and Aboriginal settlement patterns in Tasmania?

10.4.1 Pleistocene vegetation and settlement patterns in northeastern Tasmania

Pollen based vegetation reconstructions show that the northeast has experienced varied climates and plant associations for at least the past 13,000 years. Late Last Glacial grasslands and woodlands extended from the foothills of the northeastern highlands, across extensive plains and probably over the horizon to present day Victoria. The sparse nature of the vegetation at that time is reflected in the widespread occurrence of parallel longitudinal sand dunes, blown off the Bassian Plain by strong winds from the northwest during the Last Glacial (Bowden, 1981, 1984).

The Aboriginal settlement of the plains during the late Last Glacial was equally as sparse, the only evidence so far discovered being a small number of artefacts recovered from limestone caves at the eastern (Brown, 1988) and western (Bowdler, 1984) margins of the plain. The extension of the term of human occupancy in southern Tasmania to sometime prior to 30,000 years BP (Cosgrove, 1990) provides good evidence that the Bassian Plain has a history extending far into the Late Pleistocene

The lack of direct evidence for the occupation of eastern Tasmania is no reason to suppose that settlement did not take place. As noted in the previous section, there is good reason to believe that the occupation of the northeast and east has great antiquity. From a knowledge of landform and plant distributions it is possible to construct a tentative settlement model which can be directly tested by excavations and palaeoecological investigations.

During the Last Glacial a number of factors probably led to the survival of rainforest species in spite of widespread arid conditions. The most immediate factor was that low temperatures led to decrease in evaporation and a consequent increase in the effectiveness of precipitation. While this might not have been the basis for successful forest growth in all areas, it probably allowed gullies and higher easterly slopes to retain a positive water balance. In this situation, extreme westerly and easterly locations in the state would have intercepted moist northwesterly and northeasterly wind systems, thus offsetting to some extent the dessicating effects of glacial conditions.

In the northeast, the closure of Bass Strait may have led to the extension of warmer oceanic currents from the north past the Furneaux group and down the eastern Tasmanian coast during the summer growth season, resulting in the widespread occurrence of fogs and a possible increase in cloudiness. These two factors are today responsible for allowing some northeastern rainforests to exist on favourably aspected slopes in otherwise dry locations.

Also, the regional treeline at 18,000 years BP was located at about 300m which means that a large percentage of eastern Tasmania was capable of supporting tree cover even at the height of the Last Glacial. Plant distributions might have been somewhat similar to central Tasmania today, where there is no well defined treeline even at 1,200m where a theoretical climatic treeline should exist. Here it is possible to find forests and woodlands existing at higher altitudes than many areas of treeless alpine vegetation. Physiographic features which act to deflect climatic trends are of supreme importance for the long term survival of frost and drought sensitive taxa, and the significance of such local details must have been equally important during the Pleistocene.

It is important to note that the presence of glaciers and icecaps does not necessarily indicate conditions inimical to humans, or even trees and forests. Many places in the world display a thriving coexistence between all three. The Gondwanan derived floras of New Zealand and Chile highlight evolutionary similarities between those places and that of Tasmania. In a sense, it is our misfortune for the Australian plate to have arrived at lower latitudes more quickly than those countries, for what we have lost as a consequence of continental drift and Holocene warming include glaciers, snowfields, and the sight of forests crowding the edges of ice sheets.

The presence of extensive sets of fertile valley fill deposits along the rivers of the east suggests that these might be the landforms which may have supported low altitude Pleistocene forests and woodlands, as well as a complement of Aboriginal sites. The varied topographical and geological nature of eastern Tasmania is today expressed in a wide variety of vegetation communities and it is expected that a similar, if somewhat attenuated complexity, existed during the Pleistocene. In fact, it is possible to envisage an environment characterised by complex associations of subalpine, montane and lowland plants forced into locations which today support forests with either grassy or heathy understories. Such a complex landscape would offer great incentives to Aboriginal economic objectives.

10.4.2 Pleistocene vegetation and settlement patterns elsewhere in Tasmania

Elsewhere in the state, Pleistocene vegetation patterns are known almost exclusively from a major series of pollen analyses from western, central and southern Tasmania. A conventional explanation suggests that the dominant vegetation of western Tasmania consisted of extensive grasslands and sub-alpine and alpine shrubberies. It is thought that isolated pockets of forests may have existed but considering that the treeline was depressed almost to sea level at 18,000 years BP, any significant forest mass must have existed on what is now the continental shelf.

A more recent interpretation suggests that grasslands in the southwest were restricted to isolated pockets of limestone derived soils and alluvial deposits (Cosgrove *et al.*, 1990). This is supposed to have allowed Aboriginal settlement patterns to be based on the utilization of a patchy environment of great predictability. This pattern is then contrasted with the Pleistocene southeastern environment which is characterized by uniformity and unpredictability of water and faunal resources.

The arguments presented in the preceding chapter demonstrate the lack of support that palaeoenvironmental data give to this hypothesis. An alternative settlement hypothesis should take account of the fact that large contiguous areas of grassland probably existed on extensive, not isolated, limestone and glaciofluvial and alluvial soils.

Additionally, grasslands and grassy woodlands could have existed on extensive areas with sandstone and volcanic substrates. The patchiness of the southwestern environment is likely to have been far more complex than a simple dichotomy between grassland and sedgeland. Much more likely was a complex environmental patchwork which encompassed significant representatives of all the major plant formations, including forests, as well as a number of communities which do not exist today. The poor pollen production and dispersal of many Tasmanian plants ensures that many such communities will remain palynologically and therefore intellectually invisible.

It is also sure that the southeastern streams such as the Derwent, the Prosser, the Swan, the Cygnet and many others, all retained sufficient water flow to make a claim of 'unpredictability', indefensible. On this basis, Aboriginal settlement patterns in the southwest and the southeast are likely to differ more as a result of contemporary site visibility than to any real variation in the availability of primary factors such as water or energy sources. Of course, the details of energy inputs, such as the proportions of faunal elements in archaeological assemblages, will vary from west to east but this will be found to be unrelated to gross availability or predictability.

It is predicted that southwestern Tasmanian Aboriginal sites will eventually be found to encompass a range of site types ranging from isolated unifunctional activity sites to large multifunctional open sites as well as the spectacular and famous cave sites. Elsewhere, occupation will have been widespread, but the absence of cave sites will make the discovery of open sites an expensive and problematical undertaking. The first step in this task should be to identify late Pleistocene landforms and build up a palynological map of Pleistocene Tasmania based on a grid of local and regional palaeoenvironmental records.

10.5 What support is there for the theories of ecological drift and firestick farming in the ethnographic, Holocene archaeological and palaeoecological evidence from Tasmania?

Both firestick farming and ecological drift have depended to some extent on the interpretation of ethnohistoric records. Indeed, it can be reasonably asserted that both theories are historically based. Certainly they both use rates of change as central elements. In the firestick farming hypothesis, a rapid rate of vegetation change following fire is necessary in order that individuals or successive generations could perceive the need for further fires. Likewise, ecological drift posits a set of time dependent functions which are based on the reproductive and competitive abilities of plant species following or in the absence of fire.

Ecological drift could operate if a sufficient number of natural fires took place but the low incidence of such occurrences in Tasmania necessitates a further mechanism to provide ignition sources. Firestick farming theorizes that Aborigines were inveterate firelighters to the extent that they purposely managed vegetation with the controlled use of fire. Both theories are dependent on each other. Without fires lit by people, western Tasmanian forests would approach a regional climax rainforest state. Without the ability of vegetation to recover and succeed back to forest after fire, Aborigines would not have been able to maintain tracts of land in a state of anthropogenic disclimax.

Such a harmonious state of affairs could not last long. The evidence presented in Chapters 8 and 9 shows that other factors, such as edaphic conditions, can maintain communities at a disclimax.Jackson recognized that soil fertility and drainage were crucial factors as long ago as 1965 but still chose to emphasise the effects of fire. Meanwhile, Jones recognized that large areas of buttongrass moors were probably human artefacts but continued to maintain that western Tasmania was substantially uninhabited during the Holocene.

Both Jones and Jackson depended heavily on the descriptions of fire provided by the French expeditions and early surveyors, especially Henry Hellyer. If those accounts stand up to detailed scrutiny then the theories can be considered to have passed their first crucial test. Ecological drift requires a second test be applied which would establish a chronological sequence to show the successional details of a number of plant communities over timescales as long as several thousands of years. Firestick farming requires a second test which would demonstrate the histories of tracts of grassland or moorland, contained within forests, which have developed in synchrony with either initial local human occupation or an accelerated phase of cultural deposition.

10.5.1 Ecological drift

The ethnohistoric evidence shows clearly that Aborigines were a major source of ignitions in all parts of the state. On this basis alone, fire must be regarded as a normal environmental factor and not a random occurrence and therefore,one of the the basic tenets of ecological drift is vindicated. This is of course in keeping with conventional ecological wisdom. The evidence further points to a complex pattern of fire use in which regional differences may have been based on precipitation gradients. This too is in keeping with the theory for Jackson took pains to point out that his theory should only be applied to those places which are low in nutrients and which have high rainfalls. In other words, he recognized that certain adaptations of plants in dry or fertile areas might act to counter the effects of succession.

It is important to point out that if Aboriginal fire regimes were based on natural environmental gradients, it is probable that fire regimes would have altered through time according to the rate of environmental change. Places which may have supported a particular pattern of burning at 30,000 years BP would probably have had radically different regimes at 18,000, 12,000 and 3,000 years BP. Additional complications can be expected because cultural traditions are certain to have changed over that long period of time.

Specific support for ecological drift will not be found in historical records unless observations of particular places at widely varying times can be compared. At Adventure Bay for example in 1773, Tobias Furneaux noted that all the trees appeared to be burnt and that the undergrowth was open enough to give easy walking. In 1788, William Bligh noted that about 25 feet of coppice growth had emerged from the stumps of trees which had been felled 11 years previously during Cook's visit in 1777. The understory appears to have been significantly denser than that observed by Furneaux 15 years earlier This suggests that even at such an apparently bountiful location, Aboriginal fires had been absent for well over a decade. Fourteen years later in 1802, Baudin recorded that Aborigines were lighting fires at Adventure bay, although as has been explained elsewhere, the nature of these fires may not relate to normal burning patterns.

Better support for ecological drift comes from the pollen evidence presented in chapters 5 - 8. Especially interesting are the results from Big Heathy Swamp and Mathinna Plains, both of which can be regarded as regional variants of the infertile southwestern Tasmanian situation. At Big Heathy Swamp, the creation and maintainence of a grassy woodland in an area which is climatically and edaphically suitable for rainforest points to the direct use of fire by Aborigines. For approximately 2,800 years the area surrounding the swamp was maintained with little internal changes until an increase in shrubbiness heralded a transitional phase between open woodland and full forest.

The replacement of Poaceae and Asteraceae pollen by that of *Zieria*, *Phebalium* and *Coprosma* is in full accord with the predictions of Jackson. That the vegetation never succeeded back to rainforest can be attributed to the fact that occasional wildfires served to reinforce the position of *Eucalyptus* to the long term detriment of *Nothofagus* and *Atherosperma*. The core gives support to the theory of ecological drift over a timescale of 5,000 years. This sort of information is unavailable through any means other than fossil analysis.

On Mathinna Plains, the creation of a buttongrass moorland at about 1,600 years BP can be regarded as an effect of Aboriginal burning. The internal changes in moorland composition emphasise that discussion of successional changes should not be limited by present day observations. For example, the sequence shows that the buttongrass complex is a successional product of earlier Pteridophtye / Bryophyte communities. To assume that buttongrass is either the start or endpoint of Tasmanian successional sequences is to underestimate the possible floristic complexities of change over long periods of time.

10.5.2 Firestick farming

This theory gains much support from both the ethnohistorical and palynological data. Although many aspects of the theory need to be refined to take account of local environments, traditions and floristics it is considered that firestick farming is a suitable framework within which to examine many Aboriginal / land relationships.

Like many influential theories, it can be claimed that firestick farming succeeds despite the apparent lack of support for many of its basic premises. Firstly, the ethnographic evidence available to Jones in the 1960's does not necessarily demonstrate the reality of the thesis. G. A. Robinson's testimonials for example, do not show the unequivocal curation of forests or grasslands / sedgelands with the use of fire (although the deliberate use of fire is not in question). The limitations of Robinson's journals, and those of the early mariners, has been amply discussed and leads to the proposition that the use of fire in those instances was dominated by the catalystic presence of Europeans, rather than indicating any traditional day to day usage.

Furthermore, Henry Hellyer's descriptions of grasslands on the Surrey Hills and subsequent descriptions of the same area by James Backhouse Walker do not indicate that a rapid invasion by rainforest occurred after the removal of Aborigines to Flinders Island. This is a crucial point, for if the vegetation was constrained by natural processes from succeeding to rainforest, there would be no good reason for Aborigines to manage the area.

Despite this particular instance, there is a plethora of evidence to show that Aborigines could predict fire behaviour to a very fine degree. This skill is likely to have been inherited from tens of thousands of years of life experience in Asia, mainland Australia and Tasmania.

The first historical record which points to the controlled use of fire is the Du Fresne expedition of 1772. On this occasion, various crew members noted that pine like trees (probably either the fire sensitive *Phyllocladus aspleniifolius* or *Callitris rhomboidea*) seemed to be carefully protected from damage by fire. Many of the early mariners, including Tasman, Furneaux, Cook, Cox and others were convinced that fire hollowed trees were purposely created by Aborigines for habitation purposes. Bligh vigorously disagreed with this notion but posited a relationship between burnt country and the presence of Aborigines. Curiously, Bligh thought that extensive fires resulted in a diminution in the amount of game available to Aborigines.

Bass and Flinders observed patchs of burnt vegetation on islands off the south coast and had little hesitation in ascribing their cause to Aborigines. They were well aware of the controlled use of fire for they had earlier seen examples of careful burning in the Tamar River valley. Many other example are provided in chapters 2 and 3.

More significant may be the use of fire for defensive and hunting purposes as documented in the reports of Kelly, Batman, Wedge, and especially the Baudin expedition. In these encounters, Aborigines seemed to use fire in attempts to confuse and harass Europeans. If this interpretation is anywhere near the mark, it is not unreasonable to suggest that the level of sophisticated use of fire extended to other facets of their social and economic life.

As mentioned previously, the remarks by Hellyer and Sharland in relation to patch burning of the southwestern buttongrass plains is highly suggestive of a deliberate policy to maintain pockets or expanses of open vegetation in places which would normally support forest in the absence of fire.

Although the ethnohistorical evidence will always remain equivocal on the point of why Aborigines burnt particular places, there are abundant examples of vegetation patterns which point to the results of controlled fire regimes.

In contrast, the pollen evidence to date has shown little evidence to support or refute the theory. This is to be expected because most palynologists have shown little interest in reducing the scale of their observations to encompass vegetation changes which were local rather than statewide in expression. The majority of pollen sequences are deliberately taken from sites which provide regional reconstructions. In such sequences, the effects of Aborigines on local vegetation complexes are occluded by climatically driven changes.

Also, it has proven next to impossible to find evidence for synchrony between cultural and ecological phenomena. This is partly a result of the above mentioned methodological problem but also a reflection of the lack of research conducted on inland Holocene archaeological sites in western Tasmania.

This thesis has demonstrated that in the northeastern highlands, synchrony does exist. At Mathinna Plains, human occupation began about 1,600 years BP which also happens to be the date of destruction of a tract of rainforest and the initiation of peat which resulted in the formation of a buttongrass moorland. On Paradise Plains, Aboriginal artefacts are found on the surface of a grassland which was created from rainforest a just 300 years ago. Big Heathy Swamp provides an instance of change induced by Aboriginal fire at about 5,500 years BP. These are expected to be the first of many such discoveries.

The creation and maintainence of open plant communities in areas of high precipitation is be considered to be good evidence for the theory of firestick farming. It will prove difficult to find evidence in less humid environments because the successional forces which drive ecological drift are thought not to operate in those places. It is possible that firestick farming in the drier areas of northern Tasmania may relate to the management of wetlands and lagoons, rather like the systems thought to have existed in southwestern Victoria (Head, 1983, 1986, 1988). Another possibility is that efforts were directed to the extension of patches of heathland within forest, such as may have occurred at Waterhouse Point. Nevertheless, with an growing interest being shown by ecologists into the dynamics of grasslands and dry sclerophyll forests, it is to be hoped that ecological theory will develop so that criteria can be developed to differentiate between natural and anthropogenic influences in those places.

10.6 Finale

The relationship between people and their landscape is complex regardless of cultural traditions or simplicity of landscape (Head, 1986). Time itself may filter out important details, leaving only the inane, or allowing the most significant objects to survive, thwarting any attempt to understand relationships between the sacred and the profane or between the ordinary and the extraordinary

The fact that people did live in rainforest and other areas of the southwest in the late Holocene leads to the suspicion that an explanation for the apparent abandonment of the cave sites at the beginning of the Holocene has an answer in the usage of forests. Rather than rainforest being the agent for forcing people out of the southwest it is just as likely that people merely altered their lifestyle to account for warmer and wetter conditions. Instead of camping in cool wet caves it could be that Aborigines merely moved outside and began or revived a tradition of sophisticated hut building that continued up until recent times (Plomley,1966).

This thesis has presented a body of evidence derived from from widely different techniques and sources in an attempt to explain some distributions of Aboriginal sites and to present Holocene vegetation histories from northeast Tasmania. Additional evidence was been reviewed from other parts of Tasmania which allowed general observations to be made in regard to settlement patterns and long term vegetation changes. The evidence suggests that on fertile well drained sites, grasslands have been forming and transforming into forest, in what appears to be an ecologically random fashion. On infertile sites, mires were created wherever and whenever local hydrological regimes were sufficiently altered to raise local watertables. A corollary of this would be that some mires might have disapeared owing to successional processes and a lowering of watertables. It is apparent that some controlling factors have been culturally based and therefore, trends are not random at all, merely subtle and local in expression.

On this basis it is better to view Aboriginal interactions with vegetation as continuously varying , multi-directional phenomena rather than as examples of unidirectional change. In this sense Cosgrove *et al.*, (1990) come closest to appreciating the real complexity of cultural processes in Tasmania, but in the long run, still fail to come to grips with the complex nature of palaeoenvironmental data or the abilities of humans to modify the landscape and to adapt traditions to new circumstances.

Grasslands in Tasmania were a focus for economic, not domestic activities. To judge from the record from Forester Marsh, heathy understories developed on infertile soils have remained substantially unchanged for more than 4,000 years. These communities are rich in animal and vegetable foods and should not be dismissed as resource 'target areas'. Open forests and woodlands with copses of dense forest probably constituted the most attractive environment of all, especially if located with access to the coast or some other resource base.

Rainforests were not shunned by people and probably provided variety in the economic cycle. Certainly there is now abundant evidence that Aboriginal sites are found in rainforest. In fact, wherever suitably protected sites exist, the existence of Aboriginal sites is almost a certainty. More significant is the use of rainforests by Aborigines as sources of environmental diversity. In places with sufficient precipitation levels, rainforest would have proved to be a most tractable of vegetation type, well suited to manipulation by fire. Given particular combinations of atmospheric and terrestrial conditions, fires could be lit which would guarantee the destruction of a certain amount of forest without necessarily causing wildfires of disastrous proportions.

This use of fire extended to the creation of small areas of grassland within wet sclerophyll forests and rainforests, especially those which were underlain by fertile soils. Fires were also responsible for maintaining grassy and heathy understories in places which would otherwise have developed into shrubby forests.The subsequent reburning of burnt patches over a few seasons could eventually result in a total transformation from forest to grassland or sedgeland.

Wherever infertile soils occurred, fires could act to retard the successional development of forests. On the Mathinna Plains in the northeastern highlands, limited areas of buttongrass moor were created simultaneously with the onset of occupation in neighbouring rockshelters by Aborigines. This is considered to be a direct result of Aboriginal burning which altered local evapotranspiration regimes to result in the raising of watertables and the development of impeded drainage. It is highly likely that this was a deliberate action undertaken by people who wished to alter natural ecosystems for their own benefit. The open plant communities created in this fashion constitutes as much a use of rainforests as any other activity.

In other places, especially near the coast, the slow, natural creation of heathlands by the pedological process of podsolization, was accelerated by the addition of salt laden sea winds and increased frequency of fires lit by people who were attracted to the newly stabilized coastline of Tasmania some 6,000 years BP.

If people were careless with fire, escapes could occur, but these must have been relatively infrequent, for extensive areas of fire sensitive vegetation still exist after 30,000 years of occupation. These places should probably be regarded as managed forests rather than as wilderness. The firestick farming theory is considered to be an appropriate model for this type of landscape manipulation.

The ethnohistoric and archaeological data presented in Chapters 1 - 4, show that Aboriginal settlement was focussed on forests. Regardless of whether or not the forests were coastal or inland, it was in forests that most campsites existed. In the past. Tasmanian Aboriginal economies have been characterised by a reliance on either coastal or grassland resources. Considering the recent discovery of huge numbers of sites in inland forested locations and the limited area of true grasslands in Tasmania during the Holocene, it may be more accurate to suggest that the focus of Aboriginal life, for at least the past 10,000 years, revolved around the use of forests.

People entered into Tasmania when climates were milder and wetter than today before the height of the Last Glacial. It is likely that extensive wet forests dominated large areas of northern and eastern Tasmania.Under these conditions, Aborigines lived for at least 10,000 years before the glacial maximum forced treelines down to about 300 m. During this period the knowledge of forest life gained from the previous 10,000 year period was not lost. It is more likely that settlement patterns altered to cope with changing circumstances as forests were confined to valleys in the west and frost free slopes and river terraces in the east.

During the Holocene, environmental changes in Tasmania were as dramatic in many respects as during the Pleistocene. These changes may not have involved glaciers or ice bergs, but sea level rises of up to 120m and the development of modern plant communities are not inconsiderable developments. To this can be added a number of cultural innovations such as the (re?)invention of watercraft, the occupation of the Central Plateau, the articulation of a marine economy with one based on terrestrial resources and the development of an artistic tradition which encompassed sophisticated abstract motifs on both inorganic and organic surfaces.

It is a matter of priority to establish research programmes which aim to discover ways and means to identify how Aborigines balanced their social and economic aims, especially over the last few millenia. It is not enough to be dazzled by very early cultural changes in the absence of an understanding of what those changes developed into. After all, our conception of Aboriginal life is almost entirely based on images derived ethnohistorical accounts. If a major aim is to understand the distant past, we must try to understand the relationships between ethnohistory and the recent past.

The foregoing argument is relevant to all studies of the past and is applied in exactly the same fashion in palynological studies where it is recognized that an understanding of modern pollen is a necessary prerequisite to the reconstruction of past floras and environments The Aboriginal landscape which was extant 200 years ago is rapidly being destroyed by forestry, farming and industrial developments. At the present rate of forest destruction it will prove difficult enough to understand contemporary ecological relationships; how much harder then will it be to reconstruct the past? The present is more than a key to the past, it actually contains the past. In this sense every effort which is made to understand late Holocene events will be amply repaid by the greater depth of understanding which we will bring to bear on more ancient problems.

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Appendix 1

Pollen data for Tauber pollen traps (percentages).

Includes all pollen traps from Waterhouse Marsh, Forester Marsh, Big Heathy Swamp and Paradise Plains.

Column one indicates sample numbers Abbreviations (see following page) apply to all subsequent appendices.

Key to abbreviations (in approximate order of appearance in pollen diagrams).

Notho *Nothofagus cunninghamii*
Athe *Atherosperma moschatum*
Phyl *Phyllocladus aspleniifolius*
Dick *Dicksonia antarctica*
Cyat *Cyathea* sp.
Tasm *Tasmannia lanceolata*
Poma *Pomaderris apetala*
Pita *Pittosporum bicolor*
Pheb *Phebalium* sp.
Zier *Zieria* sp.
Acac *Acacia* sp.
Dodo *Dodonaea viscosa*
Burs *Bursaria viscosa*
Allo *Allocasuarina* sp.
Euc *Eucalyptus* sp.
prot Proteacaea
Bank *Banksia marginata*
Spre/g *Sprengelia incamata*
Epac Epacridaceae tetrad
Leuc *Leucopogon* sp.
Rici *Ricinocarpus pinifolius*
Aste Asteraceae
Poa Poaceae
Call *Callistemon* sp.
Msqs *Melaleuca squarrosa*
Msqm *Melaleuca squamea*
Lept *Leptospermum* sp.
Lelg *Leptospermum lanigerum*
Lesp *Leptospermum scoparium*
Chen Chenopodiaceae
Copr *Coprosma* sp.
Ampe *Amperea xiphocladus*
Boro *Boronia* sp.
Pimi *Pimelea* sp.
Corre *Correa* sp.
Rham Rhamnaceae
Lami Lamiaceae
Good Goodeniaceae
Faba Fabaceae
Gent Gentianaceae
Astl *Astelia alpina*
Plan *Plantago* sp.
Hala Halagoraceae
Apia Apiaceae
Gunn *Gunnera cordifolia*
Lily Liliaceae
Utric *Utricularia* type
Xyris Xyridaceae type
Hist *Histiopteris incisa*
Micro *Microsorum diversifolia*
herb undifferentiated herbs
shrub undifferentiated shrubs

Waterhouse Marsh pollen traps (WH1 - WH3)

Percentage

	Noth	Phyl	Dick	Cyat	Tasm	Poma	Acac	Dodo	Burs	Allo	Euc	Bank	Spre
1	0.5	0.0	1.0	0.0	0.0	3.4	0.0	1.4	0.0	47.2	5.3	1.1	0.5
2	0.0	0.0	0.8	0.0	0.0	7.8	0.0	1.8	0.3	14.0	2.4	3.6	0.9
3	1.8	0.0	1.8	0.0	0.4	6.6	0.9	0.9	0.0	21.6	8.8	2.6	0.4

Percentage

	Epac	Leuc	Aste	Poa	msqs	Msqm	Lept	Chen	Ampe	Boro	Copr	Rham	Pimi
1	0.0	2.9	3.3	23.5	1.5	0.0	2.4	1.4	0.7	0.2	0.0	0.7	0.0
2	1.8	3.1	0.0	28.5	17.7	0.0	10.3	0.8	0.5	0.4	0.0	0.0	0.0
3	0.0	1.3	0.0	33.0	9.7	0.0	4.8	0.0	0.9	0.9	0.0	0.0	0.0

Percentage

	Lami	Faba	Plan	Hala	Apia	Gunne	Lily	Xris	Utric	herb	shrub
1	0.0	0.5	0.3	0.4	0.0	0.0	0.8	0.4	0.0	0.0	0.7
2	0.0	2.1	0.6	0.1	0.0	0.0	0.9	0.0	0.0	0.5	1.2
3	0.0	0.9	0.0	0.4	0.0	0.0	2.2	0.0	0.0	0.0	0.0

Forester Marsh pollen traps (FM1 - FM3)

Percentage

	Noth	Phyl	Dick	Cyat	Tasm	Poma	Pito	Pheb	Zier	Bank	Prot	Euc	Acac
1	1.2	0.5	0.9	0.0	0.0	9.4	0.0	0.2	0.0	0.0	0.0	22.1	1.5
2	0.7	1.2	1.2	0.0	0.0	10.8	0.0	0.3	0.0	0.0	0.0	14.9	0.5
3	0.8	0.0	1.3	0.0	0.0	10.7	0.0	0.0	0.0	0.1	0.0	27.2	1.3

Percentage

	Dodo	Allo	Cheno	Poa	Aste	Spre	Epac	Ricin	Leuco	Lami	Copr	Boro	Msqs
1	0.4	8.7	0.8	30.1	4.3	0.4	2.0	1.3	1.5	0.0	0.5	0.0	3.1
2	0.0	3.4	0.1	16.1	3.1	0.9	1.7	0.5	0.8	0.0	0.4	0.0	6.1
3	0.3	2.5	0.8	45.6	3.5	0.3	0.1	0.4	1.8	0.0	1.0	0.3	0.(

Percentage

	Msqm	Lelg	lesp	Apia	Call	Good	Faba	Xyris	herbs	shrub	Gunne	Lily
1	0.0	0.0	6.7	0.0	0.0	0.5	1.2	0.0	0.9	0.9	0.0	1.1
2	0.0	0.0	14.2	0.0	0.0	0.3	21.8	0.0	1.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.1	1.1	0.0	0.6

Big Heathy Swamp pollen traps (BH1 - BH3)

Percentage

	Noth	Phyl	Dick	Cyat	Tasm	Poma	Pito	Pheb	Zier	Prot	Euc	Aca:	Dodo
1	8.4	0.0	6.1	0.0	0.2	13.2	0.0	0.0	0.0	0.0	18.0	0.0	0.0
2	5.6	0.0	2.6	0.0	1.3	3.6	0.3	0.0	0.0	0.0	36.8	0.0	1.1
3	11.6	0.0	5.7	0.0	0.0	9.4	0.0	0.0	0.0	0.0	11.6	0.0	0.0

Percentage

	Allo	Poa	Aste	Chen	Epac	Spre	Leuc	Copr	Msqs	Msqm	Call	Lept	Lami
1	3.3	30.3	1.5	0.0	0.6	0.0	2.1	7.5	0.0	0.8	0.0	2.1	0.0
2	1.8	14.6	1.2	0.0	1.4	0.0	3.5	1.2	0.0	2.1	0.0	21.0	0.0
3	2.2	18.2	0.7	1.7	0.0	0.0	4.2	1.7	0.0	12.1	0.0	13.8	0.0

Percentage

	Boro	Faba	Gent	Astl	Apia	Viol	Hist	Micro	herb	shrub
1	0.0	0.2	0.0	1.0	0.4	0.2	0.0	1.5	1.1	1.3
2	0.4	0.3	0.0	0.3	0.3	0.0	0.0	0.2	0.2	0.2
3	0.0	5.7	0.0	0.0	0.2	0.0	0.0	1.0	0.0	0.0

Paradise Plains pollen traps (PP1 - PP10)

Percentage

	Noth	Athe	Phyl	Dick	Cyat	Tasm	Poma	Pito	Pheb	Zier	Prot	Euc	Acac
1	11.4	0.2	1.7	4.8	0.2	2.0	9.9	0.0	0.0	0.0	0.0	8.3	0.4
2	7.6	0.0	0.0	6.2	0.0	0.3	8.8	0.0	0.2	0.0	0.0	2.9	1.8
3	5.5	0.0	0.0	6.7	0.6	1.5	4.9	0.0	0.0	0.0	0.0	6.1	0.7
4	5.3	0.0	0.2	4.3	0.7	1.0	5.7	0.0	0.2	0.0	1.4	6.9	0.0
5	27.4	0.0	0.0	11.6	0.3	3.1	7.2	0.0	0.0	0.0	0.1	8.5	0.0
6	13.5	0.0	0.5	9.6	0.0	1.0	13.5	0.0	0.1	0.0	0.0	9.9	0.0
7	23.7	0.0	0.0	4.9	0.3	3.7	9.3	0.0	0.3	0.0	0.0	5.0	0.5
8	32.6	0.0	0.0	4.3	0.0	2.0	12.4	0.2	0.2	0.0	0.3	4.8	0.0
9	10.0	0.1	0.0	2.6	0.0	19.6	5.3	0.0	0.0	0.0	0.0	3.4	0.0
10	17.5	20.9	0.1	7.5	0.0	26.9	4.1	0.2	0.0	0.0	0.3	3.3	0.0

Percentage

	Boro	Faba	Gent	Astl	Apia	Viol	Hist	Micro	herb	shrub
1	0.6	0.2	0.0	0.0	0.0	0.0	0.2	1.2	1.5	1.1
2	0.5	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.8	0.4
3	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.6	0.9	0.4
4	0.2	0.5	0.0	0.0	0.2	0.5	0.2	2.1	0.7	1.2
5	0.8	0.3	0.0	0.1	0.1	0.0	1.0	2.2	1.7	1.0
6	0.1	0.5	0.0	0.0	0.0	0.2	0.1	0.3	0.9	0.6
7	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.6	1.5
8	0.0	0.6	0.0	0.0	0.6	0.0	0.0	1.9	0.0	0.0
9	0.3	1.2	0.0	0.5	0.0	0.7	0.0	0.8	3.5	0.9
10	0.1	0.3	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0

Percentage

	E	Allo	Poa	Aster	Chen	Epac	Spren	Leuc	Copr	Msqs	Msqm	Lept	Call
1	0.0	1.6	34.5	1.4	0.2	0.2	0.0	0.1	1.1	0.0	1.0	15.3	0.0
2	0.0	1.7	59.6	0.0	0.0	0.0	0.0	0.8	1.8	0.0	1.6	4.4	0.0
3	0.0	2.8	20.2	4.0	0.6	0.0	0.0	0.1	0.3	0.0	1.9	41.1	0.0
4	0.0	2.6	46.9	2.6	0.0	0.9	0.0	0.5	0.2	0.0	0.7	14.0	0.0
5	0.0	3.6	20.8	2.6	1.0	0.0	0.0	0.9	1.5	0.0	0.3	1.3	0.0
6	0.0	3.8	25.8	2.0	1.0	6.1	0.0	1.4	0.5	0.0	1.0	7.3	0.0
7	0.0	1.7	40.1	3.6	0.6	0.1	0.0	0.7	0.6	0.0	0.8	1.8	0.0
8	0.0	1.9	28.9	2.6	0.0	0.5	0.0	0.5	1.4	0.0	1.1	3.3	0.0
9	0.0	1.8	32.6	5.3	0.0	0.0	0.0	0.0	0.2	0.0	0.7	10.3	0.0
10	0.0	2.0	8.5	1.2	0.0	0.0	0.0	0.3	0.2	0.0	0.5	0.5	0.0

Appendix 2

Pollen data from Waterhouse Marsh (pollen percentages and concentrations).

Concentrations in grains.gm^{-1}.10^{-3}. Column one indicates sample numbers increasing with depth.

Percentage	Noth	Phyl	Dick	Cyat	Tasm	Poma	Acac	Dodo	Burs	Allo	Euc	Bank	Spre
1	1.2	1.6	1.2	0.6	0.0	2.6	1.2	2.4	0.0	25.3	3.8	2.6	4.4
2	2.6	1.6	3.3	1.0	0.0	1.3	0.3	0.7	0.3	27.5	4.9	0.0	2.0
3	3.2	0.6	2.5	0.0	0.0	1.3	0.6	0.0	0.0	45.6	15.2	1.3	0.6
4	7.0	0.0	2.5	0.0	0.0	5.1	0.0	1.9	0.0	47.8	13.4	0.0	0.0
5	6.6	0.0	2.4	0.9	0.0	7.6	0.0	0.0	0.0	43.6	11.8	0.0	0.9
6	7.0	0.7	0.0	2.4	0.0	5.2	0.7	0.7	0.0	43.0	17.5	0.7	0.0
7	9.5	1.6	4.0	1.6	0.0	1.2	0.0	0.0	0.0	25.3	22.5	0.0	0.8
8	3.1	1.7	6.1	3.5	0.0	1.3	0.0	0.9	0.0	40.2	14.8	0.4	1.3
9	5.9	1.0	3.4	2.9	0.5	3.9	0.5	0.5	0.0	49.0	8.3	0.0	1.0
10	3.4	2.9	4.8	2.9	0.0	1.4	0.0	1.0	0.0	33.7	16.3	1.9	1.0
11	8.6	4.5	4.5	2.2	2.2	4.8	0.4	0.7	0.0	24.5	16.7	0.0	1.5
12	9.1	4.2	3.0	2.7	0.0	1.5	0.0	0.8	0.0	25.1	7.2	1.5	1.9
13	2.7	4.1	8.1	4.1	0.0	1.4	0.0	3.2	0.0	21.7	9.0	0.5	0.0
14	6.9	1.9	11.9	3.1	2.3	0.0	0.0	0.0	0.0	31.5	15.8	0.0	0.8
15	5.4	2.7	6.5	1.9	0.4	1.9	0.0	0.0	0.0	34.1	10.7	1.1	0.8
16	1.3	1.3	2.7	0.9	0.0	3.1	0.0	0.0	0.0	16.5	41.5	0.0	0.0
17	2.6	1.1	3.7	0.0	0.0	3.4	0.0	4.2	0.0	15.0	46.7	0.0	0.0
18	3.9	1.4	2.8	1.4	0.0	4.2	1.2	2.8	0.2	9.9	44.8	0.9	0.0
19	6.5	0.0	2.7	2.0	0.0	3.7	0.3	0.7	0.0	7.1	44.2	0.0	0.0
20	4.3	0.9	1.8	1.5	0.0	2.1	0.9	0.6	0.0	9.8	39.9	0.0	0.0
21	4.3	0.7	1.0	0.0	0.0	1.3	0.0	0.0	0.3	9.4	45.5	2.0	0.0
22	3.2	0.3	0.3	0.0	0.0	2.0	0.9	0.3	0.0	3.8	57.3	1.5	0.0
23	7.2	3.6	0.0	0.0	0.0	4.2	1.2	0.0	0.6	7.2	28.3	2.4	0.0
24	2.1	4.6	0.0	2.6	0.0	3.1	0.0	0.0	0.0	6.2	16.0	1.0	0.0
25	2.6	4.5	1.3	0.0	0.0	2.6	0.0	0.0	0.0	1.3	18.7	1.3	0.0
26	2.7	4.7	2.7	0.0	0.0	2.7	0.7	1.3	0.0	2.7	17.4	2.7	0.0
27	1.9	3.8	3.8	0.0	0.0	1.9	0.0	1.9	1.0	4.8	16.3	2.9	0.0

Percentage

	Leuc	Aste	Poa	Msqs	Msqm	Lept	Chen	Copr	Ampe	Boro	Pimi	Corre	Rham
1	3.0	0.0	15.3	22.1	0.0	2.4	2.8	0.8	0.0	0.0	0.0	0.0	0.0
2	1.0	0.7	17.7	24.6	0.0	1.0	2.6	0.3	0.0	0.7	0.0	0.0	0.0
3	3.8	0.0	8.2	7.6	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0
4	3.2	4.5	9.6	0.0	0.0	0.0	1.3	0.0	0.6	0.0	0.0	0.0	0.0
5	1.9	4.7	7.1	4.7	0.0	0.0	0.0	0.0	1.4	1.9	0.0	0.9	0.5
6	0.0	3.5	6.3	2.8	2.4	0.3	2.1	0.0	1.4	0.0	0.0	0.0	0.0
7	0.0	5.9	10.3	0.0	5.5	0.0	4.7	0.0	0.4	0.0	0.0	0.0	3.6
8	0.0	3.5	9.6	0.0	2.2	0.9	2.6	0.0	3.1	0.0	0.0	0.0	2.6
9	1.0	2.9	10.3	2.5	0.0	0.0	1.0	0.0	1.0	0.5	0.0	0.0	0.0
10	0.5	4.3	4.8	0.5	1.0	13.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0
11	3.3	4.5	2.6	0.0	0.0	3.7	5.6	1.1	4.1	0.0	0.0	0.0	0.0
12	0.4	2.3	9.9	0.0	1.5	15.6	1.1	0.0	4.2	0.0	0.0	0.0	0.0
13	2.7	5.0	14.0	1.4	0.0	3.2	0.0	0.5	4.5	0.0	0.0	0.0	0.0
14	0.0	1.9	10.8	0.0	0.0	2.3	2.3	0.0	5.4	0.0	0.0	0.0	0.0
15	0.0	2.3	11.5	1.1	2.3	4.2	1.5	0.4	1.1	0.0	0.0	0.0	0.0
16	0.0	4.0	11.6	2.7	0.0	1.8	4.5	0.0	0.9	0.4	0.0	0.0	1.8
17	0.0	4.7	9.0	0.0	0.3	0.8	2.6	0.5	1.1	0.0	0.0	0.0	0.8
18	0.0	5.1	8.1	1.4	2.1	0.7	1.8	0.0	0.0	0.0	0.5	0.5	1.2
19	0.0	3.1	13.6	8.5	0.0	2.4	1.7	0.0	0.0	0.0	0.0	0.3	0.0
20	0.3	2.4	17.1	8.2	0.0	2.7	2.7	0.6	0.0	0.0	0.6	0.0	0.6
21	0.3	4.3	13.0	4.3	0.0	1.0	4.7	0.0	0.0	0.0	0.0	0.0	1.0
22	0.3	2.9	11.0	6.1	0.0	0.0	3.5	0.0	0.0	0.3	0.3	0.0	1.2
23	0.0	6.6	21.7	0.0	6.6	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	17.5	21.1	2.6	2.6	1.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	10.3	27.1	3.9	1.3	3.2	5.8	0.6	1.3	0.0	0.0	0.0	0.0
26	0.0	9.4	25.5	3.4	0.0	2.0	6.7	0.0	2.0	1.3	0.0	0.0	0.0
27	0.0	8.7	25.0	0.0	0.0	0.0	8.7	0.0	4.8	0.0	0.0	0.0	0.0

Percentage

	Faba	Plan	Hala	Apia	Gunne	Lily	Utric	Xyris	herb	shrub
1	0.0	1.0	2.8	0.0	0.0	2.4	0.4	0.0	0.0	0.0
2	0.7	0.3	3.3	0.0	0.0	1.6	0.0	0.0	0.0	0.0
3	0.6	0.6	2.5	0.0	0.6	2.5	0.0	0.0	0.0	0.0
4	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	1.4	0.0	0.0	0.9	0.0	0.0	0.0	0.5
6	0.0	0.7	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.8	0.0	0.8	1.6	0.0	0.0	0.0	0.0
8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
9	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0
10	0.5	1.0	1.4	0.5	0.0	0.0	0.5	0.0	0.0	0.0
11	0.7	0.0	1.5	0.0	0.7	0.0	0.0	0.0	0.0	0.0
12	1.9	0.0	1.9	3.0	0.0	0.4	0.0	0.0	0.0	0.8
13	0.9	2.7	1.8	1.8	0.0	0.0	0.0	0.0	0.0	1.4
14	0.4	0.0	0.0	0.8	0.0	0.0	0.4	0.0	0.8	0.0
15	1.5	0.0	2.7	0.0	0.0	0.0	0.4	0.0	1.1	0.0
16	0.0	0.0	2.7	0.9	0.0	0.0	0.0	1.3	0.0	0.0
17	0.0	0.3	1.1	0.3	0.5	1.1	0.0	0.0	0.0	0.3
18	0.0	0.7	3.0	0.5	0.0	0.0	0.0	0.0	0.2	0.9
19	0.0	0.0	1.4	0.0	0.0	0.7	0.0	0.3	0.0	0.7
20	0.0	0.9	0.6	0.0	0.0	0.0	0.3	0.0	0.3	0.6
21	0.0	0.7	4.7	0.0	0.0	0.0	0.3	0.3	0.0	0.3
22	0.3	0.6	2.3	0.0	0.0	1.2	0.0	0.6	0.0	0.0
23	0.0	3.0	1.2	0.0	0.0	1.2	0.0	3.6	0.0	0.0
24	0.0	2.6	12.4	0.0	0.0	0.0	0.0	0.5	0.0	0.0
25	0.0	2.6	5.2	0.6	1.3	0.0	0.0	3.9	0.0	0.0
26	0.0	1.3	1.3	0.0	0.0	2.7	0.0	4.7	0.0	0.0
27	0.0	1.0	3.8	0.0	0.0	1.9	0.0	3.8	0.0	0.0

Concentration

	Noth	Phyl	Dick	Cyat	Tasm	Poma	Acac	Dodo	Burs	Allo	Euc	Bank	Spre
1	0.5	0.7	0.5	0.3	0.0	1.1	0.5	1.0	0.0	10.9	1.6	1.1	1.9
2	0.6	0.4	0.8	0.2	0.0	0.3	0.1	0.2	0.1	6.6	1.2	0.0	0.5
3	0.8	0.2	0.6	0.0	0.0	0.3	0.2	0.0	0.0	11.4	3.8	0.3	0.2
4	1.2	0.0	0.4	0.0	0.0	0.9	0.0	0.3	0.0	8.1	2.3	0.0	0.0
5	1.2	0.0	0.4	0.2	0.0	1.3	0.0	0.0	0.0	7.7	2.1	0.0	0.2
6	1.3	0.1	0.0	0.5	0.0	1.0	0.1	0.1	0.0	8.2	3.3	0.1	0.0
7	1.6	0.3	0.7	0.3	0.0	0.2	0.0	0.0	0.0	4.3	3.9	0.0	0.1
8	1.0	0.6	2.1	1.2	0.0	0.4	0.0	0.3	0.0	13.5	5.0	0.1	0.4
9	1.8	0.3	1.1	0.9	0.2	1.2	0.2	0.2	0.0	15.1	2.6	0.0	0.3
10	0.9	0.8	1.3	0.8	0.0	0.4	0.0	0.3	0.0	9.4	4.6	0.5	0.3
11	3.3	1.7	1.7	0.8	0.8	1.8	0.1	0.3	0.0	9.3	6.4	0.0	0.6
12	4.8	2.2	1.6	1.4	0.0	0.8	0.0	0.4	0.0	13.1	3.8	0.8	1.0
13	0.9	1.4	2.8	1.4	0.0	0.5	0.0	1.1	0.0	7.5	3.1	0.2	0.0
14	1.7	0.5	2.9	0.7	0.6	0.0	0.0	0.0	0.0	7.5	3.8	0.0	0.2
15	1.8	0.9	2.2	0.6	0.1	0.6	0.0	0.0	0.0	11.4	3.6	0.4	0.3
16	0.7	0.7	1.4	0.5	0.0	1.6	0.0	0.0	0.0	8.3	20.9	0.0	0.0
17	2.7	1.1	3.7	0.0	0.0	3.5	0.0	4.2	0.0	15.1	47.0	0.0	0.0
18	2.7	1.0	1.9	1.0	0.0	2.9	0.8	1.9	0.2	6.9	31.1	0.6	0.0
19	4.4	0.0	1.8	1.4	0.0	2.5	0.2	0.5	0.0	4.8	29.8	0.0	0.0
20	2.5	0.5	1.1	0.9	0.0	1.3	0.5	0.4	0.0	5.8	23.8	0.0	0.0
21	2.1	0.3	0.5	0.0	0.0	0.6	0.0	0.0	0.2	4.5	22.0	1.0	0.0
22	3.3	0.3	0.3	0.0	0.0	2.1	0.9	0.3	0.0	3.9	59.7	1.5	0.0
23	3.0	1.5	0.0	0.0	0.0	1.7	0.5	0.0	0.2	3.0	11.6	1.0	0.0
24	0.4	1.0	0.0	0.5	0.0	0.7	0.0	0.0	0.0	1.3	3.4	0.2	0.0
25	0.4	0.7	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.2	2.9	0.2	0.0
26	0.4	0.7	0.4	0.0	0.0	0.4	0.1	0.2	0.0	0.4	2.5	0.4	0.0
27	0.1	0.3	0.3	0.0	0.0	0.1	0.0	0.1	0.1	0.3	1.1	0.2	0.0

Concentration

	Leuc	Aste	Poa	Msqs	Msqm	Lept	Chen	Copr	Ampe	Boro	Pimi	Corre	Rham
1	1.3	0.0	6.6	9.5	0.0	1.0	1.2	0.3	0.0	0.0	0.0	0.0	0.0
2	0.2	0.2	4.2	5.9	0.0	0.2	0.6	0.1	0.0	0.2	0.0	0.0	0.0
3	0.9	0.0	2.1	1.9	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.5	0.8	1.6	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0
5	0.3	0.8	1.3	0.8	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.2	0.1
6	0.0	0.7	1.2	0.5	0.5	0.1	0.4	0.0	0.3	0.0	0.0	0.0	0.0
7	0.0	1.0	1.8	0.0	1.0	0.0	0.8	0.0	0.1	0.0	0.0	0.0	0.6
8	0.0	1.2	3.2	0.0	0.7	0.3	0.9	0.0	1.0	0.0	0.0	0.0	0.9
9	0.3	0.9	3.2	0.8	0.0	0.0	0.3	0.0	0.3	0.2	0.0	0.0	0.0
10	0.1	1.2	1.3	0.1	0.3	3.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0
11	1.3	1.7	1.0	0.0	0.0	1.4	2.1	0.4	1.6	0.0	0.0	0.0	0.0
12	0.2	1.2	5.2	0.0	0.8	8.1	0.6	0.0	2.2	0.0	0.0	0.0	0.0
13	0.9	1.7	4.9	0.5	0.0	1.1	0.0	0.2	1.6	0.0	0.0	0.0	0.0
14	0.0	0.5	2.6	0.0	0.0	0.6	0.6	0.0	1.3	0.0	0.0	0.0	0.0
15	0.0	0.8	3.8	0.4	0.8	1.4	0.5	0.1	0.4	0.0	0.0	0.0	0.0
16	0.0	2.0	5.9	1.4	0.0	0.9	2.3	0.0	0.5	0.2	0.0	0.0	0.9
17	0.0	4.8	9.0	0.0	0.3	0.8	2.7	0.5	1.1	0.0	0.0	0.0	0.8
18	0.0	3.5	5.6	1.0	1.4	0.5	1.3	0.0	0.0	0.0	0.3	0.3	0.8
19	0.0	2.1	9.2	5.7	0.0	1.6	1.1	0.0	0.0	0.0	0.0	0.2	0.0
20	0.2	1.5	10.2	4.9	0.0	1.6	1.6	0.4	0.0	0.0	0.4	0.0	0.4
21	0.2	2.1	6.3	2.1	0.0	0.5	2.3	0.0	0.0	0.0	0.0	0.0	0.5
22	0.3	3.0	11.5	6.4	0.0	0.0	3.6	0.0	0.0	0.3	0.3	0.0	1.2
23	0.0	2.7	8.9	0.0	2.7	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	3.7	4.5	0.5	0.5	0.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	1.6	4.3	0.6	0.2	0.5	0.9	0.1	0.2	0.0	0.0	0.0	0.0
26	0.0	1.3	3.6	0.5	0.0	0.3	1.0	0.0	0.3	0.2	0.0	0.0	0.0
27	0.0	0.6	1.7	0.0	0.0	0.0	0.6	0.0	0.3	0.0	0.0	0.0	0.0

Concentration

	Faba	Plan	Hala	Apia	Gunne	Lily	Utric	Xyris	herb	shrub
1	0.0	0.4	1.2	0.0	0.0	1.0	0.2	0.0	0.0	0.0
2	0.2	0.1	0.8	0.0	0.0	0.4	0.0	0.0	0.0	0.0
3	0.2	0.2	0.6	0.0	0.2	0.6	0.0	0.0	0.0	0.0
4	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.1
6	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.1	0.0	0.1	0.3	0.0	0.0	0.0	0.0
8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
9	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0
10	0.1	0.3	0.4	0.1	0.0	0.0	0.1	0.0	0.0	0.0
11	0.3	0.0	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.0
12	1.0	0.0	1.0	1.6	0.0	0.2	0.0	0.0	0.0	0.4
13	0.3	0.9	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.5
14	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.2	0.0
15	0.5	0.0	0.9	0.0	0.0	0.0	0.1	0.0	0.4	0.0
16	0.0	0.0	1.4	0.5	0.0	0.0	0.0	0.7	0.0	0.0
17	0.0	0.3	1.1	0.3	0.5	1.1	0.0	0.0	0.0	0.3
18	0.0	0.5	2.1	0.3	0.0	0.0	0.0	0.0	0.2	0.6
19	0.0	0.0	0.9	0.0	0.0	0.5	0.0	0.2	0.0	0.5
20	0.0	0.5	0.4	0.0	0.0	0.0	0.2	0.0	0.2	0.4
21	0.0	0.3	2.3	0.0	0.0	0.0	0.2	0.2	0.0	0.2
22	0.3	0.6	2.4	0.0	0.0	1.2	0.0	0.6	0.0	0.0
23	0.0	1.2	0.5	0.0	0.0	0.5	0.0	1.5	0.0	0.0
24	0.0	0.5	2.6	0.0	0.0	0.0	0.0	0.1	0.0	0.0
25	0.0	0.4	0.8	0.1	0.2	0.0	0.0	0.6	0.0	0.0
26	0.0	0.2	0.2	0.0	0.0	0.4	0.0	0.7	0.0	0.0
27	0.0	0.1	0.3	0.0	0.0	0.1	0.0	0.3	0.0	0.0

Appendix 3

Pollen data from Forester Marsh (percentages and concentrations).

Concentrations in grains.gm^{-1}.10^{-3}. Column one indicates sample numbers increasing with depth.

Percentage

	Noth	Phyl	Dick	Cyat	Tas	Poma	Pito	Pheb	Zier	Prot	Bank	Euc	Acac
1	2.5	0.5	0.5	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	39.0	1.0
2	3.1	0.0	2.6	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	41.0	0.9
3	3.0	0.0	4.9	0.6	0.0	2.7	0.0	0.0	0.0	0.0	0.0	56.7	0.6
4	5.6	0.3	2.4	1.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	59.6	1.0
5	4.4	0.0	3.8	0.3	0.0	3.8	0.0	0.0	0.0	0.0	0.0	58.3	0.3
6	3.6	0.0	2.0	0.6	0.0	4.2	0.0	0.0	0.0	0.0	0.0	60.2	0.6
7	4.4	0.3	4.1	0.3	0.0	3.2	0.0	0.3	0.0	0.0	0.0	61.9	0.6
8	4.4	0.5	2.8	0.5	0.0	8.0	0.0	0.3	0.0	0.0	0.0	53.7	0.0
9	3.2	0.0	5.2	0.3	0.0	4.8	0.0	0.3	0.0	0.0	0.0	60.6	1.0
10	2.7	0.5	5.2	0.5	0.0	5.4	0.0	0.0	0.0	0.0	0.0	60.7	0.0
11	3.4	0.0	5.4	1.0	0.0	6.5	0.0	0.0	0.0	0.3	0.0	51.4	0.3
12	5.5	0.0	3.6	1.6	0.0	6.6	0.0	0.0	0.0	0.3	0.0	52.2	0.5
13	5.1	1.1	7.8	3.0	0.0	4.3	0.0	0.0	0.0	0.3	0.0	48.1	0.3
14	11.1	1.0	0.0	1.0	0.0	7.4	0.0	0.0	0.0	0.0	0.0	41.9	0.3
15	11.7	1.9	4.2	1.5	0.0	6.8	0.0	0.0	0.0	0.0	0.0	45.3	0.4
16	11.2	1.4	4.1	0.3	0.0	8.8	0.0	0.0	0.0	0.0	0.0	42.5	0.7
17	18.7	2.0	5.3	0.7	0.0	7.3	0.7	0.7	0.0	0.0	0.0	36.3	0.0
18	16.7	2.1	4.9	0.0	0.0	11.5	0.7	0.0	0.0	0.0	0.0	38.7	1.4
19	14.2	1.5	3.0	3.4	0.0	11.6	0.4	0.7	0.0	0.0	0.7	26.1	0.4
20	8.6	2.1	4.5	0.5	0.0	6.8	0.3	0.0	0.0	0.5	0.0	44.8	0.5
21	9.4	0.9	4.4	0.6	0.0	5.0	0.0	0.0	0.0	0.3	0.0	51.0	0.3
22	8.0	1.7	4.4	0.8	0.0	6.9	0.0	0.0	0.0	0.3	0.0	42.7	0.3
23	0.5	0.3	3.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	0.0
24	2.5	0.3	2.8	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	45.3	0.0
25	4.3	0.8	2.7	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	19.8	0.0
26	5.5	0.9	5.0	0.9	0.0	2.3	0.0	0.0	0.0	0.0	0.0	23.3	0.0

Percentage

	Dodo	Chen	Poa	Aste	Spre	Epac	Leuc	Rici	Lami	Copr	Boro	Msqs	Msqm
1	0.5	0.5	25.5	2.5	1.5	0.5	0.5	2.0	0.0	0.0	0.0	2.0	0.0
2	0.0	0.9	17.0	3.1	1.7	0.4	0.9	1.3	0.0	0.0	0.0	7.0	1.7
3	0.6	0.0	3.0	4.3	0.6	0.3	0.6	0.3	0.0	0.3	0.0	4.9	0.0
4	1.0	1.4	1.4	3.5	0.3	0.7	0.0	0.3	0.0	0.3	0.0	7.0	0.0
5	1.2	0.6	0.9	3.0	0.3	0.3	0.0	0.3	0.0	0.0	0.0	5.3	0.0
6	0.6	0.8	1.4	2.2	0.0	0.0	0.8	0.0	0.3	0.0	0.3	5.6	0.0
7	0.3	2.2	1.0	2.2	0.0	1.0	0.6	1.0	1.3	0.0	0.0	3.5	0.0
8	0.5	1.8	0.5	3.1	0.5	0.8	1.5	0.0	0.0	0.0	0.0	8.0	0.0
9	0.0	2.9	1.9	2.9	0.0	1.3	0.6	0.0	0.0	0.0	0.3	0.0	0.0
10	0.0	1.5	0.0	2.2	0.0	0.5	0.7	0.0	0.0	0.5	0.2	4.2	0.0
11	0.7	0.0	0.3	2.7	0.0	0.0	1.0	0.0	0.0	0.3	0.0	6.8	0.0
12	0.3	1.4	0.8	3.8	0.5	0.3	0.5	0.0	0.0	0.0	0.0	3.8	0.8
13	0.0	0.0	0.3	1.9	0.0	0.8	0.0	0.0	0.0	0.0	0.0	1.4	0.0
14	0.0	0.3	0.0	2.0	0.0	0.0	1.3	0.0	0.0	0.3	0.0	7.4	0.0
15	0.4	0.8	0.8	1.9	0.8	0.0	1.5	0.0	0.0	0.0	0.0	6.0	0.0
16	0.3	1.4	0.7	2.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	5.1	0.0
17	0.0	2.0	1.0	0.7	0.7	1.0	0.7	0.3	0.0	0.3	0.0	3.3	0.0
18	0.0	2.1	0.0	3.1	0.0	0.0	0.7	0.0	0.0	0.0	0.3	1.0	0.0
19	0.0	2.2	1.9	3.4	1.1	0.0	0.7	0.0	0.0	0.7	0.4	2.6	0.0
20	0.3	0.5	1.6	1.0	0.0	0.5	0.5	0.0	0.0	0.0	0.3	2.4	0.0
21	0.6	0.3	1.8	1.8	0.9	0.3	0.3	0.0	0.0	0.0	0.0	3.5	0.0
22	0.0	1.1	0.8	2.5	0.3	0.0	0.0	0.0	0.6	0.6	0.0	1.7	0.0
23	0.0	0.3	1.3	0.3	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.3	0.0
24	0.0	0.3	0.0	0.9	0.0	0.9	0.3	0.3	2.2	0.0	0.0	2.2	0.6
25	0.8	0.4	0.0	1.6	0.0	1.9	0.4	0.8	2.3	0.4	0.0	3.5	0.0
26	0.0	0.0	0.5	0.0	0.0	1.8	0.9	0.9	4.1	0.9	0.0	5.0	0.0

Percentage

	Leig	Lesp	Apia	Call	Good	Faba	Xris	Lily	Gunn	herb	shrub
1	1.0	0.0	1.0	0.5	0.5	1.0	3.0	0.5	0.0	2.5	0.0
2	0.9	0.4	0.4	0.4	0.4	2.2	3.5	2.2	0.0	0.0	2.2
3	3.0	0.0	0.0	0.3	0.6	0.9	0.0	0.0	0.0	0.0	2.7
4	1.0	0.0	0.0	0.3	0.0	0.7	0.3	0.7	0.0	0.0	0.0
5	0.3	0.0	0.0	0.0	0.0	1.8	0.3	1.2	0.0	0.0	0.0
6	1.1	0.0	0.0	0.0	0.3	0.8	0.6	1.1	0.0	0.0	6.4
7	1.6	0.0	0.0	0.0	0.0	0.6	0.0	0.3	0.0	0.0	0.0
8	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
9	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.3	0.3	3.2
10	1.2	0.0	0.0	0.0	0.0	0.7	0.0	0.2	0.0	0.0	0.0
11	2.0	0.0	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	3.1
12	1.4	0.0	0.0	0.0	0.0	0.3	0.8	0.0	0.0	0.0	5.7
13	1.1	0.0	0.0	0.0	0.0	0.3	4.1	0.5	0.8	0.0	1.9
14	3.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	4.7
15	1.1	0.0	0.8	0.0	0.0	0.8	0.4	0.4	0.0	0.0	5.7
16	0.3	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	5.8
17	0.0	0.0	0.0	0.0	0.0	0.3	2.0	0.0	1.0	0.0	3.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	1.0	4.2
19	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	0.0	0.0	4.5
20	1.0	0.0	0.0	0.0	0.0	0.8	2.4	0.0	0.3	0.0	3.7
21	0.3	0.0	0.0	0.6	0.0	0.0	1.2	0.0	0.0	0.6	6.5
22	0.8	0.0	0.0	0.0	0.0	0.6	0.6	1.1	0.0	0.0	11.8
23	0.3	0.0	0.0	0.0	0.0	0.3	0.5	0.3	0.0	0.0	18.9
24	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	21.9
25	0.0	0.0	0.0	0.0	0.4	0.0	0.0	1.2	0.0	0.8	42.8
26	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	32.0

Concentration

	Noth	Phyl	Dick	Cyat	Tas	Poma	Pito	Pheb	Zier	Prot	Bank	Euc	Acac
1	6.3	1.3	1.3	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	98.8	2.5
2	9.1	0.0	7.8	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	122.5	2.6
3	5.6	0.0	9.0	1.1	0.0	5.1	0.0	0.0	0.0	0.0	0.0	105.0	1.1
4	4.0	0.2	1.7	0.7	0.0	2.5	0.0	0.0	0.0	0.0	0.0	42.5	0.7
5	4.6	0.0	4.0	0.3	0.0	4.0	0.0	0.0	0.0	0.0	0.0	60.0	0.3
6	4.4	0.0	2.4	0.7	0.0	5.1	0.0	0.0	0.0	0.0	0.0	72.8	0.7
7	4.5	0.3	4.2	0.3	0.0	3.2	0.0	0.3	0.0	0.0	0.0	63.2	0.6
8	4.6	0.5	3.0	0.5	0.0	8.4	0.0	0.3	0.0	0.0	0.0	56.9	0.0
9	5.1	0.0	8.2	0.5	0.0	7.7	0.0	0.5	0.0	0.0	0.0	96.1	1.5
10	6.4	1.2	12.2	1.2	0.0	12.8	0.0	0.0	0.0	0.0	0.0	143.0	0.0
11	5.7	0.0	9.2	1.7	0.0	10.9	0.0	0.0	0.0	0.6	0.0	86.7	0.6
12	10.4	0.0	6.7	3.1	0.0	12.4	0.0	0.0	0.0	0.5	0.0	98.9	1.0
13	3.8	0.8	5.9	2.2	0.0	3.2	0.0	0.0	0.0	0.2	0.0	36.0	0.2
14	17.9	1.6	0.0	1.6	0.0	12.0	0.0	0.0	0.0	0.0	0.0	67.9	0.5
15	35.1	5.7	12.5	4.5	0.0	20.4	0.0	0.0	0.0	0.0	0.0	135.9	1.1
16	34.5	4.2	12.5	1.0	0.0	27.2	0.0	0.0	0.0	0.0	0.0	130.6	2.1
17	65.5	7.0	18.7	2.3	0.0	25.7	2.3	2.3	0.0	0.0	0.0	127.5	0.0
18	50.7	6.3	14.8	0.0	0.0	34.9	2.1	0.0	0.0	0.0	0.0	117.4	4.2
19	35.2	3.7	7.4	8.3	0.0	28.7	0.9	1.9	0.0	0.0	1.9	64.8	0.9
20	11.8	2.9	6.1	0.7	0.0	9.3	0.4	0.0	0.0	0.7	0.0	61.4	0.7
21	11.9	1.1	5.6	0.7	0.0	6.3	0.0	0.0	0.0	0.4	0.0	64.4	0.4
22	23.0	4.8	12.7	2.4	0.0	19.9	0.0	0.0	0.0	0.8	0.0	123.1	0.8
23	0.3	0.1	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.7	0.0
24	1.4	0.2	1.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	24.8	0.0
25	1.6	0.3	1.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	7.6	0.0
26	0.9	0.1	0.8	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.7	0.0

Concentration

	Dodo	Chen	Poa	Aste	Spre	Epac	Leuc	Rici	Lami	Copr	Boro	Msqs	Msqm
1	1.3	1.3	64.6	6.3	3.8	1.3	1.3	5.1	0.0	0.0	0.0	5.1	0.0
2	0.0	2.6	50.8	9.1	5.2	1.3	2.6	3.9	0.0	0.0	0.0	20.9	5.2
3	1.1	0.0	5.6	7.9	1.1	0.6	1.1	0.6	0.0	0.6	0.0	9.0	0.0
4	0.7	1.0	1.0	2.5	0.2	0.5	0.0	0.2	0.0	0.2	0.0	5.0	0.0
5	1.2	0.6	0.9	3.0	0.3	0.3	0.0	0.3	0.0	0.0	0.0	5.5	0.0
6	0.7	1.0	1.7	2.7	0.0	0.0	1.0	0.0	0.3	0.0	0.3	6.8	0.0
7	0.3	2.3	1.0	2.3	0.0	1.0	0.6	1.0	1.3	0.0	0.0	3.6	0.0
8	0.5	1.9	0.5	3.3	0.5	0.8	1.6	0.0	0.0	0.0	0.0	8.4	0.0
9	0.0	4.6	3.1	4.6	0.0	2.0	1.0	0.0	0.0	0.0	0.5	0.0	0.0
10	0.0	3.5	0.0	5.2	0.0	1.2	1.7	0.0	0.0	1.2	0.6	9.9	0.0
11	1.1	0.0	0.6	4.6	0.0	0.0	1.7	0.0	0.0	0.6	0.0	11.5	0.0
12	0.5	2.6	1.6	7.2	1.0	0.5	1.0	0.0	0.0	0.0	0.0	7.2	1.6
13	0.0	0.0	0.2	1.4	0.0	0.6	0.0	0.0	0.0	0.0	0.0	1.0	0.0
14	0.0	0.5	0.0	3.3	0.0	0.0	2.2	0.0	0.0	0.5	0.0	12.0	0.0
15	1.1	2.3	2.3	5.7	2.3	0.0	4.5	0.0	0.0	0.0	0.0	18.1	0.0
16	1.0	4.2	2.1	6.3	3.1	0.0	3.1	0.0	0.0	0.0	0.0	15.7	0.0
17	0.0	7.0	3.5	2.3	2.3	3.5	2.3	1.2	0.0	1.2	0.0	11.7	0.0
18	0.0	6.3	0.0	9.5	0.0	0.0	2.1	0.0	0.0	0.0	1.1	3.2	0.0
19	0.0	5.6	4.6	8.3	2.8	0.0	1.9	0.0	0.0	1.9	0.9	6.5	0.0
20	0.4	0.7	2.2	1.4	0.0	0.7	0.7	0.0	0.0	0.0	0.4	3.2	0.0
21	0.7	0.4	2.2	2.2	1.1	0.4	0.4	0.0	0.0	0.0	0.0	4.5	0.0
22	0.0	3.2	2.4	7.1	0.8	0.0	0.0	0.0	1.6	1.6	0.0	4.8	0.0
23	0.0	0.1	0.7	0.1	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.1	0.0
24	0.0	0.2	0.0	0.5	0.0	0.5	0.2	0.2	1.2	0.0	0.0	1.2	0.3
25	0.3	0.1	0.0	0.6	0.0	0.7	0.1	0.3	0.9	0.1	0.0	1.3	0.0
26	0.0	0.0	0.1	0.0	0.0	0.3	0.1	0.1	0.6	0.1	0.0	0.8	0.0

Concentration

	Lelg	Lesp	Apia	Call	Good	Faba	Xris	Lily	Gunn	herb	shrub
1	2.5	0.0	2.5	1.3	1.3	2.5	7.6	1.3	0.0	6.3	0.0
2	2.6	1.3	1.3	1.3	1.3	6.5	10.4	6.5	0.0	0.0	6.5
3	5.6	0.0	0.0	0.6	1.1	1.7	0.0	0.0	0.0	0.0	5.1
4	0.7	0.0	0.0	0.2	0.0	0.5	0.2	0.5	0.0	0.0	0.0
5	0.3	0.0	0.0	0.0	0.0	1.8	0.3	1.2	0.0	0.0	0.0
6	1.4	0.0	0.0	0.0	0.3	1.0	0.7	1.4	0.0	0.0	7.8
7	1.6	0.0	0.0	0.0	0.0	0.6	0.0	0.3	0.0	0.0	0.0
8	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1
9	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.5	0.5	5.1
10	2.9	0.0	0.0	0.0	0.0	1.7	0.0	0.6	0.0	0.0	0.0
11	3.4	0.0	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	5.2
12	2.6	0.0	0.0	0.0	0.0	0.5	1.6	0.0	0.0	0.0	10.9
13	0.8	0.0	0.0	0.0	0.0	0.2	3.0	0.4	0.6	0.0	1.4
14	4.9	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	7.6
15	3.4	0.0	2.3	0.0	0.0	2.3	1.1	1.1	0.0	0.0	17.0
16	1.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	17.8
17	0.0	0.0	0.0	0.0	0.0	1.2	7.0	0.0	3.5	0.0	10.5
18	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	3.2	12.7
19	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	0.0	0.0	11.1
20	1.4	0.0	0.0	0.0	0.0	1.1	3.2	0.0	0.4	0.0	5.0
21	0.4	0.0	0.0	0.7	0.0	0.0	1.5	0.0	0.0	0.7	8.2
22	2.4	0.0	0.0	0.0	0.0	1.6	1.6	3.2	0.0	0.0	34.1
23	0.1	0.0	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	9.8
24	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	12.0
25	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.0	0.3	16.5
26	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	5.0

Appendix 4

Pollen data from Big Heathy Swamp (percentages and concentrations).

Concentrations in grains.$gm^{-1}.10^{-3}$. Column one indicates sample numbers increasing with depth.

Percentage

	Noth	Phyl	Dick	Cyat	Tasm	Poma	Pito	Pheb	Zier	prot	Euc	Acac	Dodo
1	5.3	0.0	15.2	1.3	0.0	5.0	0.0	0.7	0.0	0.7	26.8	3.0	0.0
2	5.8	0.6	10.4	0.0	0.0	1.2	0.3	0.0	0.0	0.0	42.8	1.7	0.6
3	8.3	0.0	11.1	0.9	0.9	1.8	0.0	0.0	0.0	0.6	35.7	1.2	0.6
4	4.3	0.0	14.4	4.8	0.0	2.7	1.6	2.1	1.1	1.6	19.8	1.6	0.0
5	1.3	2.2	13.3	0.0	0.0	2.2	0.0	0.0	0.0	1.3	29.4	0.3	0.0
6	6.5	0.5	5.9	1.1	0.0	2.7	1.1	1.1	0.0	1.1	41.4	0.0	0.0
7	8.4	1.2	10.9	1.7	0.0	3.7	0.5	0.5	0.5	0.5	29.1	0.2	0.0
8	6.6	2.9	5.4	0.5	0.0	1.7	0.2	0.0	0.0	0.2	33.4	0.0	0.0
9	3.8	0.6	13.5	0.0	0.0	0.8	0.2	0.0	0.0	0.6	38.8	0.6	0.0
10	7.2	0.6	3.2	1.6	0.4	9.6	0.0	0.0	0.0	0.0	25.1	0.8	0.0
11	3.1	1.0	7.7	1.9	0.0	7.1	0.8	0.0	0.0	0.0	14.3	1.4	0.0
12	8.7	2.4	12.3	1.5	0.0	1.2	0.0	0.0	0.0	0.0	9.0	0.0	1.8
13	2.1	1.6	11.5	2.1	0.3	1.8	0.0	0.0	0.0	0.0	14.1	2.1	0.0
14	1.2	0.0	9.9	0.0	0.0	4.9	0.0	0.0	0.0	0.0	13.6	0.0	0.0

Percentage

	Poa	Aste	Chen	Epac	Spre	Leuc	Copr	Msqs	Msqm	Call	Lept	Lami	Boro
1	10.3	1.7	1.3	1.0	4.0	0.0	0.7	0.0	1.3	0.0	3.6	0.0	0.0
2	5.5	2.9	1.2	0.9	4.0	0.0	1.4	0.0	9.5	0.0	2.9	0.0	0.6
3	7.1	1.8	0.0	2.8	4.6	0.0	0.9	0.0	5.5	0.0	1.8	0.0	0.0
4	1.1	4.3	1.1	1.6	1.1	0.5	0.0	0.0	4.3	0.0	1.6	0.0	0.0
5	7.0	5.4	1.9	2.2	1.6	0.0	2.5	0.0	6.6	0.0	1.9	0.0	0.0
6	3.8	3.8	0.5	0.5	5.9	0.0	0.0	5.9	1.6	0.0	0.5	0.0	0.0
7	3.7	5.2	0.5	1.5	1.7	0.0	1.5	4.9	2.0	0.0	2.5	0.0	0.0
8	2.2	5.1	2.2	0.5	4.1	0.7	0.0	4.9	2.2	0.0	2.7	0.0	0.0
9	3.0	3.4	1.1	1.9	2.5	0.0	1.3	3.2	2.1	0.0	0.8	0.0	0.0
10	0.0	4.6	0.4	3.0	6.4	0.0	2.4	4.2	0.8	0.0	2.6	0.0	0.0
11	5.2	10.0	0.8	4.8	2.3	0.0	0.4	4.6	1.2	0.0	7.7	0.0	0.0
12	5.7	6.6	0.6	7.8	15.0	0.9	0.0	2.1	3.9	0.0	7.2	0.0	0.0
13	14.7	9.4	1.0	3.4	9.7	0.0	1.6	1.6	3.9	0.0	5.0	0.0	0.0
14	22.2	9.9	0.0	7.0	4.1	0.4	0.0	2.5	2.9	0.0	2.5	0.0	1.2

Percentage

	Faba	Genty	Astl	Apia	Viol	Hist	Micro	herb	shrub
1	0.0	0.0	4.0	2.6	0.0	0.0	1.0	5.0	2.0
2	0.0	0.0	1.2	0.6	0.0	0.0	0.9	0.0	0.0
3	0.0	0.0	0.9	0.0	0.0	0.0	0.9	0.0	8.3
4	0.0	0.0	1.6	0.5	0.0	1.1	0.0	0.0	23.5
5	0.0	0.0	0.9	0.0	0.0	0.0	0.0	2.2	13.3
6	0.0	0.5	0.0	0.5	0.0	0.0	0.5	0.0	10.2
7	0.0	0.0	0.7	0.0	0.0	0.7	0.0	0.0	14.8
8	0.2	0.0	0.0	0.0	0.0	0.0	0.5	2.0	15.6
9	1.5	0.0	0.2	0.0	0.0	0.0	0.8	1.5	16.9
10	0.8	0.0	4.8	0.6	0.0	0.0	1.6	2.0	10.2
11	0.2	0.0	8.5	0.0	0.0	0.0	1.0	0.6	9.7
12	1.2	0.0	1.5	0.0	0.0	0.0	0.0	0.6	9.9
13	1.6	0.0	0.5	0.5	0.0	0.0	0.0	0.3	6.8
14	0.0	0.0	4.9	0.0	0.8	0.0	0.4	1.6	6.6

Concentration

	Noth	Phyl	Dick	Cyat	Tasm	Poma	Pito	Pheb	Zier	prot	Euc	Acac	Dodo
1	1.0	0.0	2.8	0.2	0.0	0.9	0.0	0.1	0.0	0.1	4.9	0.5	0.0
2	8.1	0.8	14.6	0.0	0.0	1.6	0.4	0.0	0.0	0.0	59.8	2.4	0.8
3	9.1	0.0	12.1	1.0	1.0	2.0	0.0	0.0	0.0	0.7	39.0	1.3	0.7
4	6.1	0.0	20.6	6.9	0.0	3.8	2.3	3.1	1.5	2.3	28.3	2.3	0.0
5	2.0	3.5	20.9	0.0	0.0	3.5	0.0	0.0	0.0	2.0	46.2	0.5	0.0
6	12.4	1.0	11.3	2.1	0.0	5.2	2.1	2.1	0.0	2.1	79.4	0.0	0.0
7	34.3	5.0	44.3	7.1	0.0	15.1	2.0	2.0	2.0	2.0	118.9	1.0	0.0
8	18.0	8.0	14.6	1.3	0.0	4.7	0.7	0.0	0.0	0.7	91.1	0.0	0.0
9	9.7	1.6	34.6	0.0	0.0	2.2	0.5	0.0	0.0	1.6	99.4	1.6	0.0
10	15.0	1.2	6.7	3.3	0.8	20.0	0.0	0.0	0.0	0.0	52.0	1.7	0.0
11	7.0	2.2	17.5	4.4	0.0	16.2	1.7	0.0	0.0	0.0	32.3	3.1	0.0
12	20.1	5.6	28.5	3.5	0.0	2.8	0.0	0.0	0.0	0.0	20.8	0.0	4.2
13	1.6	1.2	8.6	1.6	0.2	1.4	0.0	0.0	0.0	0.0	10.5	1.6	0.0
14	0.4	0.0	3.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	4.1	0.0	0.0

Concentration

	Poa	Aste	Chen	Epac	Spre	Leuc	Copr	Msqs	Msqm	Call	Lept	Lami	Boro
1	1.9	0.3	0.2	0.2	0.7	0.0	0.1	0.0	0.2	0.0	0.7	0.0	0.0
2	7.7	4.0	1.6	1.2	5.7	0.0	2.0	0.0	13.3	0.0	4.0	0.0	0.8
3	7.7	2.0	0.0	3.0	5.0	0.0	1.0	0.0	6.1	0.0	2.0	0.0	0.0
4	1.5	6.1	1.5	2.3	1.5	0.8	0.0	0.0	6.1	0.0	2.3	0.0	0.0
5	10.9	8.4	3.0	3.5	2.5	0.0	4.0	0.0	10.4	0.0	3.0	0.0	0.0
6	7.2	7.2	1.0	1.0	11.3	0.0	0.0	11.3	3.1	0.0	1.0	0.0	0.0
7	15.1	21.2	2.0	6.0	7.1	0.0	6.0	20.1	8.1	0.0	10.1	0.0	0.0
8	6.0	14.0	6.0	1.3	11.3	2.0	0.0	13.3	6.0	0.0	7.3	0.0	0.0
9	7.6	8.6	2.7	4.9	6.5	0.0	3.2	8.1	5.4	0.0	2.2	0.0	0.0
10	0.0	9.6	0.8	6.2	13.3	0.0	5.0	8.7	1.7	0.0	5.4	0.0	0.0
11	11.8	22.7	1.7	10.9	5.2	0.0	0.9	10.5	2.6	0.0	17.5	0.0	0.0
12	13.2	15.3	1.4	18.0	34.7	2.1	0.0	4.9	9.0	0.0	16.7	0.0	0.0
13	10.9	7.0	0.8	2.5	7.2	0.0	1.2	1.2	2.9	0.0	3.7	0.0	0.0
14	6.8	3.0	0.0	2.1	1.3	0.1	0.0	0.8	0.9	0.0	0.8	0.0	0.4

Concentration

	Faba	Genty	Astl	Apia	Viol	Hist	Micro	herb	shrub
1	0.0	0.0	0.7	0.5	0.0	0.0	0.2	0.9	0.4
2	0.0	0.0	1.6	0.8	0.0	0.0	1.2	0.0	0.0
3	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	9.1
4	0.0	0.0	2.3	0.8	0.0	1.5	0.0	0.0	33.6
5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	3.5	20.9
6	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	19.6
7	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0	60.4
8	0.7	0.0	0.0	0.0	0.0	0.0	1.3	5.3	42.6
9	3.8	0.0	0.5	0.0	0.0	0.0	2.2	3.8	43.2
10	1.7	0.0	10.0	1.2	0.0	0.0	3.3	4.2	21.2
11	0.4	0.0	19.2	0.0	0.0	0.0	2.2	1.3	21.8
12	2.8	0.0	3.5	0.0	0.0	0.0	0.0	1.4	22.9
13	1.2	0.0	0.4	0.4	0.0	0.0	0.0	0.2	5.1
14	0.0	0.0	1.5	0.0	0.3	0.0	0.1	0.5	2.0

Appendix 5

Pollen data from Una Plain (percentages and concentrations).

Concentrations in $grains.gm^{-1}.10^{-3}$. Column one indicates sample numbers increasing with depth.

Percentage

	Noth	Phyll	Dick	Cyat	Poma	Tasm	Pito	Pheb	Zier	Prot	Euc	Acac	Dodo
1	16.3	0.0	5.1	0.0	1.7	0.0	0.0	0.0	1.1	0.0	10.7	0.0	0.6
2	22.9	0.7	4.2	0.0	2.1	0.0	0.0	0.0	0.0	0.0	7.6	0.0	0.0
3	23.1	3.3	4.2	0.0	5.7	0.0	0.0	0.0	0.0	0.5	14.6	0.0	0.0
4	29.6	0.0	5.6	0.6	3.1	0.0	0.6	0.0	0.0	0.0	14.2	0.6	0.0
5	26.6	1.0	6.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0	19.6	0.0	0.0
6	23.7	0.0	3.5	3.5	0.6	0.0	0.0	1.2	0.6	0.0	13.3	0.0	0.6
7	28.8	3.2	8.3	2.6	1.9	0.0	0.0	0.0	0.0	1.3	12.2	0.0	0.0
8	26.4	0.4	6.6	3.1	2.2	0.0	0.0	0.0	0.0	0.0	9.7	0.0	0.9
9	30.1	2.2	4.8	4.3	3.2	0.5	0.0	0.0	0.0	0.5	7.5	0.0	0.0
10	23.6	4.1	4.1	3.1	1.5	0.5	0.0	0.0	1.0	0.0	7.7	0.0	0.0
11	26.4	5.6	3.0	3.6	2.0	1.5	0.0	1.0	0.5	1.0	6.6	0.0	0.5
12	12.5	5.6	4.4	2.5	2.5	1.9	1.3	0.0	0.0	2.5	7.5	0.0	0.0
13	12.9	0.0	1.6	4.0	0.0	0.0	1.6	0.0	0.0	0.0	6.5	1.6	0.0

Percentage

	Poa	Aste	Chen	Epac	Spre	Leuc	Copr	Msqs	Msqm	Cal	Lept	Lami	Boro
1	12.9	2.2	0.0	0.6	7.3	1.1	0.0	0.0	28.1	0.0	0.0	0.6	2.8
2	11.8	3.5	0.0	1.4	5.6	0.0	1.4	3.5	21.5	0.0	0.0	0.7	0.0
3	9.9	1.4	0.9	0.5	3.3	0.5	0.0	6.1	13.7	0.0	5.2	0.0	0.0
4	9.9	1.2	1.2	0.6	6.2	0.0	0.0	4.9	8.6	0.0	0.6	0.6	0.0
5	5.0	4.0	1.5	0.5	5.5	1.0	0.0	5.5	3.5	0.0	1.0	2.0	0.0
6	10.4	1.2	0.6	0.6	6.4	0.6	0.0	4.0	9.8	0.0	0.0	1.7	1.2
7	5.1	0.0	1.3	0.0	8.3	0.0	0.0	3.2	7.7	0.0	0.0	1.3	0.6
8	6.6	3.5	0.4	0.9	13.2	1.3	0.4	2.2	6.2	0.0	0.0	1.3	0.9
9	12.4	4.3	0.0	4.3	5.9	1.1	0.0	2.2	3.2	0.0	0.0	0.5	0.0
10	7.2	4.6	0.0	2.6	6.7	4.1	0.5	3.1	6.7	0.0	0.0	0.0	0.0
11	5.6	3.6	0.0	2.0	7.1	1.5	1.5	2.0	7.6	0.0	0.0	0.0	0.0
12	14.4	3.8	0.6	1.9	4.4	2.5	0.6	1.9	5.0	0.0	13.8	0.0	0.0
13	11.3	4.0	10.5	2.4	4.8	2.4	0.0	1.6	4.8	0.0	12.1	0.0	0.0

Percentage

	Faba	Gent	Astl	Apia	Viol	Hist	Micr	herb	shrub
1	1.1	2.8	0.6	0.6	0.0	0.0	0.6	0.0	1.7
2	0.0	1.4	3.5	0.7	0.0	1.4	0.0	0.0	2.8
3	0.0	0.0	1.4	0.0	0.0	0.0	0.9	1.4	1.9
4	0.6	0.0	0.0	0.0	0.6	0.6	0.0	2.5	2.5
`5	0.0	0.0	1.0	0.0	0.0	0.0	1.0	4.0	3.0
6	1.2	1.2	0.6	0.0	0.0	0.0	2.9	1.7	2.9
7	1.3	0.0	1.9	0.0	0.0	0.6	0.0	4.5	1.3
8	0.9	0.0	0.0	0.4	0.0	0.0	3.5	1.8	0.9
9	0.0	0.0	4.3	0.0	0.0	0.0	3.2	0.0	0.0
10	0.5	0.0	5.6	0.0	0.5	2.6	0.0	1.0	1.5
11	0.0	0.0	4.1	0.0	1.0	2.0	0.0	1.5	2.5
12	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.6	0.6
13	0.0	0.0	12.9	0.0	0.8	0.0	1.6	0.8	0.8

Concentration

	Noth	Phyll	Dick	Cyat	Poma	Tasm	Pito	Pheb	Zier	Prot	Euc	Acac	Dodo
1	6.0	0.0	1.9	0.0	0.6	0.0	0.0	0.0	0.4	0.0	3.9	0.0	0.2
2	9.0	0.3	1.6	0.0	0.8	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
3	17.0	2.4	3.1	0.0	4.2	0.0	0.0	0.0	0.0	0.3	10.7	0.0	0.0
4	18.6	0.0	3.5	0.4	1.9	0.0	0.4	0.0	0.0	0.0	8.9	0.4	0.0
5	26.9	1.0	6.1	1.5	1.0	0.0	0.0	0.0	0.0	0.0	19.8	0.0	0.0
6	26.7	0.0	3.9	3.9	0.7	0.0	0.0	1.3	0.7	0.0	15.0	0.0	0.7
7	33.2	3.7	9.6	3.0	2.2	0.0	0.0	0.0	0.0	1.5	14.0	0.0	0.0
8	37.3	0.6	9.3	4.3	3.1	0.0	0.0	0.0	0.0	0.0	13.7	0.0	1.2
9	30.9	2.2	5.0	4.4	3.3	0.6	0.0	0.0	0.0	0.6	7.7	0.0	0.0
10	22.5	3.9	3.9	2.9	1.5	0.5	0.0	0.0	1.0	0.0	7.3	0.0	0.0
11	27.5	5.8	3.2	3.7	2.1	1.6	0.0	1.1	0.5	1.1	6.9	0.0	0.5
12	6.4	2.9	2.2	1.3	1.3	1.0	0.6	0.0	0.0	1.3	3.8	0.0	0.0
13	4.6	0.0	0.6	1.4	0.0	0.0	0.6	0.0	0.0	0.0	2.3	0.6	0.0

Concentration

	Poa	Aste	Chen	Epac	Spre	Leuc	Copr	Msqs	Msqm	Cal	Lept	Lami	Boro
1	4.8	0.8	0.0	0.2	2.7	0.4	0.0	0.0	10.4	0.0	0.0	0.2	1.0
2	4.6	1.4	0.0	0.5	2.2	0.0	0.5	1.4	8.4	0.0	0.0	0.3	0.0
3	7.3	1.0	0.7	0.3	2.4	0.3	0.0	4.5	10.0	0.0	3.8	0.0	0.0
4	6.2	0.8	0.8	0.4	3.9	0.0	0.0	3.1	5.4	0.0	0.4	0.4	0.0
`5	5.1	4.1	1.5	0.5	5.6	1.0	0.0	5.6	3.6	0.0	1.0	2.0	0.0
6	11.7	1.3	0.7	0.7	7.2	0.7	0.0	4.6	11.1	0.0	0.0	2.0	1.3
7	5.9	0.0	1.5	0.0	9.6	0.0	0.0	3.7	8.9	0.0	0.0	1.5	0.7
8	9.3	5.0	0.6	1.2	18.6	1.9	0.6	3.1	8.7	0.0	0.0	1.9	1.2
9	12.7	4.4	0.0	4.4	6.1	1.1	0.0	2.2	3.3	0.0	0.0	0.6	0.0
10	6.8	4.4	0.0	2.4	6.4	3.9	0.5	2.9	6.4	0.0	0.0	0.0	0.0
11	5.8	3.7	0.0	2.1	7.4	1.6	1.6	2.1	7.9	0.0	0.0	0.0	0.0
12	7.3	1.9	0.3	1.0	2.2	1.3	0.3	1.0	2.5	0.0	7.0	0.0	0.0
13	4.1	1.4	3.8	0.9	1.7	0.9	0.0	0.6	1.7	0.0	4.3	0.0	0.0

Concentration

	Faba	Gent	Astl	Apia	Viol	Hist	Micr	herb	shrub
1	0.4	1.0	0.2	0.2	0.0	0.0	0.2	0.0	0.6
2	0.0	0.5	1.4	0.3	0.0	0.5	0.0	0.0	1.1
3	0.0	0.0	1.0	0.0	0.0	0.0	0.7	1.0	1.4
4	0.4	0.0	0.0	0.0	0.4	0.4	0.0	1.6	1.6
`5	0.0	0.0	1.0	0.0	0.0	0.0	1.0	4.1	3.0
6	1.3	1.3	0.7	0.0	0.0	0.0	3.3	2.0	3.3
7	1.5	0.0	2.2	0.0	0.0	0.7	0.0	5.2	1.5
8	1.2	0.0	0.0	0.6	0.0	0.0	5.0	2.5	1.2
9	0.0	0.0	4.4	0.0	0.0	0.0	3.3	0.0	0.0
10	0.5	0.0	5.4	0.0	0.5	2.4	0.0	1.0	1.5
11	0.0	0.0	4.2	0.0	1.1	2.1	0.0	1.6	2.6
12	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.3	0.3
13	0.0	0.0	4.6	0.0	0.3	0.0	0.6	0.3	0.3

Appendix 6

Pollen data from Mt. Victoria (percentages only).

Column one indicates sample numbers increasing with depth.

Percentage

	Total		Noth	Phyl	Dick	Cyat	Tasm	Poma	Pito	Pheb	Zier	Prot	Euc
1	100.0	13.1	17.1	0.3	14.6	6.7	0.0	7.3	0.0	0.0	0.0	5.8	12.5
2	100.0	7.3	30.1	0.3	16.1	2.8	0.0	4.5	0.0	0.0	0.0	2.4	12.2
3	100.0	14.6	23.8	2.7	15.7	2.7	5.9	0.5	0.0	0.0	1.1	10.8	9.7
4	100.0	22.4	30.9	2.0	23.0	3.9	0.0	1.3	0.7	0.0	1.3	9.9	8.6

Percentage

	Dodo	Allo	Poa	Aste	Chen	Epac	Spre	Leuc	Copr	Msqs	Msqm	Call	Lept
1	0.0	4.6	2.7	2.1	0.0	0.9	0.0	2.4	0.6	1.2	5.8	0.0	5.2
2	0.0	1.4	1.7	3.5	0.0	0.0	0.0	2.8	0.3	3.8	9.4	0.0	1.4
3	0.0	1.6	2.7	2.7	0.0	0.0	0.0	0.0	0.0	0.5	7.0	0.0	0.0
4	0.0	2.6	2.6	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Percentage

	Boro	Faba	Gent	Astl	Apia	Viol	Hist	Micr	herb	shrub	v	b
1	0.0	0.0	0.0	0.9	0.0	0.0	0.0	1.8	1.5	4.6	0.0	0.0
2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
3	0.0	2.2	0.0	2.7	0.0	0.0	0.0	2.7	0.0	3.8	0.0	0.0
4	0.0	1.3	0.0	2.6	0.0	0.0	0.0	3.9	0.0	0.7	0.0	0.0

Appendix 7

Pollen data from Leedway Lagoon (percentages only).

Column one indicates sample numbers increasing with depth.

Percentage

	Noth	Phyl	Dick	Cyat	Tasm	Poma	acac	Dodo	Burs	Allo	Euc	Bank	Spre
1	3.6	0.0	1.0	0.0	0.0	1.6	0.0	0.0	0.0	7.3	39.6	1.0	0.0
2	3.6	0.0	0.0	0.4	0.0	1.4	0.0	0.7	0.0	6.8	37.4	1.4	0.0
3	9.5	1.9	0.4	0.0	0.4	0.0	0.0	0.4	0.0	9.5	38.2	1.1	0.0

Percentage

	Leuc	Aste	Poa	Msqa	Msqm	Lept	Chen	Copr	Ampe	Boro	Pimi	Corr	Rham
1	0.0	12.5	17.2	1.0	0.5	0.0	10.9	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	11.0	17.1	2.5	0.0	0.0	11.4	0.0	0.4	0.0	0.0	0.0	2.1
3	0.0	12.6	15.6	0.0	0.0	0.4	5.7	0.0	0.4	0.0	0.0	1.1	1.9