Site Unseen:
Archaeology, Cultural Resource Management, Planning and Predictive Modelling in the Melbourne Metropolitan area.

Shaun Canning.
B.A.; B. App. Sci. (Hons)

A thesis submitted in total fulfilment
of the requirements for the degree of
Doctor of Philosophy

School of European and Historical Studies
Faculty of Humanities and Social Sciences

La Trobe University
Bundoora, Victoria, 3086
Australia.

17 November 2016

This thesis is dedicated to the memory of

Wayne Peter Drew

Yorta Yorta Man and Parks Victoria Ranger.

31 January 1958 –17 February 2001

List of Figures

List of Tables

Abstract

This thesis presents the results of an archaeological predictive modelling program conducted near Melbourne, Victoria. The major aim of the project was to establish a predictive model of Aboriginal archaeological site location to be incorporated into the statutory planning process at the local government level. The often-competing demands and agendas of academic archaeology and cultural resource management is the intellectual backdrop against which this thesis was written.

A major component of the thesis was the collection of a dataset independent of the data managed and held by Aboriginal Affairs Victoria (AAV). This independent data set was collected to compare and contrast with the large quantity of data that has accumulated in the AAV site registry. A significant quantity of new archaeological information was generated during the 2000-2001 field seasons of this project.

The overwhelming majority of archaeological data held by AAV for the study area is the product of cultural resource management oriented surveys. These reports are considered a major source of primary archaeological data and are extensively reviewed. The study area also contains many significant archaeological sites, which have been the subject of several archaeological investigations – namely the Keilor and Green Gully burials, the Lancefield hatchet quarry, and the Sunbury earth rings. These sites and their contexts are discussed in detail.

Various models of the Aboriginal utilisation of the study area are advanced. These models are both deductive and inductive in nature. The deductive models are based primarily upon palaeoecological evidence, utilising archaeological and ethnographic data where it is available. An inductive GIS-based model is also developed for the study area, based predominantly upon the existing AAV data, and the various environmental parameters believed to have influenced Aboriginal settlement patterns and behaviour in the study area. Recommendations are made as to the manner in which models should be developed in future, and how they can be incorporated into the statutory planning and management process. Potential areas of future cultural resource management and academic research are also highlighted.

Statement of Authorship

Unless where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma.

No other person's work has been used without due acknowledgement in the main text of this thesis.

This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

Signed: ________________________

Shaun Canning
17 November 2016

Acknowledgments

This thesis would not have been possible were it not for the financial support of the Australian Research Council and Aboriginal Affairs Victoria, and the academic support of the Archaeology Program of La Trobe University, Bundoora. The ARC (SPIRT) Grant provided a postgraduate scholarship for the duration of the project; while Aboriginal Affairs Victoria generously provided additional funding for fieldwork, salaries, equipment and additional expenses. The Archaeology Program of La Trobe University, Bundoora, provided vehicles and field equipment.

Firstly, I would like to thank my supervisors. Drs. Richard Cosgrove and David Frankel of the Archaeology Department of La Trobe University have provided enormous support throughout the duration of this project. Ms. Nora van Waarden of Aboriginal Affairs Victoria provided a liaison role with AAV throughout the first 18 months of project, and I thank her. Thanks must also go to the staff and students of the Archaeology Program of La Trobe University. Particular thanks go to Rudi Frank, Wei Ming, Tim Murray, and Stella Bromilow. Dr. Phillip Edwards provided valued comments on an early draft of the thesis outline. Dr. Nicola Stern kindly provided a draft copy of *Written in Stone* for my use, as well as providing a much-needed copy of Glynn Isaac's 'Scatter's between the Patches' paper. Thanks also to Assoc. Prof. Dirk Spennemann, Dr. Bernie Joyce, and Dr. Jim Bowler for providing much needed resources or comment.

Ghattas Sayej, Josara De Lange, Ilya Berelov, Tom Rymer, David Wines, Jenny Porter, Christine Williamson, Libby Riches, and Asa Ferrier have been the best group of people anybody could ever wish to meet and work with. Plenty of liquid refreshment went into the making of this thesis, and many of those named were probably responsible. My thanks to you all. Thanks also to Peter Tremain, Diann Witney, Yalmambirra, Joanna Fresløv, Andrew Long, and Sam Wickman for your encouragement and support.

An enormous number of people made the fieldwork component of this project possible. To all those who volunteered for the various fieldwork sessions - thank you for your enormous efforts. The unusually hot summer made field survey a particularly unpleasant experience for some of you. I hope the heat; fires, snakes and flies did not take too great a toll. Thanks to the staff of Parks Victoria, AAV and La Trobe University who provided valued field assistance. Richard MacNeill (AAV) provided extensive GIS assistance in the early days of the project. Thanks to the various private landowners who allowed us on to their properties to conduct parts of this fieldwork. As far as I know, we did not lose any sheep.

During the course of this survey, a variety of people from three Aboriginal communities participated in the survey. Trevor Abrahams, Frank Abrahams, Greg Edwards (Wathaurong Co-Operative), Craig Beams (Ballarat Aboriginal Co-Operative) and Bob Mullins (Wurrundjeri) provided invaluable field assistance. Their contribution to this project was both vital and enormous. The project could not have run as smoothly and as efficiently without the contributions of these individuals and their respective organizations. Barry Coombes, Indigenous Liaison Officer with Parks Victoria also gave considerable support in the field.

Numerous Parks Victoria staff offered enormous support and assistance throughout the fieldwork component of the project. Parks Victoria Rangers-in-Charge Fiona Smith and Chris Worrall allowed access to areas under their management, as well as help in the field, and the loan of equipment. Without the assistance of Parks Victoria, much of the fieldwork component of this project would not have been possible. Thanks to Mike Cusack for helping with some GIS issues early on in the project.

Thanks also to Viki Spedding of the Upper Maribyrnong Catchment Landcare Group for her help in organizing access to private lands in the Darraweit Guim area. Journalist, Helen Grimaux produced a wonderful newspaper article for me at the beginning of the project. Thanks to John Hoban, Tom Hoban, and John Lewis for access to their properties for surveying during the Deep Creek sections of the fieldwork. Thanks to Craig Sandy of Omnistar Pty Ltd for the supply and maintenance of DGPS equipment for this project. Peter Terrett, Managing Director of Rapid Map Global also provided some valuable assistance with Omnilite DGPS equipment. Lisa Hayward, Eduction Co-Coordinator of SAFE Software Systems Inc. generously supplied free access to the full range of FME SAFE products for GIS data conversion and manipulation.

Thanks also to my families – my parents, Jim and Dianne who have always offered their unwavering support, and Rochelle's family, the 'Jacarak Mafia'- John, Charmaine and Kerry. I could not have done it without you all.

I would like to dedicate this thesis to the memory of Wayne Drew. Wayne was instrumental in the planning of the survey and assisting in organising the fieldwork locations. Wayne's enthusiasm and encouragement resulted in the inclusion of both Organ Pipes NP and Woodlands Historic Park in this survey. Wayne spent many long hours in the field with us before his tragic and untimely death mid-way through the last week of the survey. Wayne's death was a heartfelt and bitter blow to all those who had worked with him during this project. Wayne is sadly missed.

Finally, my heartfelt thanks are due to my partner, Rochelle. Without her constant love and support over the past seven years, none of this would have been possible. I thank you for your patience, humour, love and encouragement.

Chapter One

1. Introduction and Background

This thesis presents the results of a project initiated by Dr. Richard Cosgrove and Dr. David Frankel of the Archaeology Department, La Trobe University, and Ms. Nora Van Waarden of Aboriginal Affairs Victoria (AAV). The project was subsequently named the Basalt Plains Archaeology Project (BPAP), and commenced in November 1999. The research was funded by an Australian Research Council (ARC) Australian Post-Graduate Award – Industry (APA (I)) Scholarship and by funds generously provided by Aboriginal Affairs Victoria. The research was based in the Archaeology Program at La Trobe University, Bundoora, and in the Heritage Services Branch of Aboriginal Affairs Victoria.

1.1. Thesis Aims

This thesis is an attempt to merge the often-disparate objectives, methods and results of two very different pursuits – academic archaeology and cultural resource management (CRM). At times, this thesis appears to be an exercise in pure archaeology, while at other times it is more like a CRM project. As well as attempting to bring together the often divergent aims and outcomes of the two branches of archaeology – the pure and applied for want of a better analogy – industry (AAV), academic and Aboriginal community stakeholders also placed the project within a matrix of often opposing tensions and restraints. The outcomes of this project hopefully satisfy as many of the stakeholders as possible, while ultimately addressing the more specific questions.

The primary aim of this thesis is the construction of predictive models of Aboriginal archaeological site distribution within the Melbourne metropolitan area, utilising the existing Aboriginal Affairs Victoria (AAV) sites database, and additional archaeological data collected specifically for this thesis. While the aims and methods of this thesis generally adhere to the original research design formulated by Cosgrove, Frankel and van Waarden (1997) (See Appendix 9-2), some critical departures from the original design were necessary.

Although the primary aim of the thesis is the construction of predictive models of archaeological site locations, it also identifies and addresses a number of secondary issues and aims. From an applied or management perspective, this thesis aims to provide an assessment of the reliability of the AAV sites database, and to develop protocols for the incorporation of archaeological data into the statutory planning process. From the research or academic perspective, this thesis aims to critically evaluate the current archaeological data held by AAV, and to assess the varied quality of this data. In addition, this thesis will attempt to develop a regional archaeology based primarily upon the vast quantities of surface evidence from survey and the relatively small number of relevant excavations. Finally, implications for Aboriginal land-use and adaptation to changing environments in prehistory will be drawn from the models developed in this thesis.

1.2. Introductory Remarks

As stated above, a primary goal of this project was the development of predictive models of the spatial distribution of Aboriginal archaeological material in and around the Melbourne metropolitan area. This incorporates an assessment of the reliability of the Aboriginal Affairs Victoria sites database, and the development of protocols for the incorporation of Aboriginal cultural heritage data into the statutory planning process. Accurate predictive models for cultural resource management are often considered essential for management agencies, statutory authorities, planners and developers. In addition, models of past land use contribute to the understanding of local or regional prehistory.

This project is primarily based upon two independent data sets. The first of these is the archaeological sites register, maintained by the Heritage Services Branch of Aboriginal Affairs Victoria. This register includes data collected through various archaeological endeavours over the last 25 years. There were approximately 23,000 archaeological sites registered in Victoria as of May 2002 (Julia Cusack, Personal Communications, 2002). The term 'site' covers a multitude of archaeological occurrences throughout Victoria, including shell middens, scarred trees, stone arrangements, human burials, hearths, mounds, isolated artefacts, and stone artefact scatters. Many of these site types include a wide variety of forms, content and size. The second data set is the results of the archaeological fieldwork conducted for this dissertation.

Predictive modelling has been a feature of both academic archaeology and cultural heritage management since the mid-1970s (Altschul, 1990), as both a pure research activity and a management tool. The advent and rapid development of Geographic Information Systems (GIS) has particularly hastened the development of, and demand for, predictive modelling in the CRM arena. In simple terms, a predictive model may be thought of as a series of tools that utilise various forms of archaeological data to forecast or predict trends or patterns (Warren, 1990a, 1990b). Models are however, simplified representations of the real world, and can never hope to represent the true complexity of real-world situations. This cannot be stressed enough in any form of modelling exercise, but particularly in applied archaeology where the resource base is finite, and modelling errors could be irreversibly destructive. Existing data may be used in a variety of ways in developing predictive models. Existing theoretical perspectives that aim to elucidate causal relationships or patterning in the archaeological record may also be used. Similarly, empirical observations made in the field may be used to construct the model. Models may be developed via deduction from a body of theory, or inductively from empirical, replicable, field or laboratory based observations. In reality, most models tend to be a combination of both the deductive and inductive types, using various data sources.

Archaeological modelling methods range from the relatively straightforward ‘red flag’ modelling such as that conducted by Altschul (1990), through to vastly more complex models based upon multivariate statistical analyses, artificial neural networks, or genetic algorithm programs (Dalla Bona, 1994; Kohler, 1988; Kvamme, 1988a, 1988b; Moon, 1993; Westcott, 2000). The ‘appropriateness’ of each approach is largely dependant on the context of the required outcomes (research or management), the period in which to generate the models, and the people involved. There are no universal answers or templates. The majority of management-based models (or models developed for cultural resource management) are relatively straightforward and flexible tools. Simplicity and flexibility are often seen as being of greatest importance in models designed as management tools, where the responsiveness of the management agency to threat or enquiry is paramount, rather than overly complex ‘academic’ models (Warren, 1990a, 1990b).

Complex or cumbersome mathematical or statistical models are, in general, not particularly easy to use. Indeed, not all archaeologists or cultural resource managers have the statistical or mathematical skill to make sense of certain types of models. If this is the case, the model has failed one of the fundamental requirements of a successful model – useability. Any management tool or model developed should be ‘useable’ by archaeologists, planners and local government authorities. One of the great dangers in developing any type of model is that the outcomes of the modelling process can be taken as 'fact' by the end users. An archaeological predictive model may create a series of predictions as to where archaeological materials are or are not located; however if it is not operationalised and tested in the field, then the model outcome remains a series of untested hypotheses. One of the challenges in developing these types of predictive models for management agencies or other authorities is ensuring their appropriate usage when in the hands of non-archaeologists, councils, planners or other land management agencies. The best model in the world is of little use if it is taken at face value and never tested or refined. A true predictive model is therefore never complete; the process is flexible and requires constant input and refinement.

A critical theoretical and methodological issue for this project and the practice of archaeology and CRM in general is defining what actually constitutes an archaeological 'site'. The common perception in many arenas is that an archaeological site is self-explanatory concept or notion requiring no further elucidation or development. This is the view dominating much of the Australian archaeological and CRM literature. The implications of this in general, and specifically on this project will be explored in detail in Chapter 4.

One of the key data sets for this project is the database of archaeological sites maintained by AAV. Since the introduction of the *Archaeological and Aboriginal Relics Preservation Act (Vic) 1972*, the statutory authority responsible for the management of Aboriginal cultural heritage material in Victoria has been AAV (or its predecessor, the Victoria Archaeological Survey – VAS). Although the role of this statutory organization has changed enormously since 1972, one of the core responsibilities remains the construction, maintenance and management of a site registry. The site registry currently contains approximately 23,000 records of archaeological sites located throughout Victoria. This vast quantity of information was entered and stored until mid-2002 in a DOS-based program, MINARK, written by Dr. Ian Johnson in the early 1980s. The successor to MINARK is a relational database system written using Microsoft Access, which came into full operation in early to mid-2002. This changeover of computerised data management systems resulted in some significant data access problems for this project. These issues are discussed in detail in Chapter 5.

The AAV site registry files have accumulated steadily over the last 25 or so years, and are the result of many varied sources, including casual observations, small-scale localised surveys, excavations, rigorous research based projects and large-scale regional projects. The majority of early data held in the site registry was as a direct result of VAS fieldwork and excavation activities. In its early years, the VAS conducted extensive archaeological survey and excavation programmes throughout Victoria. The remainder of the recorded sites were contributed by volunteer or amateur archaeologists and students involved in the VAS field school programme. Priority was given to research and fieldwork activities by VAS in the first years of its operation in an attempt to understand the prehistory of Victoria (Coutts and Witter, 1977:1-2).

Amateur and professional alike have created this data over the years. The actual areal coverage of the site registry is relatively small, and is best described as 'patchy'. There has been no overall statewide approach to sampling, and coverage is highly variable both within and between different regions. The site data has accumulated (in places) largely by chance (Rhoads and Bird, 2000). While virtually all of the state has been covered by a variety of archaeological projects, the actual amount of ground surface covered by archaeological survey of one type or another in Victoria is, according to the AAV survey and reports GIS layers, approximately 100,000 hectares. This does not mean that 100,000 hectares has been surveyed to any particular standard or style. Rather, this figure simply indicates that some type of archaeological survey activity has taken place in areas totalling 100,000 hectares across the state. What we do not know is the comparability between these areas in terms of survey methodology, research design and geophysical limitations. The problems inherent in this data are crucial to understanding the limits of useability for purposes such as archaeological modelling and statutory planning.

Although it is relatively straightforward to calculate the amount of geographic space that has been the interest or focus of archaeological work, this is by no means the same as calculating or knowing the amount of actual 'on-the-ground' survey. The differences may appear semantic, but they are vast. For example, an archaeological project may be designed within a study area of 1,000 hectares of hitherto unsurveyed lands. However, only a small percentage of this land will ever be closely inspected. The project methodology may include a sampling method that will determine where and how much land is to be selected for scrutiny. If a random, probability based, sample is employed across the study area, and the randomly selected areal units are in turn closely inspected, then inferences can be drawn regarding the archaeological picture across the whole study area. These inferences, made from the data collected using a rigorous and replicable methodology, allow a picture of the archaeology of an area to emerge. Probabilistic survey sampling methodologies however, are seldom applied in management archaeology in Victoria, and indeed most sampling strategies rely on the selection of mapped landscape attributes believed to have significant archaeological potential (Attenbrow, 1988; Rhoads, 1992; Spennemann, 1995; Witter, 1977).

The reality of archaeological survey in Victoria is somewhat removed from the idealised situation discussed above. Numerous variables set archaeological fieldwork apart from many other disciplines, although it is acknowledged that each discipline has its own difficulties. The over-riding assumption that field archaeologists must work with is that just because a survey failed to locate cultural material does not mean there is no cultural material in that locality. When dealing with surface survey, archaeological material can and does remain undiscovered through problems of ground surface visibility and burial of ancient land surfaces. This lack of visibility may be caused by thick vegetation, thick ground-litter from vegetation, shifting unconsolidated surface materials, agricultural activities, unobtrusive stone tool colour or even poor weather conditions (Coutts and Witter, 1977:56-57; Ebert, 1988; Rhoads, 1992). Although an archaeological report or paper may state that its study area was 1,000 hectares, more often than not, a much smaller area was in fact inspected. Coupled with highly variable visibility, only a minute fraction of these 1,000 hectares normally offers the ‘window of opportunity’ through which to locate archaeological materials. The most rigorous of survey designs cannot produce archaeological data if the surveyor(s) cannot see the ground. This visibility dilemma is far worse in some parts of the state than others, is predominantly seasonal, and is subject to local variations (i.e. droughts, rabbit infestation, floods, weeds). The Melbourne metropolitan fringe, particularly the Western Volcanic Plains where fieldwork for this project was based, could generally be classed as offering quite poor archaeological visibility (i.e. less than 20% - Presland, 1983; Simmons and Djekic, 1981). This is also an area under intensive development pressures (Fyfe, 2002). These methodological limitations will be discussed in Chapter 5.

European and American experience has led to the use of extensive shovel test pitting or coring regimes in areas where visibility or time is a problem (Lightfoot, 1986; Lynch, 1980; Shott, 1985; Stein, 1986; Stone, 1981). This method has met with some success in these environments. In Australia, however, these methods have yielded only limited success (Smith, 1995a, 1995b).

Other quality control issues must be addressed in regards to the AAV database. The thousands of records in the database (upwards of 2,000,000 data fields) are the cumulative product of hundreds of practitioners over a period of some 25 years. These individuals may have had different archaeological skills, knowledge and abilities. Is there inherent bias or inadequacies in the 23,000 records held by AAV? What effect will this bias or inadequacy have on developing predictive models? Finally, if there are inadequacies in the data, what methods can be utilised to firstly, assess this inadequacy, and secondly attempt to overcome it?

Protocols or procedures for the incorporation of Aboriginal cultural heritage data into the statutory planning process are another major required outcome of this project. At present, most developers in Victoria are under no obligation to seek clearance from AAV before commencing land-altering activities (Bowman, 2001). Similarly, there are no mandatory surveying requirements before most developments commence. In essence, protecting Aboriginal archaeological material in Victoria is nearly always reactive rather than proactive. The protection offered by the *Archaeological and Aboriginal Relics Preservation Act (Vic) 1972*, is only truly useful once an item has been located, assessed and registered. Archaeological surveys are now often recommended by AAV before development activity as a matter of policy.

Traditional legislative approaches for the protection of cultural heritage material are usually 'rearguard' actions. The shortcomings of the legislation (i.e. no mandatory surveying regulations and no development clearance requirements from AAV) means that archaeological materials are at far greater risk of being disturbed or destroyed by development than if survey was mandatory. Destruction of the archaeological record is permanent and irreversible. The difficulty here is that because the legislation does not provide for mandatory surveying, and AAV cannot enforce this as a requirement, there is a need to find an alternative way ensuring that mandatory surveying in advance of development becomes standard practice. Mandatory surveying requirements help alleviate the risks of destroying or disturbing as yet undiscovered archaeological materials in the course of any land altering activities. Although this would create some exciting opportunities in archaeology and CRM, numerous issues would need to be addressed. Arguably, the most significant of these issues would be cost. Would developers, and ultimately the consumer, be willing to accept and bear the cost of compulsory archaeological surveying?

A more palatable method of introducing localised archaeological surveying would be the use of 'sensitivity' zone overlays in all local government area planning schemes. If, for example, a development were to occur within 100 metres of a water source in the western suburbs of Melbourne, then the relevant council would require an archaeological survey to be completed. This is a highly simplified and localised example. 'Sensitivity zone models' need to be carefully developed at high resolution for all areas, as no two locations are alike. This type of model will be explored in this thesis. Once designed, a model of this type can easily be incorporated into the Victorian planning scheme as a Victorian Planning Provision overlay. The challenge, if a model of this type were to become incorporated into everyday use at a local government level is to (a) determine the accuracy of the model, (b) train non-archaeologists in the use of the model and methodology, (c) continually up-date the model, and (d) ensure on-the-ground survey continues to augment the modelling process.

Ultimately, one of the goals of best practice cultural resource management is the preservation of representative samples of the various types of cultural material present within any given area or region. This goal is more or less accepted by the cultural resource management profession as the most appropriate method of (a) managing the resource base, and (b) ensuring the conservation of a portion of the resource base for future generations. This style of management is not without its share of problematic issues however. Questions as to the representativeness of the material so far set aside for conservation are commonly raised within the CRM and wider archaeological literature (Read, 1986; Smith, 1993). Equally, problematic discussions involving the assessment of the various significance criteria are commonplace in the relevant literature, and contribute to lively debate within CRM generally (Bickford and Sullivan, 1984; Bowdler, 1984; Canning, 1999; Flood, 1984; Hughes and Sullivan, 1981; Sullivan and Bowdler, 1984; Witter, 1984). Some of the critical questions, which are addressed throughout the course of this thesis, involve these fundamental issues in CRM. Does predictive modelling or sensitivity zoning contribute to the preservation of representative samples of the cultural resource database, or does this form of investigation actually detract from CRM's goals? Can this type of modelling assist in the assessment of significance, or does this type of activity hinder significance assessment? Significance and representativeness issues will be addressed in Chapter 6.

The modelling process will be discussed in detail in Chapters 6. Recommendations regarding the incorporation of archaeological models into the statutory planning process and future directions for Victorian CRM will also be discussed in chapter 6. Finally, conclusions from this research programme will be presented in Chapter 7.

1.3. Conventions and Definitions

There are numerous technical terms used throughout this thesis, in some cases with varied meanings, from one geographic locality to the next.

1. The term 'opportunistic' sampling appears regularly throughout the thesis. To avoid confusion, opportunistic sampling is defined here as non-probability, judgemental or intuitive sampling (Neuman, 1997). The term 'off-site' is also used extensively. It is used here to mean any method of archaeological sampling or survey where the distribution of archaeological material is the object of study, and not the location of discrete archaeological 'sites'.

2. Various Geographic Information System (GIS) processes have been utilised throughout this thesis. Explanation of the processes (i.e. how a particular process was applied) is generally not given. GIS method and theory is largely beyond the scope of the thesis. While a reasonable degree of GIS aptitude is called for to create many of the data sets and analyses, no programming or other special skills (other than a knowledge of the programs) have been utilised or are required. In general, most of the GIS operations have been conducted using *ArcView 3.2a*, including Spatial Analyst, 3d Analyst and numerous third party extensions.

3. I use the term 'contact' in this thesis to refer to the period of first contact between Europeans and Aboriginal people in Australia (Murray, 1996). The term prehistoric is used with some trepidation; however, the term is used in this thesis to refer to the entire period of Aboriginal occupation of Australia before the arrival of Europeans.

4. All measurements are metric, unless otherwise stated.

5. The archaeological significance of cultural materials is discussed in depth throughout this thesis. Archaeological significance and cultural significance are integral to the overall assessment of the total cultural significance of an item or site. However, this project is strictly archaeological in nature, and as such does not attempt to address the issue of contemporary cultural significance of the material studied to Aboriginal people. This is not intended in any way to diminish the cultural significance of these items to the

traditional owners. This thesis only addresses the archaeological or scientific aspect of cultural significance.

6. To ensure that Aboriginal cultural interests were respected, representatives of the various Aboriginal communities were employed to participate in the fieldwork component of the project. Aboriginal Affairs Victoria provided the funding to ensure that thorough and inclusive negotiation and involvement of the various local Aboriginal communities occurred throughout the project. Aboriginal staff members of Parks Victoria also made significant contributions to the successful completion of the fieldwork component of this project.

7. In places it has not been posible to overide the default US English spelling used by Arcview 3.2. Thus, on the occassional map the words ‘kilometre’ and ‘metre’ are spelt in the US fashion.

The following chapter introduces the study area for this thesis.

Chapter Two

2. Introducing the Study Area

This chapter introduces the wider study area chosen for the Basalt Plains Archaeology Project (BPAP). As well as defining the study area, this chapter provides an overview of the available ethnographic information, and the physiographic and environmental attributes of the study area. This includes a discussion of the prevailing environmental conditions from the late Pleistocene to the present.

2.1. The Study Area

Choosing a study area for this project was limited by numerous constraints. The major constraint was the requirement that predictive models of Aboriginal archaeological site location be developed for the urban fringe of the Melbourne metropolitan area. It was decided to locate the study area to the northwest of the Melbourne metropolitan area for several reasons. Firstly, the area on the urban-rural fringe to the northwest of Melbourne is one of rapid urban expansion. Secondly, comparatively large tracts of public land (such as National Parks) were easily accessible. Thirdly, large areas of private land were accessible beyond the metropolitan area. Finally, the area contains a rich archaeological record, which has undergone decades of academic research and CRM efforts. Within the greater study area, four locations were chosen in which to conduct the fieldwork component of this project. Each of these locations is discussed in more detail in Chapter 5. The general location of the study area is shown in Figure 2.1 (below).

Defining the boundaries of any study area is usually a relatively arbitrary affair in one sense, and highly organised and constrained in another. For this thesis, the regional study area boundary was largely chosen arbitrarily, while the individual survey areas were chosen with great care. Various attributes of the study area are described in detail below. The study area extends from Woodlands Historic Park north to Darraweit Guim in the foothills of the Great Dividing Range, then approximately 80 kilometres west to the Brisbane Ranges National Park.

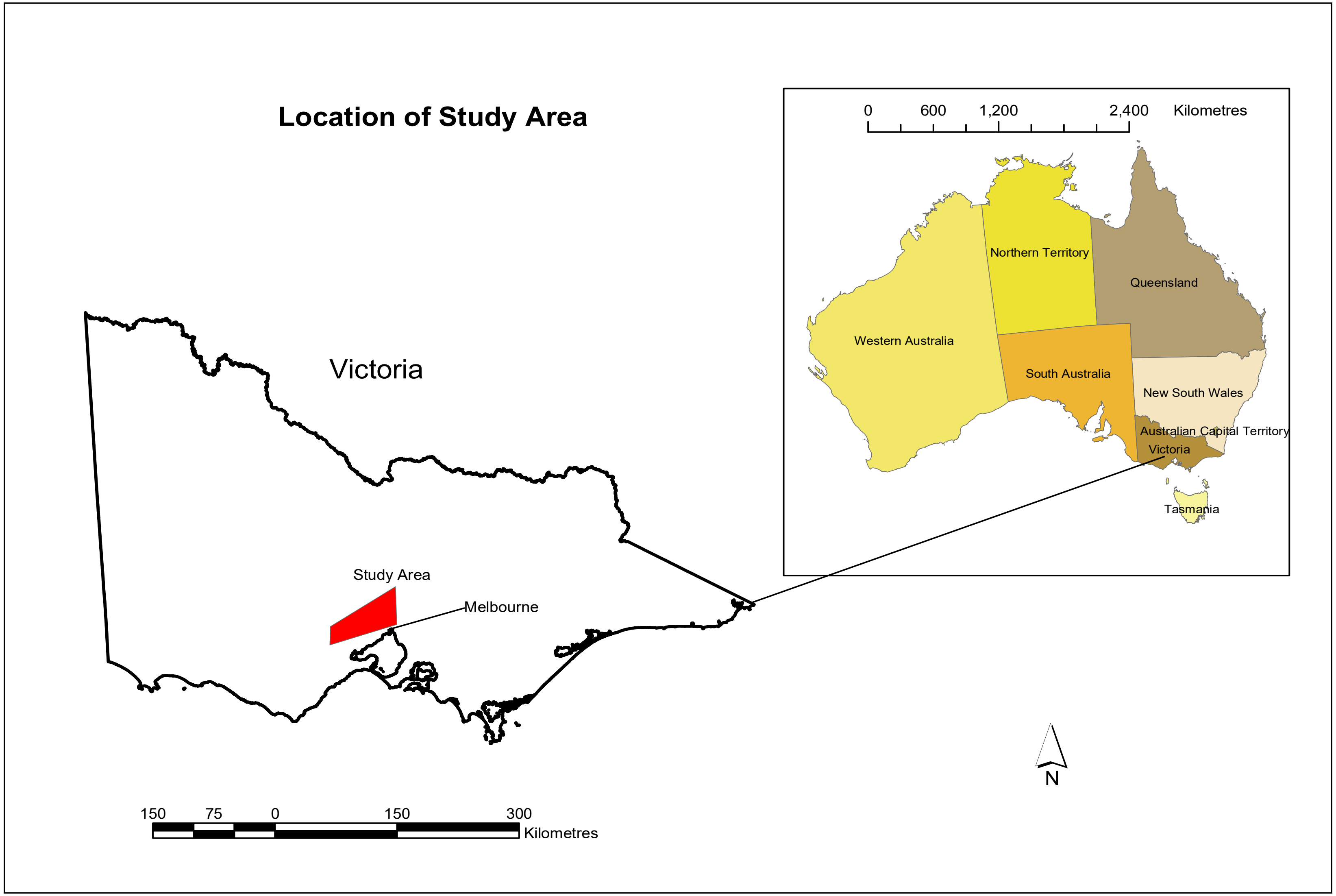


Figure 2-1: Map of Victoria at left. Map of Australia (top right) showing the location of the Study Area for this project, and the location of Melbourne. Scale refers only to the map of Victoria.

The study area encompasses an area of approximately 295,000 hectares. The study area follows the southern foothills of the Great Dividing Range for most of the length of its northern boundary, reaching approximately 600 metres above sea level near Mount Macedon. In the south and southwest; the study area is dominated by vast expanses of basalt plain, known as the Victorian or Western Victorian Basalt Plains. These plains extend for several hundred kilometres, from Melbourne to the South Australian border (Rosengren, 1999). Approximately 69.5% (See Table 2-2, below) of the study area consists of basalt plain. The west of the study area is dominated by the Brisbane Range, rising 440 metres above the surrounding expanses of basalt plain (Parks Victoria, 1997).

2.2. Geology and Geomorphology

The study area covers parts of the Western and Eastern Victorian Highlands, south of the Great Dividing Range, with most of it falling on the Western Victorian Volcanic Plains (Hills, 1975). Figure 2-3 (below) highlights the extent of the Western Victorian Volcanic Plains. While this area of basalt plain is somewhat geologically homogenous, the remainder of the study area exhibits greater geological diversity. Underlying the quaternary basalt of the 'Newer Volcanics' are large expanses of Ordovician sedimentary and Silurian metamorphic and sedimentary rocks. There are small formations of Permian sandstones, mudstones and conglomerates in the central north of the study area, predominantly to the north of the Brisbane Ranges. The west of the study area displays a relatively large area of Tertiary sands and silty clays (i.e. the Werribee formation), while similar conditions exist in the southeast corner of the study area, near Keilor. Small occurrences of Devonian granites, adamellites and feldspar occur in the southeast and southwest of the study area (i.e. Woodlands Historic Park) (Cochrane, Quick and Spencer-Jones, 1995; Parks Victoria, 1998a, 1998b).

Geological Period	Millions of Years	Hectares	% Of Area
Quaternary	<2 Mya	198834	67.5
Tertiary	65-2	40460	13.7
Permian	280-225	3113	0.8
Devonian	395-345	3673	1.2
Silurian	435-395	15468	5.2
Ordovician	500-435	33641	11.4
Total		295192	100.0

Table 2-1: Age in Millions of Years (Mya) of the various geological units present in the study area, and the proportion of each geological unit included in the study area.

Topographically, the study area is also varied. This has created some of the key geomorphic features that may have influenced the prehistoric Aboriginal populations of the region. The most significant of these features are the deeply incised river valleys, eroded downwards through the relatively thin mantle of basalt covering so much of the study area. The geomorphologist Jim Bowler comments:

> 'The Maribyrnong River, rising on the southern flanks of the divide near Mount Macedon, carried large quantities of yellow silt. Like the fine grained silt from glacial and periglacial environments in Europe, China and New Zealand, this material was formed by frosts shattering rock on the highland slopes. The resulting fine silt was washed into valley floors. Some was then blown across the land during droughts and the rest was swept away by rivers to be deposited further downstream. The thick silt deposits near Keilor originated in this way between 25,000 and 14,000 years ago. Humans were attracted by the resources of the river and by the protection provided by its valley. Artefacts, hearths and human remains found in the Keilor silts shows that people lived in the region throughout the coldest period. The conditions that deposited the silts at Keilor also contributed to the thick silt of the Werribee delta and spread a veneer of quartz over the otherwise quartz-free basaltic plains of Western Victoria' (Bowler, 1987:29).

Across the study area the major topographic feature is the relatively flat expanses of basalt plain. Elevation throughout the study area varies from approximately 10 metres above sea level (MASL) in the southern sections of the study area, to approximately 600 MASL near Mount Macedon in the north. The study area displays a gradual slope from north to south, seaward at a rate of between 0.5% and 0.8% (Jeffery, 1981).

There are five major geomorphic units within the study area, and three major landform types. These are shown in Table 2-2, below. The geomorphic units are:

1.1- Eastern Victorian Dissected Uplands (1.0% of study area)

2.1-Western Victorian Dissected Uplands (28.7% of study area)

7.1- West Victorian Volcanic Plains (61.9% of study area)

7.2- West Victorian Volcanic Plains – Stony (7.6% of study area)

8.3- South Victorian Coastal Plains (0.8% of study area).

Landform	1.1	2.1	7.1	7.2	8.3	Total (ha)	% of area
Steep Hill	482	39505	-	-	-	39987	13.5
Gentle Hill	2118	19006	-	416	2244	23785	8.1
Plain	343	26259	182762	22054	-	231419	78.4
Total (ha)	2944	84770	182762	22470	2244	295192	100.
% of Total	1.0	28.7	61.9	7.6	0.8	100	

Table 2-2: Sum of landforms and geomorphic units within the study area. Plain(s) make up the majority of the study area (69.5%), represented mostly by the Geomorphic Units (GMU) 7.1 and 7.1.

The dominant soils of the region are mostly clays associated with the newer volcanic plains. These clays are prone to seasonal cracking with changes in moisture levels, as they are generally less than two metres thick (Rosengren, 1999). The undulating plains are also characterised by the occurrence of basalt 'floaters' – large isolated basalt rocks suspended in the soil matrix above the underlying bedrock. The flatter areas of the plains are prone to waterlogging in the wetter months, as the heavy clays do not permit water to drain easily (Llewelyn-Davies Kinhill Pty Ltd., 1975).

2.3. Modern Climate and Vegetation

In its lower reaches, the Maribyrnong River passes through the driest area in Victoria south of the Great Dividing Range. The higher ground to the west and northwest (i.e. the Macedon Ranges, the You Yangs, and the Otways) creates a rain shadow affecting all of the leeward side of the mountains. The Melbourne region is characterised as a temperate climate, with warm dry summers, higher rainfall in spring, and lower rainfall in winter. (Melbourne and Metropolitan Board of Works, 1984). Very high rainfall (over 700mm per annum) in the Mount Macedon region causes severe flooding in the Maribyrnong River and its tributaries. Figure 2-2 shows the distribution of modern rainfall in the study area. There have been at least 22 major floods along the Maribyrnong River since records have been kept (1871), occurring with greater frequency before the urbanisation of the outer Melbourne area. Storm water and run-off containment has reduced the severity of flooding throughout much of the catchment (Melbourne and Metropolitan Board of Works, 1984). The study area is also prone to prolonged severe drought, as experienced throughout the region during 2002/2003, with rainfall falling below 50% of modern mean values.

European settlement has all but removed the indigenous flora of the basalt plains. It is estimated that less than one percent of the indigenous vegetation of the basalt plains survives (Jones, 1999; Ladd, 1976; Lunt, 1998; Sutton, 1916). The majority of the study area displays a relative paucity of ecosystem diversity. It is only in the north of the study area, in the approaches to the Great Divide that the level of ecosystem diversity increases. In the Great Dividing Range, we find 'substantial areas of geologically youthful, uplifted land, with diverse topography and soils, relatively high rainfall, and an impressive variety of ecosystems' (Smith, 1986: 19). The greatest ecological diversity in the majority of the study area is to be found at the interface of the basalt plains and the deeply incised river valleys, such as characterised by the Maribyrnong and Werribee River valleys. The basalt plains are however, virtually devoid of indigenous tree cover. The reason for this is not entirely clear. It is possible that a combination of relative aridity, poor drainage, strong winds, and heavy clay soils generally prohibits tree growth (Rosengren, 1999). Jeffrey (1981) also contends that the shrink/swell cycle of the clay soils from season to season may damage or restrict the roots of any young tree seedlings, thus preventing growth. The characteristic herbs and grasses of the basalt plains are also able to out-compete trees for the available moisture.

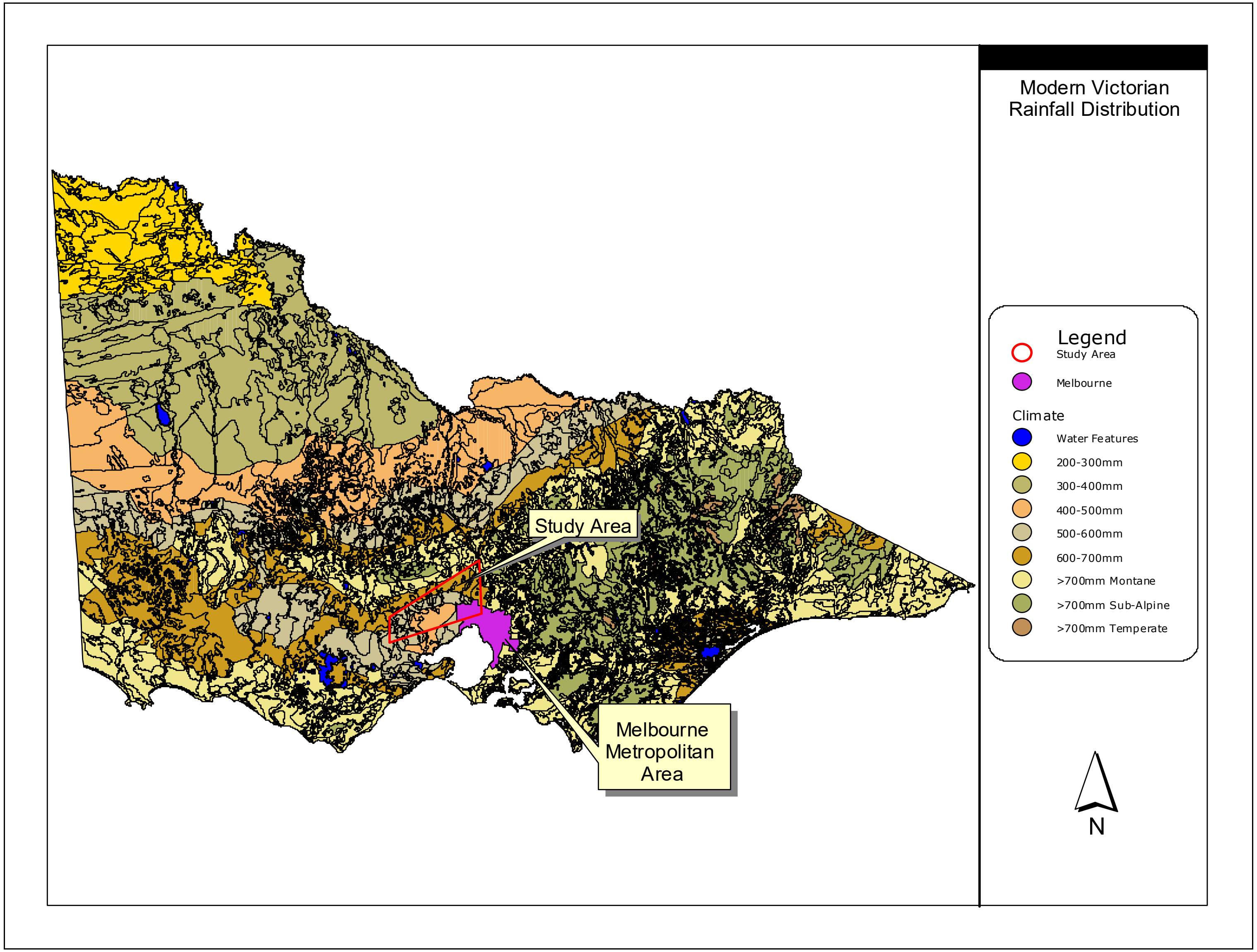


Figure 2-2: Modern rainfall distribution.

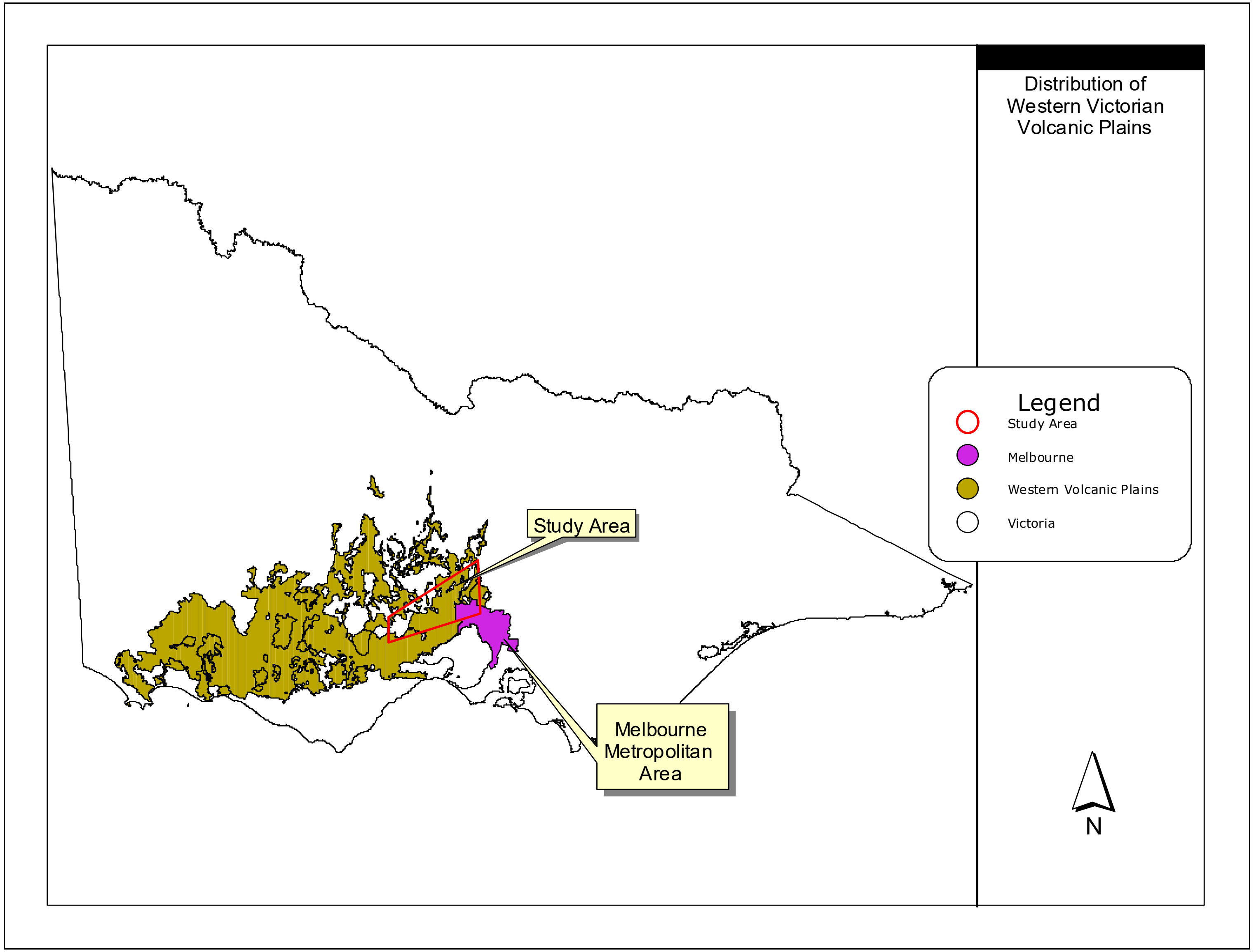


Figure 2-3: Extent of the Western Volcanic Plains

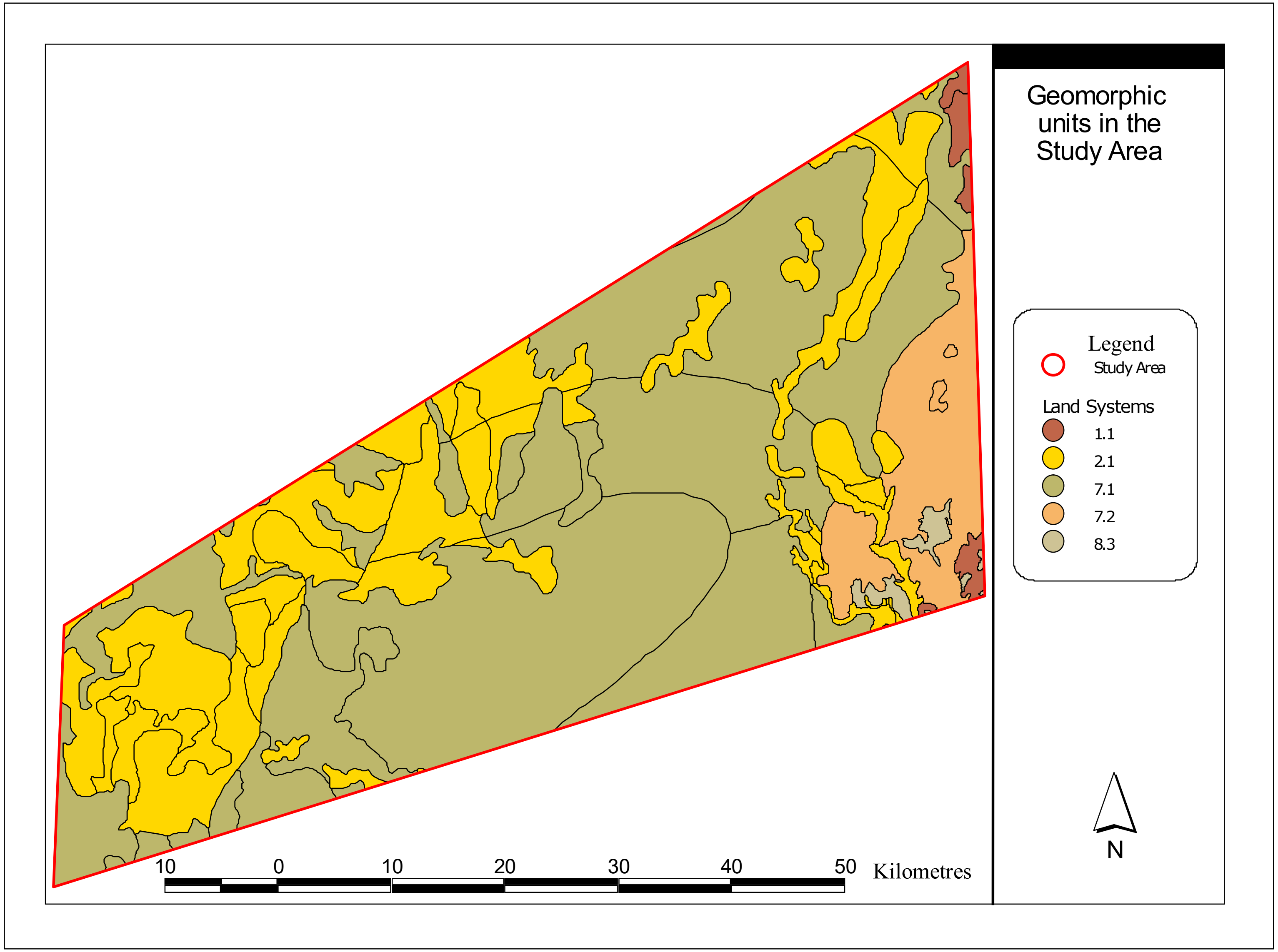


Figure 2-4: Distribution of various geomorphic units within the study area.

2.4. Climate and Climate History

> 'Australia is by far the driest, smallest, flattest, most infertile, climatically most unpredictable, and biologically most impoverished continent' (Diamond, 1997: 296).

Radical, but gradual, climate change has been a feature of southeastern Australia throughout the late Pleistocene and Holocene periods. This section will briefly outline these climate changes over the last 40,000 years, and highlight the fact that throughout these changes Aboriginal people were moving through a series of vastly different landscapes, adapting to conditions unrecognisable in the region today.

Pleistocene

Broad scale but mostly gradual climatic change characterises most of the late Pleistocene epoch (i.e. 40,000 BP – 10,000 BP). To date, a variety of methods have been utilised to reconstruct Australian late quaternary environmental sequences. The majority of palaeoenvironmental data is derived from aquatic sources replete with fossiliferous sediments containing ancient pollen and charcoal samples (Kershaw, 1995). Reconstructions of late quaternary climates generally show that conditions became cooler and drier from approximately 25,000 BP, reaching the coldest and driest period at the height of the Last Glacial Maximum (LGM) approximately 18,000 BP. Prior to the onset of increasing aridity and cooling at 25,000 BP, the continent had been generally warmer and wetter (Wasson and Donnelly, 1991).

At the height of the LGM, when climatic conditions are generally regarded as being at the coldest and driest, mean annual temperatures across south-eastern Australia were between 3° and 10° C below contemporary temperature ranges (Kershaw, 1995; Wasson and Donnelly, 1991). Significantly, the snow line was lowered to about 1,000 metres above sea level (Hope, 1994; Kershaw, 1995; Wasson and Donnelly, 1991); rainfall was 30% to 50% of contemporary mean annual totals, while wind speeds were 120% to 250% greater than contemporary means. Throughout southeastern Australia lake levels were generally low, while further inland, lakes were mainly dry (Wasson and Donnelly, 1991).

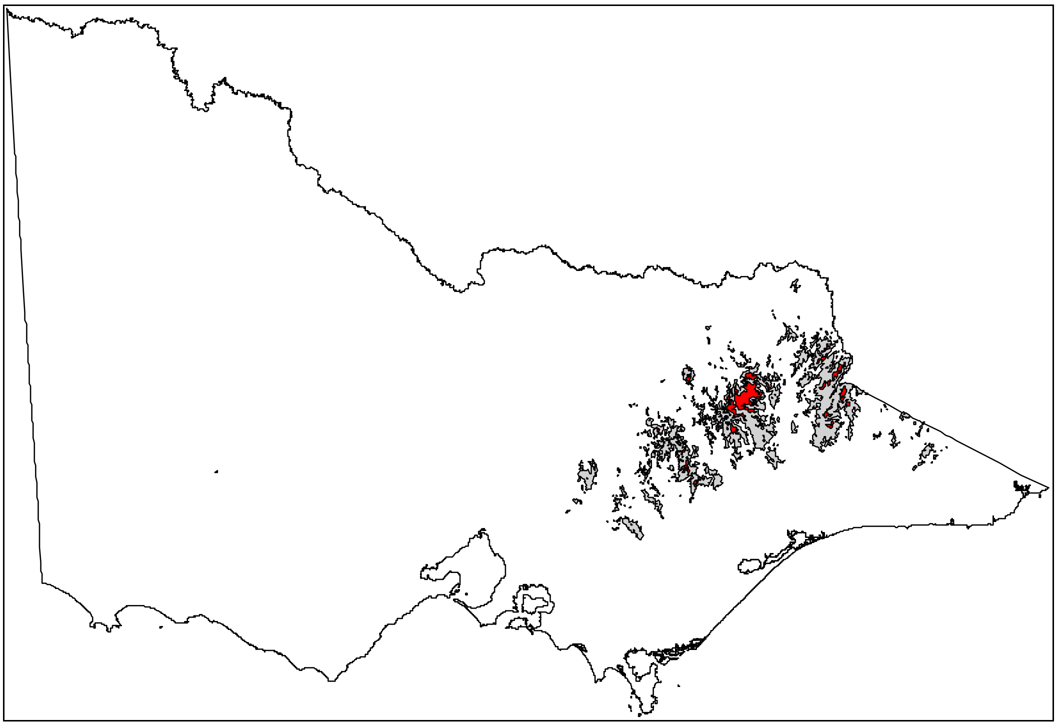


Figure 2-5: Map of Victoria showing the approximate extent of LGM snowline (>1,000 metres) shaded grey, and the contemporary snowline (> 1,400 metres) shaded red. Note: The coastline shown in this map is modern, and not the LGM coastline.

Vast tracts of south-eastern Australia were virtually treeless (Hope, 1994) at this time, despite forested environments being widespread previously, with *Casuarina* and *Eucalyptus* taxa comprising only minor elements of the pollen samples analysed (Kershaw, 1995). Better-watered and sheltered 'micro-habitats' (Kershaw, 1995: 661) or 'eco-niches' (Hope, 1994: 381) allowed small communities of these tree taxa to survive through the extremes of the LGM. Away from these favoured 'micro-habitats', the landscape was generally one of cold steppe-like grasslands, and herb-fields (Mulvaney and Kamminga, 1999). At some time close to the LGM, between 25,000 BP and 20,000 BP Australia's megafaunal species became extinct (Jones, 1968; Marshall, 1974), although it is thought that some may have survived in refugia until much later (Mulvaney and Kamminga, 1999). A recent alternative view proposed by Roberts *et al* (2001) argues that all megafauna were extinct by 46,000 BP. Various hypotheses have been advanced as to the cause(s) of megafaunal extinction – which may have involved a combination of environmental, biological or anthropogenic factors (Duncan, 1998; Flannery, 1994; Gill, 1978; Gillespie *et al.*, 1978; Ladd, 1976; Marshall, 1974; Mulvaney and Kamminga, 1999; Orchiston, Miller and Glenie, 1977). Excavations continuing at Cuddie Springs in New South Wales have provided the only unequivocal evidence of interaction between humans and megafauna, with residues present on excavated stone tools showing that they may have been used to butcher the carcases of various extinct megafaunal species (Wroe and Field, 2001: 21-25).

The extremity of global climatic conditions at the peak of the LGM resulted in vast amounts of surface water being frozen in glaciers and ice fields, particularly in the northern hemisphere. This phenomenon resulted in fluctuations of global sea levels. At around 18,000 BP, sea levels were (on average) 65 metres below present day levels (Mulvaney and Kamminga, 1999). Indeed, sea levels have been lower than at present for most of the preceding 120,000 years (Chappell and Thom, 1977), with a period of slightly higher sea levels between 6000-5000 BP (Mulvaney and Kamminga, 1999).

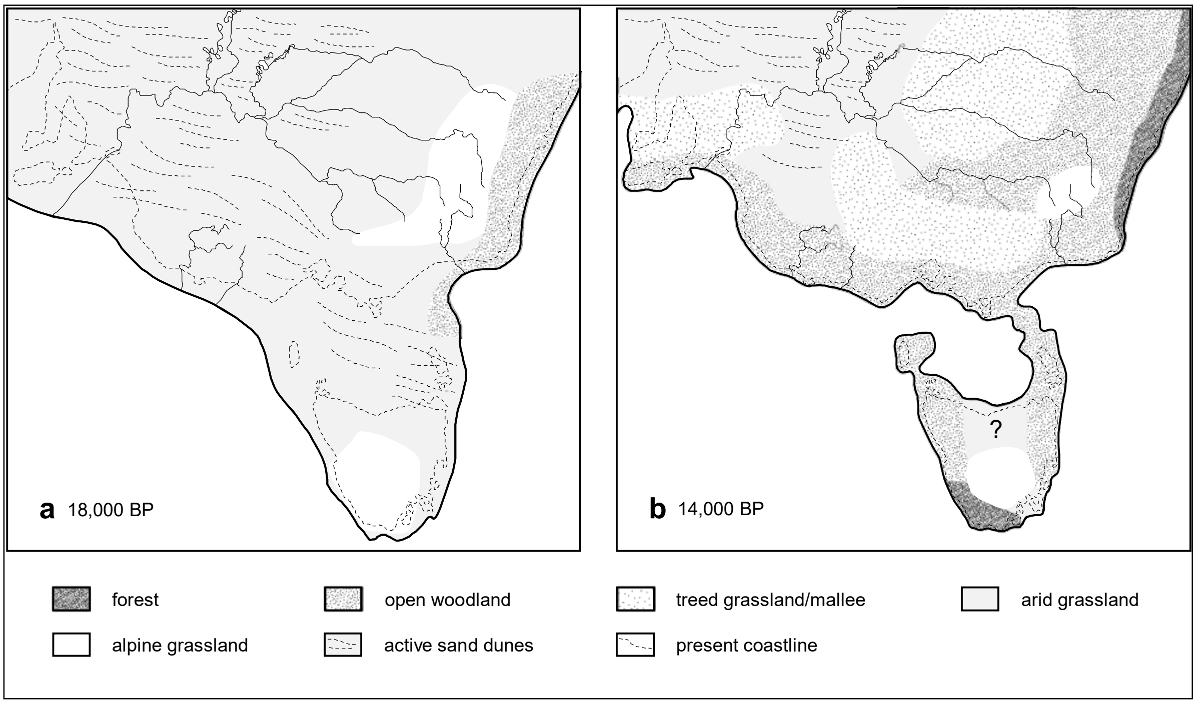


Figure 2-6: Coastline of southeastern Australia at (a) 18,000 BP and (b) 14,000 BP. (After Bird and Frankel, 1998:57; Chappell 2001).

Archaeological evidence from a variety of locations has shown that people were present in southeastern Australia throughout all of the climatic changes of at least the last 30,000 years. In Victoria, the sites of Clogg's Cave (Flood, 1974), New Guinea II (Ossa, Marshall and Webb, 1995), Keilor (Bowler, 1969, 1970; Burke, 1990; Gallus, 1974, 1976; Gill, 1953b, 1954, 1955, 1966; Munro, 1997; Simmons and Ossa, 1978; Witter and Simmons, 1978) and the Gariwerd Ranges (Bird and Frankel, 1998; Bird, Frankel and Van Waarden, 1988) demonstrate this human occupation history. Recent work by John Tunn at Brimbank Park has also revealed dates on a hearth feature of circa 16,000 BP (Tunn, 2002). South, across Bass Strait, Tasmanian sites such as Parmerpar Meethaner (Cosgrove, 1995a), Nunamira (Cosgrove, 1989; Cosgrove, Allen and Marshall, 1990), Bone Cave (Allen, 1989), and ORS 7 (Cosgrove, 1995b; McNiven *et al.*, 1993) have revealed some 35,000 years of Aboriginal occupation. North, evidence from Lake Mungo in western New South Wales, for example, has shown Aboriginal occupation of that region for in excess of 30,000 years (Mulvaney and Kamminga, 1999: 194-199).

At various times throughout the last 250,000 years, Tasmania was linked to the mainland by a broad land bridge, known as the 'Bassian Plain' (Chappell and Thom, 1977:275-291). Climatic amelioration after the LGM, leading to a gradual release of waters trapped in ice fields and higher rainfall levels, lead to the final inundation of the Bassian Plain after 14,000 BP (Jones, 1977; Ross, 1986; Chappell, 2001), cutting Tasmania off from the mainland once more (Sim, 1990).

Holocene

From the climatic extremes of the LGM at approximately 18,000 BP, the climate of southeastern Australia gradually began to change once more. Between 16,000 and 10,000 BP, both rainfall and temperatures increased. Although rainfall was higher during this period, evaporation rates were also higher, resulting in little change in the available moisture levels (except in lakes) from the LGM (Jones, 1999). At the Holocene-Pleistocene transition, approximately 10,000 BP, rainfall across much of the region rose significantly (Jones, 1995). Temperatures and rainfall are generally thought to have peaked between 8,000 and 6,000 BP (Lourandos, 1997; Wasson, Fleming and Donnelly, 1991). Coincident with the changing rainfall and temperature patterns, prevailing vegetation regimes also changed considerably. In many areas grasslands gave way to re-colonising forest communities. However, the majority of the study area for this thesis has been dominated by grasslands and herb fields since approximately 14, 000 BP (Jones, 1999).

The peak in temperature and rainfall between 8,000 and 6,000 BP also coincides with lake levels being at their highest, and wind speeds approximating modern values, indicated by a general lack of aeolian dune building (Wasson and Donnelly, 1991; Wasson, Fleming and Donnelly, 1991). Around 2,000 BP there appears to have been a short-lived cooler and drier phase, although palaeoclimatologists warn that this data is 'reliant upon methods very close to the limits of their precision' (Wasson and Donnelly, 1991: 30).

Perhaps the most dramatic change to occur during the transition from the drier and cooler Pleistocene to the generally warmer and wetter Holocene was the rise of global sea levels. Although there is much debate and little agreement on the timing and extent of Holocene sea level fluctuations in Australia (Rowland, 1983), the significant rise which isolated Tasmania from the mainland occurred somewhere between approximately

14,000 and 9,000 BP (Chappell, 2001; Kershaw, 1995). Sea levels rose continuously — sometimes at the rate of 10-15 metres per thousand years — (Mulvaney and Kamminga, 1999), reaching their present level after 6,000 BP. The transition to generally warmer and wetter conditions during the Holocene encouraged the re-colonisation of many tree species previously climatically restricted in distribution. Areas of wet sclerophyll forest and open woodland, in particular, rapidly expanded throughout much of southeastern Australia (Kershaw, 1995). The Holocene therefore can be characterised as a period of initially rapid climate change, followed by periods of stable, yet regionally variable, climatic conditions (Wasson and Donnelly, 1991; Wasson, Fleming and Donnelly, 1991).

2.5. Ethnographic Land Use Model

Ethnographic information collected during the first years of contact between Aboriginal people and Europeans provides us with a vital interpretative link to the ways in which Aboriginal people organised their everyday lives in the recent past. Archaeologists utilise the ethnographic record as a means of informing aspects of the archaeological record. This ethnographic data provides a series of vignettes of Aboriginal behaviour in the years immediately after initial contact. By piecing together this information, it is possible to construct very general ideas of how Aboriginal people utilised landscapes or resources, or to develop models of Aboriginal behaviour to help explain the archaeological record (Frankel, 1991).

While the available ethnographic data is a valuable historical resource, it must be treated with caution. The data has flaws and limitations. It should not be relied upon as the basis for the reconstruction of Aboriginal society or land use practices in prehistory (Murray and Walker, 1988; Wobst, 1978). What the data does provide though is a view of Aboriginal society at, or just after, the point of contact between two very different cultures. Eurocentric notions of cultural superiority somewhat cloud many of the early ethnographic accounts of Aboriginal society (Coutts, Witter and Parsons, 1977: 132-134; McBryde, 1984a). As well as biases introduced by a Eurocentric worldview, the collection of ethnographic data during the first years of settlement in Victoria was by no means consistent. In some areas, a relatively large body of ethnographic literature exists, while in other areas there may be no ethnographic data at all. This means that the level of ethnographic detail known for each area differs enormously, and the inferences that can be drawn for each area similarly differ. It must also be remembered that the ethnographic accounts were often recorded after Aboriginal populations had suffered almost irreparable damage, and the data recorded were one or two generations removed from pre-contact times (Coutts, Witter and Parsons, 1977; McBryde, 1984a: 132-134). Despite the inherent limitations of this data, ethnographic accounts of Aboriginal society during the years immediately after contact can be used as a means of informing archaeological investigations.

By necessity, the ethnographic information for the study area will be synthesized into a brief general account of various aspects of Aboriginal life at the time of contact. This form of synthesis is required as much of the ethnographic data is simply not available. From the available data, it is possible to build a very basic picture of Aboriginal life at the time of first contact with Europeans.

Social Organization

The principal unit of Aboriginal social organization in the southern parts of Victoria was the clan. The clan unit in southern Victorian Aboriginal society was a patrilineal descent group, sharing historical, spiritual, economic, territorial and genealogical identity (Barwick, 1984; Clark, 1990). At the time of first contact between Aboriginal people and Europeans, much of southern and central Victoria was the traditional estate of five tribal groups known as the 'Kulin'. Each of the five tribes of the Kulin consisted of numerous smaller clans. The common spiritual, economic, genealogical and political identities shared by many of the clan groups, resulted in the larger tribal groups also being intimately interconnected. The study area for this thesis encompasses sections of the traditional territories of the Wada Wurrung (or Wathaurong), Djadja Wurrung (or Jajowrong), and Woi Wurrung (or Woiwurung) tribal groups. The diversity in spelling reflects the uncertainty of both early ethnographic recordings, and contemporary debates as to the correctness of the various naming conventions.

Name	Territory
Bun Wurrung	Mornington Peninsula and Westernport Bay, north into the Dandenong's
Woi Wurrung	Yarra and Maribyrnong rivers and surrounding tributaries. Too Mt Macedon, Mt William, Kilmore. East of the Werribee river
Wada Wurrung	Bellarine Peninsula, Otway Ranges, west of the Werribee river to Streatham
Djadja Wurrung	Loddon and Avoca river catchments, Bendigo
Daung Wurrung	Kilmore to Euroa, east too Mt Buller, west to Kyneton.

Table 2-3: Tribes of the Kulin Language group. These tribal groups consisted of numerous smaller clans. There are numerous variations in the spelling of each clan or tribe name, however for consistency in this section I will follow Clark (1990).

The clan was further subdivided into individual family groupings, known as a ‘band’ (Presland, 1994). These smaller family units were the principal economic unit of the clan on a day-to-day basis. Social, ceremonial, or ritual gatherings between band, clan and tribe were common. At these gatherings ceremonial duties were discharged, alliances formed, marriages arranged, goods traded, and kinship obligations met. Gatherings of up to 800 people at a time were known to have occurred in the study area (McBryde, 1978; McBryde, 1984a: 139; McBryde, 1984b: 279).

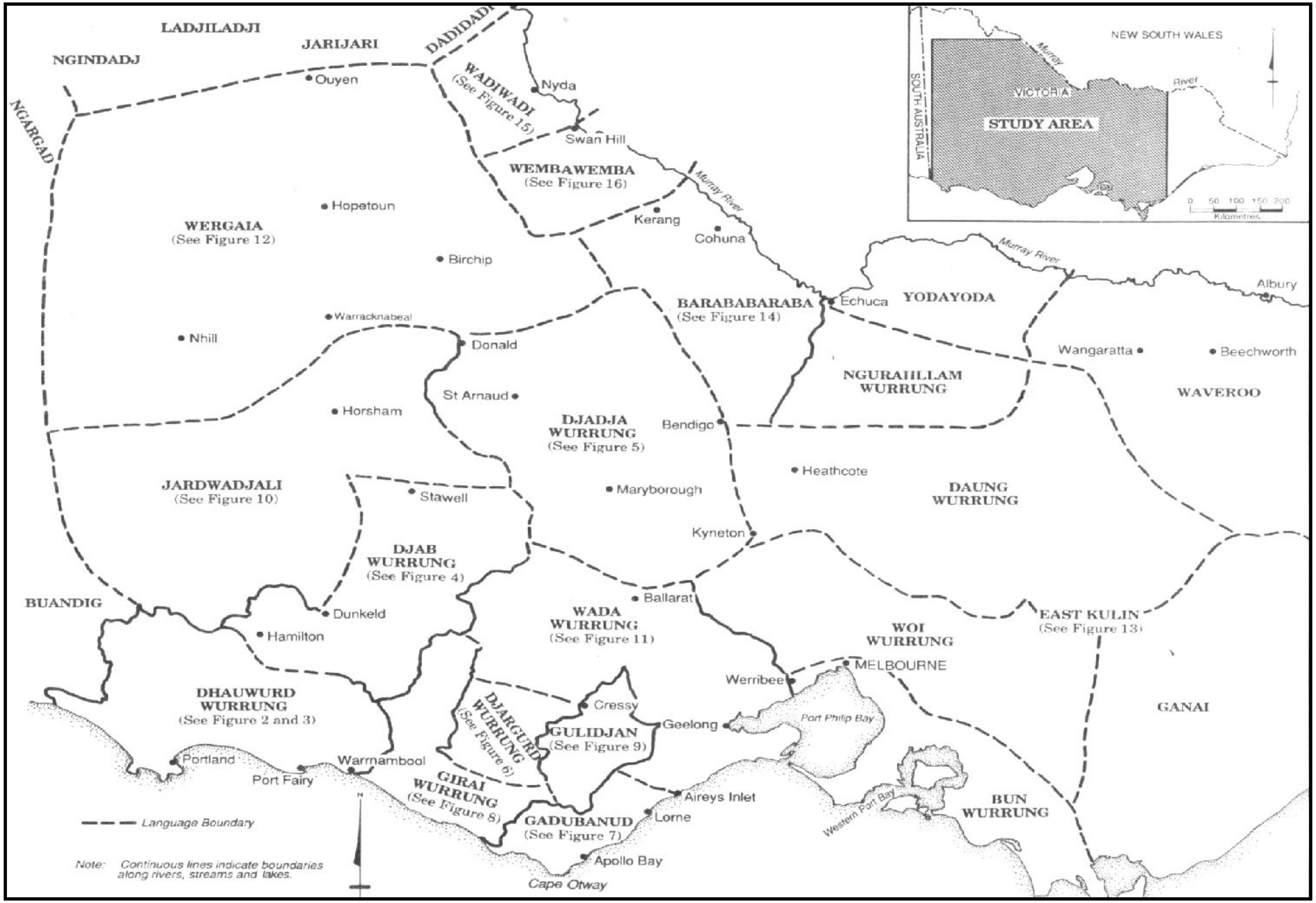


Figure 2-7: Tribal Boundaries in Victoria (after Clark 1990).

Economy

The traditional territories of the Wathaurong and Woiwurung encompassed a vast range of available economic resources. The traditional territories of both tribes stretched from the foothills of the Great Dividing Range in the north, south to sheltered bays, and the open ocean. While there is no doubt that members of the various clan groups within both the Wathaurong and Woiwurung tribal areas would have utilised both coastal and hinterland resources, the areas under investigation in this thesis are somewhat removed from the coast.

In the study area for this thesis there have been several compilations of plant and animal species present. While these are modern accounts of biological diversity, for the most part these compilations assume that these species would have been indigenous to the same regions in the recent past. Indeed, the compilations for Woodlands Historic Park (Table 2-4, below) were collected to reflect what the landscape and fauna might have been like in 1840. Table 2-4 presents a summary of the flora and fauna data available for selected sites within the study area. While it is unlikely that Aboriginal people made use of all species of flora and fauna, the number of available species illustrates the biological diversity present. As Table 2-4, below, shows the various locations examined were home to in excess of 300 vascular plant species, 150 species of birds, 15 species of mammals, 9 species of amphibians, numerous reptiles, and several species of fish (Carr *et al.*, 1996; Parks Victoria, 1997, 1998a, 1998b).

Area	Flora	Fauna
Brisbane Ranges National Park	619 Vascular Species	170 birds, 25 mammals, 24 reptiles, 15 amphibians
Woodlands Historic Park	343 Vascular Species	150 birds, 15 mammals, 9 amphibians, 6 reptiles, 3 fish
Woodlands Historic Park	347 Vascular Species	148 birds, 15 mammals, 9 amphibians, 16 reptiles, 3 fish
Organ Pipes National Park	Not Known	15 mammals, 88 birds, 6 amphibians, 13 reptiles

Table 2-4: Summary of various plant and animal species present in various areas in contemporary times. While not all would have been utilised, the numbers of species present demonstrates the enormous biological diversity available.

From early ethnographic accounts and contemporary research, it is known that Aboriginal people of the Melbourne region hunted, fished, or trapped a wide variety of fauna. This dependence on local flora and fauna demanded extensive knowledge of variations in seasonal availability and ecology (Coutts, 1981a, 1981b; Kirk, 1981). The animals hunted throughout the Melbourne region included kangaroo, emus, possum, bandicoot, koala, echidna, wombat, and a variety of reptiles and smaller marsupials (Bunce, 1859; Thomas, 1854; Winter, 1837). Birds were caught in nets, traps or by hand. Fishing by trap or spear and eel harvesting were also widely used modes of food procurement throughout southeastern Australia (Bunce, 1859; Coutts, 1981b).

Aboriginal people also placed great reliance upon the procurement of plant foods from their clan estates. While hunting activities often receive priority in contemporary accounts of prehistoric ways of life, the procurement and processing of various plant taxa was of vital economic importance (Gott, 1982: 59-67). The ethno-botanist Beth Gott estimated that vegetable foods gathered from the basalt plains made up approximately half of the diet of the Aboriginal population of the current study area

Certain plant foods are regarded as having been staples in Aboriginal diets prior too European settlement. The 'Yam Daisy' (Frankel, 1982a: 43-45) or *'Murnong'* (Gott, 1982: 59-67; 1983: 2-18) – *Microseris scapigera* -is particularly noted as having been a staple food throughout the study area, and indeed many parts of Victoria. Other plants contributed to nutritional requirements, as well as having medicinal uses or a more utilitarian function in the manufacture of utensils, string, baskets or clothing. The importance of subterranean tubers, such as the 'yam daisy' however was its ease of procurement and consistency of availability. Not only was this food source extensive and required limited processing, it was available year round (Gott, 1982: 59-67), and 'was always a fallback food' (Gott, 1999: 41-45).

Trade and Exchange

The work of Isabel McBryde at the Mt William greenstone quarry (McBryde, 1978, 1979; McBryde, 1984a; McBryde, 1984b; McBryde and Harrison, 1981; McBryde and Watchman, 1976) established the existence of a complex trade and exchange network operating in the study area at the time of European contact. McBryde successfully identified the source of hundreds of greenstone hatchet heads found across southeastern Australia since European settlement. While there were several sources identified, McBryde was able to show that the greenstone sourced from the Mount William quarry was more widely distributed across southern Australia than that from any other quarry – more of the Mount William greenstone had travelled further than stone from any other source. The significance of this is not simply that the material was widely distributed, the significance of the dispersal lies in the fact that Mount William greenstone was found in areas where the extant population had access to local greenstone of equal quality and utility.

McBryde (1984b: 268) found that greenstone quarried from other sources tended to be found within about 100 kilometres of the source, while the majority of the Mount William greenstone in McBryde's sample (n=224) was located at distances greater than 300 kilometres from the source, and was generally distributed to the west of Mt William. This patterned distribution in the archaeological record cannot simply be explained as a coincidence, or an artefact of site survival. Clearly, some type of behavioural influence was determining the widespread dispersal of this material. The survival of complete uncurated hatchet heads at great distances from the source, and the existence of heavily worked hatchet heads from other quarries in the same assemblages as the currated material indicate that the greenstone from Mount William held far more than just utility value. Frankel (1991: 128) however, noted a problem with McBryde's analysis. The way in which McBryde calculated the distribution and density of axe heads from the Mt William quarry created a distortion in the data. McBryde calculated the number of hatchet heads in 50 kilometre wide bands radiating away from Mt William. McBryde did not account for the increase in area of each of these bands, as each band got further away from Mt William. Frankel (1991) recalculated McBryde's data for the area west of the Mt William quarry. While the results were broadly similar, the ratio of hatchet heads found per 10,000m^2 was higher closest to the quarry, and very few hatchets were found between 50-150km from their source, and the distribution at greater distances is more even than McBryde's analysis suggests (Frankel, 1991: 128).

The patterned distribution observed by McBryde (McBryde, 1978; McBryde, 1984a; McBryde, 1984b; McBryde and Harrison, 1981; McBryde and Watchman, 1976) can be interpreted as part of a complex ethno-historical system of trade and exchange between the Kulin 'owners' of the Mt William greenstone quarry, and the recipients of its product (i.e. hatchet heads). The widely distributed nature of the Mt. William greenstone indicates that this particular stone held much more than simple utility value. The goods being traded (i.e. the greenstone) were more meaning-laden than a piece of stone would otherwise suggest. The items being exchanged formed part of a larger reciprocity system, where information, meaning, and socio-political identity were encoded in the act of exchange; and indeed, were the currency.

The patterning of the distribution of Mt William greenstone was also found to reflect the alliance and kin networks of the Kulin and their closest allies. McBryde (1984b: 284) identified that greenstone from Mt William occurred most abundantly in areas linguistically related to the Kulin, such as central and north-western Victoria, south-western Victoria, and south-eastern South Australia. The distribution of Mt William greenstone also illustrates the ethnographically recorded socio-cultural isolation that existed between the Kurnai of eastern Victoria, and the Kulin of central Victoria. The enmity that existed between the two language groups resulted in a distinct social, political and economic boundary between the Kulin and the Kurnai, and open hostility between the two groups was relatively common (McBryde, 1984b). McBryde's (1984b: 278) analysis showed that although 70% of the Mt William greenstone in her sample was found distributed outside of the Kulin territories, none found its way east of Wilson's Promontory into the lands of the Kurnai people.

European Impressions

A passage written by Aboriginal Protector William Thomas to colonial Superintendent Charles La Trobe describes the daily activities of members of the Kulin tribes near Melbourne.

> 'In the Kulin tribes they seldom travel more than six miles a day. In their migratory movements, all are employed. Children getting gum, knocking down birds; women are digging up roots, killing bandicoots, getting grubs, the men hunting and scaling trees for opossums. They are mostly at the encampment an hour before sundown… (Thomas, 1854: 397-434).

Many early European settlers were often struck by the ease with which the Aboriginal inhabitants of the area could procure sufficient resources for themselves. This is almost to be expected in one sense, as some of the early European settlements of the Melbourne region initially struggled in the new and strange conditions (Shaw, 1996: 1-16).

Exploring north-west of Geelong in early 1837, Thomas Learmonth and his party surprised a large Aboriginal camp 'at the mouth of the Pirron Yalloak…we came upon them so suddenly that they had time only to set fire to their mia-mias as a signal of danger to the other tribes' (Learmonth, 1853: 96). By this action, it must have been apparent to Learmonth and party that there were other camps of indeterminate number located nearby. Learmonth continued; 'near our encampment we found a fishing weir of the natives, in which were small conical nets of good workmanship. Nearly a bushel of delicious little fish like whitebait was in the nets, part of which we took, and faithfully remunerated the owners by giving provisions to a couple of men whom we induced to approach' (Learmonth, 1853:96). This seemingly casual encounter throws some light upon the efficiency of Aboriginal fishing technology, the abundance of fish available, and the importance of aquatic environments. A 'bushel' is approximately 30 kilograms (67 pounds), which is a considerable number of fish trapped - allowing a significant number of people to be fed. This is the yield presumably from one weir and one set of nets, for a part of one day. The fish caught may have been one of the numerous indigenous fish species from Victorian waterways, which normally do not exceed 8-10cm in length. Species such as Smelt, Hardyhead, Gudgeon, Pigmy Perch, Gobies, and Galaxids were all relatively abundant (Barnham, 1998).

Another early settler, Evelyn Pittfield Sturt appeared impressed at the skill shown by Aboriginal people in the procurement of ducks.

> It is curious to observe the skill shown by the natives in their pursuit of game. They catch vast numbers of ducks in an ingenious manner. The lagoons run for some length, narrowing at the end, where the trees close in; two or three blacks plant themselves near this narrow pass, having extended a large net from tree to tree, the others then proceed to the top of the lagoon driving the ducks before them. As they fly by the ambuscade, they throw their boomerangs whizzing over the heads of the birds, which dreading that their enemy, the hawk, is sweeping at them, make a dash for the trees, strike the net, and fall as if shot, when the natives dash in after them. I imagine it is a panic, which seizes the poor birds, for I have seen a hundred caught by such means' (Sturt, 1853).

Joseph Tice Gellibrand remarked:

> 'In the winter season they live principally upon fish and game. Upon the plains, there are immense quantities of Rats which resemble the English Rat and of which the natives are very fond. The women and children are employed in catching these rats at the same time they gather the roots' (Gellibrand, 1836: 6-35).

While there is a general paucity of ethnographic data available for most of the study area, it is nonetheless possible to advance a generalised model of Aboriginal land use for the region.

2.6. Aboriginal Land Use Model

Basalt Plains

From the limited ethnographic data, it is clear that parts of the basalt plains of the Melbourne area were a valuable resource, rich in game and vegetable foods. However, the very nature of the plains landscape would have restricted many of the activities of Aboriginal people. Irrespective of season, the plains offer very little shelter from the elements. During wetter periods, the easily waterlogged plains offer very little protection from wind or rain, while fuel for fires would have been hard to obtain. During the hotter months, the lack of trees and fresh water on the plains would have equally restricted Aboriginal use of this environment.

It is likely that Aboriginal use of the plains landscape was predominantly seasonal. The archaeological record of these activities will be limited to isolated artefact locations and small single-episode campsites, indicative of sporadic activities on the plains. Year-round foraging activities, such as the collection of *Microseris scapigera,* will have left virtually no archaeological signature on the plains. The occurrence of mounds may indicate *Murnong* processing activities, however this has not been demonstrated archaeologically in the study area. Hunting activities will have left only slight traces through the occasional occurrences of isolated artefacts, or small accumulations of artefacts. Areas of swamp situated on the plains will also have been utilised seasonally. The archaeological record of this activity will be the presence of repeat-episode campsites located around the margins of swampy areas (du Cros, 1989).

River and Creek Valleys

The deeply incised river and creek valleys, common in the study area, have been the focus of many previous archaeological investigations – both academic and management orientated (Bowler, 1970; Bowler *et al.*, 1967; Burke, 1989, 1990; Casey and Darragh, 1970; Coutts and Cochrane, 1977; du Cros, 1989; Duncan, 1998; Ellender, 1988; Gallus, 1983; Gill, 1955; Mulvaney, 1964; Munro, 1997; Rhodes, 1990; Tunn, 1997). These valleys would have provided the most advantageous settlement localities for Aboriginal people throughout the history of human settlement in the region.

The valley environments provided Aboriginal people with a range of necessary resources, as well as providing shelter from the elements, timber for fires, tools, and housing; all manner of food sources, and stone for tool manufacture. The importance of the availability of perennial fresh water to the resident Aboriginal populations also cannot be overlooked. The valley landscapes may also have served as travel routes throughout much of the study area (du Cros, 1989). The intensity of occupation and use of the incised valleys is reflected in a relatively rich and dense archaeological record.

Intensive use of these environments has resulted in the formation of an almost continuous distribution of archaeological material within a corridor on either side of the waterways forming the valleys. The evidence for intensive Aboriginal occupation of these areas is manifested in a great many high density artefact scatters, scarred trees, stone quarries, fish traps, human burials, and earth mounds. The nature of the alluvial sediments in certain areas (i.e. Keilor) has revealed that this spatially continuous pattern is not of recent origin, but has a demonstrable Pleistocene antiquity (Gill, 1966; Tunn, 1997, 1998). The deeply stratified alluvial sequences found in the valley landscapes have the potential to reveal the archaeological signatures of spatially varied but continuous activities over a period of at least 30,000 years.

Hills

Very little archaeological or ethnographic evidence exists to assist in the construction of land use models for the hill environments. Where there are archaeological sites, they have been interpreted as evidence for ephemeral procurement activities during times seasonally suited for utilising the higher regions of the study area. Pleistocene utilisation of higher altitudes would have been limited, given the extreme climatic conditions and restricted growth patterns of many vegetation communities, and the subsequent restrictions on the distribution of fauna. Without archaeological or ethnographic evidence however, it can only be assumed that Aboriginal people did utilise the higher zones of the study area, particularly during the Holocene. To what degree this zone was utilised is not known.

An idealized Aboriginal land use model for the late Holocene is shown in Figure 2-8. This model is predominantly constructed from the ethnographic information available for the study area and does not include the exploitation of coastal environments, as these environments lie well outside of the current study area.

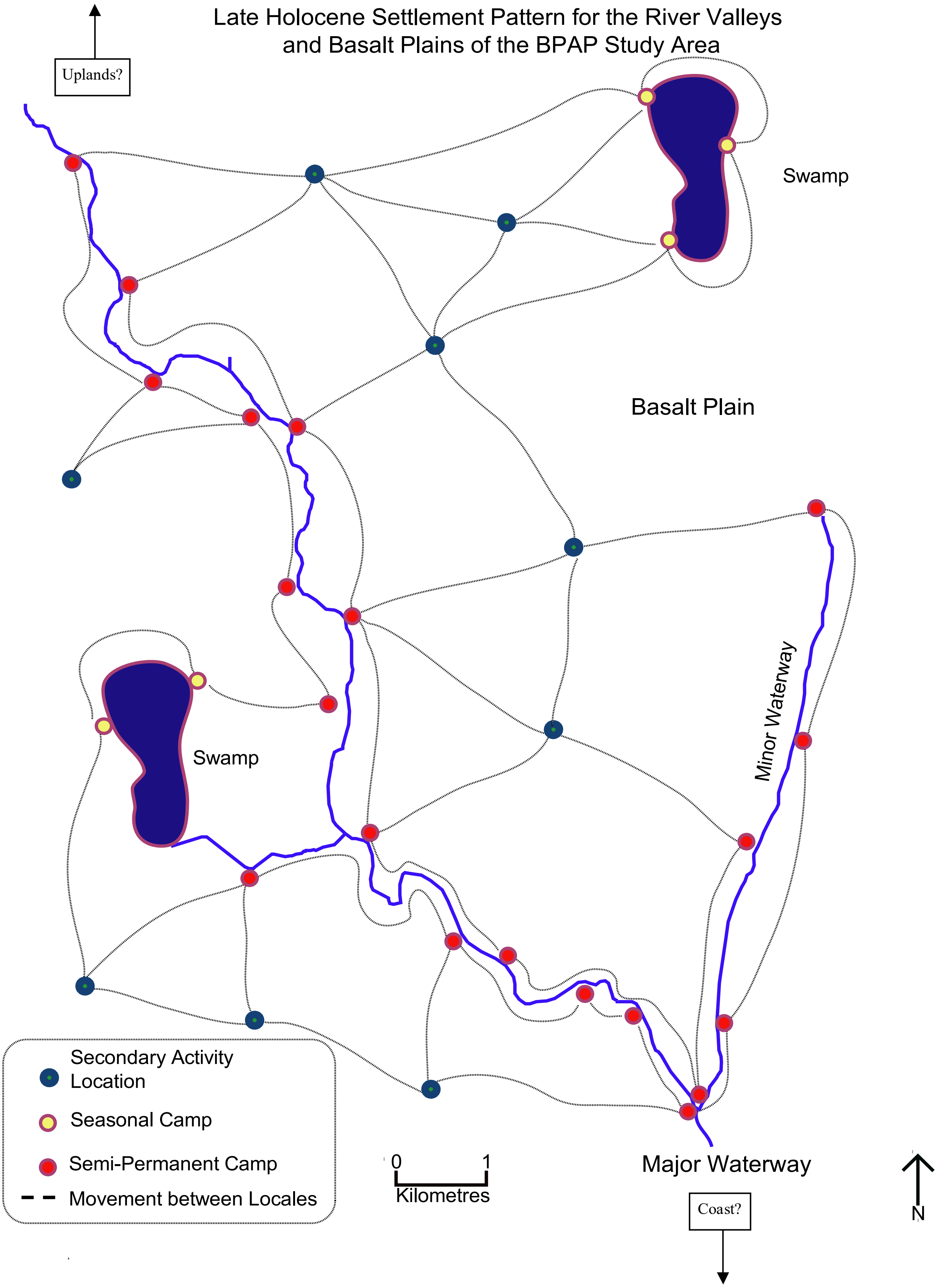


Figure 2-8: Idealized Late Holocene seasonal Aboriginal settlement pattern of the basalt plains and River Valleys within the BPAP study area.

Archaeological Implications

The archaeological implications of a land use model of this nature in the current study area are varied. Pleistocene evidence to support the model is only likely to have survived *in situ* in the deeply incised river valleys that feature significant deposits of ancient alluvium. The archaeological evidence demonstrating aspects of human behaviour in these deposits will most likely be limited to stone artefact occurrences, human remains and hearth features (Tunn, 1997). Holocene data to support the land use model are more varied, yet will be predominantly limited to the more modern geomorphic surfaces of the same geographic locales as the Pleistocene evidence. Early Holocene data will include a wider range of archaeological phenomena including stone artefact occurrences, earth mounds, hearths, shell middens, and human remains. Late Holocene archaeological data will include all of the preceding types of data, and will include more recent archaeological phenomena such as earth rings, or scarred trees. The irony of the archaeology of the study area is that the majority of ^{14}C determinations date Pleistocene sites or non-cultural features (71.7%). The 53 ^{14}C determinations available were derived from only six sites in the study area. Dated sites (n=6) account for less than 1% of the extant data, while the remaining 99% of data is currently not directly dateable (i.e. surface artefact scatters and scarred trees). Typological dating schemes are discussed in detail below. Table 2-5 summarises the ^{14}C determinations for the study area.

Site Name	Site Type	^{14}C Determinations	Holocene	Pleistocene	Non-Cultural or Geological Features
Springfield Gorge	Burial	1	1	0	0
Gisborne Hearth	Open Site/Hearth	2	2	0	0
Lancefield Swamp	Megafauna	10	0	0	10
Maribyrnong Terraces	Sub-Surface Open Site	4	3	0	1
Keilor	Burial	19	6	11	2
Green Gully	Burial	17	3	0	14
Total		53	15	11	27
		100%	28.3%	20.7%	51.0%

Table 2-5: Summary of the ^{14}c determinations from the study area for this project. Data sourced from Godfrey *et al* (1996).

The lack of available chronological data severely limits the inferences that can be drawn from the majority of the archaeological material located in the study area. Similarly, as will be discussed below, typological or functional characteristics of artefact assemblages do not provide a direct chronological framework to assist in the interpretation of the majority of the extant archaeological data. This is severely limiting, and has implications for the construction of any models of archaeological sensitivity or site probability. Relative dating of geomorphological units is one approach to this problem that is feasible in some parts of the study area, and has recently been applied at Brimbank Park by Tunn (1997; 1998). The application of this approach however is limited to those areas featuring the necessary geomorphological features (i.e. deeply stratified alluvial deposits).

2.7. Previous Archaeological Research

The majority of research activity within the study area has been directed toward the Keilor and Green Gully sites. These are arguably the most significant archaeological discoveries yet made in the study area.

Keilor and Green Gully

Through the work of a great many individuals (Bowler, 1969, 1970; Gill, 1953, 1954, 1955, 1966; Keble and Macpherson, 1946; Mahony, 1943; Wunderly, 1943) spanning several decades, much has been determined from the single cranium discovered at Keilor. The initial investigations revealed that, based on size and anatomical attributes, the cranium most probably belonged to a middle-aged male (Wunderly, 1943). This has subsequently been the subject of some debate, with Alan Thorne placing the male crania into the modern female range of size variability (Thorne, 1977: 189; 1980). This conclusion, however, was rejected by Brown who determined that the cranium was that of a 'large and robust male' (Brown, 1987: 45).

Initial estimates of the age of the Keilor cranium relied solely upon erroneous geological and geomorphological associations. The development of ^{14}C dating techniques during the 1950s provided a means to date the Keilor cranium, independent of the problematic geomorphic correlations postulated by Mahony (1943). Edmund Gill (1953) produced the first ^{14}C dates for the Keilor crania site. Gill dated various cultural features from the location where the Keilor cranium was originally recovered. This series of dates provided an absolute age of between 9,000 and 10,000 years for the terraces in which the cranium was located. Gill (1966) subsequently revised these ages upwards, and finally settled upon an age of 19,000 years BP for the Keilor cranium. This age was based upon his belief that the cranium was a true fossil, and as such was older than the terraces in which it was discovered, and the numerous similar dates coming to light from all over Australia during the 1960s. Mulvaney (1964) attempted to answer many of the lingering questions surrounding the Keilor site by conducting a new series of excavations. This was, however, unsuccessful as a flash flood washed all of Mulvaney's excavation into the Maribyrnong River (Mulvaney, 1964).

While there are data indicating human presence throughout southeastern Australia as early as 30,000 years ago, many of the older ^{14}C determinations existing for the study area date non-cultural events (i.e. sediments associated with artefacts), and as such should be regarded with some caution (Gallus, 1969; Godfrey *et al.*, 1996).

The latest archaeological investigations at Brimbank Park, in close proximity to the Green Gully site, have revealed a continuous and stratified, late Pleistocene and early Holocene sequence in buried sediments, providing a view of a buried landscape. The density of artefacts recorded by John Tunn in the Keilor Terraces was found to be very high. The data led Tunn to postulate that as many as 1.25 million artefacts may be present in this buried landscape at Brimbank Park. The spatially continuous nature of the record observed by Tunn and the estimated density of archaeological material present in late Pleistocene and early Holocene contexts, suggests a relatively intensive occupation of these valley environments over a considerable period (Tunn, 1997, 1998).

2.8. Wider Victorian Pleistocene Archaeology

Archaeological data from the Pleistocene period is relatively limited in Victoria, despite many years of investigation and an ever-increasing number of known Pleistocene sites. Pleistocene archaeological evidence of human occupation in Victoria is essentially restricted to a handful of excavated site - Kow Swamp, Clogg's Cave, Billimina, Drual, New Guinea II, Lake Bolac, and Lancefield Swamp.

Kow Swamp

Between 1968 and 1972 Alan Thorne excavated the skeletal remains of approximately 22 individuals from Kow Swamp, near Leitchville, Victoria. The skeletal material dates from between 13,000 ± 250 (ANU-403b) and approximately 6,500 years BP. The Kow Swamp burials are best known for their place within the wider debate of human origins in Australia and Aboriginal skeletal morphology than any other issue. Detailed reports on the Kow Swamp burials have never been published, and the remains have subsequently been reburied (Brown, 2002; Lourandos, 1997; Mulvaney and Kamminga, 1999; Thorne and Macumber, 1972).

Clogg's Cave

Josephine Flood excavated this limestone cave, located at Buchan in East Gippsland, during 1971-72. Human occupation of Clogg's Cave dates to 17,720±840 BP (ANU-1044). As well as an extensive suite of extant faunal remains, limited extinct faunal remains, and some bone points from the Pleistocene levels of the excavated deposits, a small amount of lithic material was recovered (Flood, 1974). Seventy artefacts were recovered from the excavated deposits. These artefacts consisted of a microlithic industry dating to about the last 1,000 years, with an underlying macro-lithic industry. The microlithic artefacts were generally 'bipolar scaled artefacts, small low-angled scrapers and backed blades' (Flood, 1974:176-177). Flood (1974) also noted that geometric microliths dominated the backed blades found, as was the case in other Victorian sites. The raw materials found at Clogg's Cave include quartz, chert, jasper, and quartzite. Silcrete is noticeably absent from the Clogg's Cave assemblage.

Flood (1974) concluded from the evidence at Clogg's Cave, and various other Australian Pleistocene assemblages, that there was generally little change in the form of the lithic assemblage at Clogg's Cave until after about 8,000 years ago. It was not until the introduction of hafting technology, and the 'small tool phase' that any great variation is seen in the assemblage (Flood, 1974:184-185). The small amount of lithic material recovered from Clogg's Cave renders it difficult to compare the assemblage to other contemporaneous assemblages in any detail.

New Guinea II

The discovery of the New Guinea II cave site is attributed to Rudy Frank of La Trobe University. Situated on the western margin of the Snowy River, 50 kilometres from the coast, New Guinea II was excavated between 1980 and 1985 by staff and students of La Trobe University. The area inside the cave proper was not excavated to protect fragile rock art, however some 45 square metres near the cave entrance was investigated (Ossa, Marshall and Webb, 1995). The results from New Guinea II were broadly similar to those of Clogg's Cave. Significant quantities of faunal remains were discovered, along with five bone points. A small amount of lithic material was recovered predominantly chert (n=164), quartz (n=30), and other fine-grained siliceous materials (n=52). Other raw materials present included a quantity of limestone flakes (n=10). Ossa *et al* (1995) classified artefacts with a mass greater than 5 grams as being 'large', while those less than 5 grams were considered 'small'. Of the 285 artefacts recovered in the shelter area, 88.1% were recorded as being ‘small’. There were few formal tools recovered during the excavations. Core/Pebble tools were the most common, but Ossa *et al* (1995) note that this classification is not without its problems. One small blade core was located deep in the sequence, while the remainder of the small blade cores were located in the upper levels of the deposit. Only two geometric microliths were recovered, and these were in the upper two layers of the deposit. Ossa *et al* (1995) conclude that the material recovered demonstrates a low-density occupation sequence commencing approximately 21,000 BP and continuing until the late Holocene.

Drual and Billimina

These two important rock shelter sites are located in the Grampians-Gariwerd ranges of southwestern Victoria. Originally excavated by Peter Coutts and the VAS in 1975 (Bird, Frankel and Van Waarden, 1988; Coutts and Lorblanchet, 1982), both of these sites have later proved to possess far greater antiquity and diversity than was at first thought. Prior to recent reassessments of the material from Drual and Billimina it was argued that these sites were only occupied in the late Holocene, as recently as 3,500 BP (Mulvaney and Kamminga, 1999), and that no clear change or variation was discernable in the stone tool assemblages (Bird and Frankel, 1998). A program of redating sediment and re-analysing lithic materials from these sites led to a radical reassessment of both the antiquity of the sites, and the variation in the stone tool assemblages.

New radiocarbon determinations from Drual revealed basal occupation dates of approximately 22,000 BP. Similarly, newly dated evidence from Billimina provided a non-basal date of approximately 9,000 years BP, allowing Bird and Frankel (1998) to argue that cultural material began to accumulate at Billimina before 10,000 BP. These age estimates are significantly different to the original dates obtained by Coutts, and resulted in a reappraisal of the sequence of human occupation of this part of southwestern Victoria. Both assemblages are defined as being of low density. Although the raw material types present at Drual are diverse, Billimina does not display the same diversity (Figure 2-9).

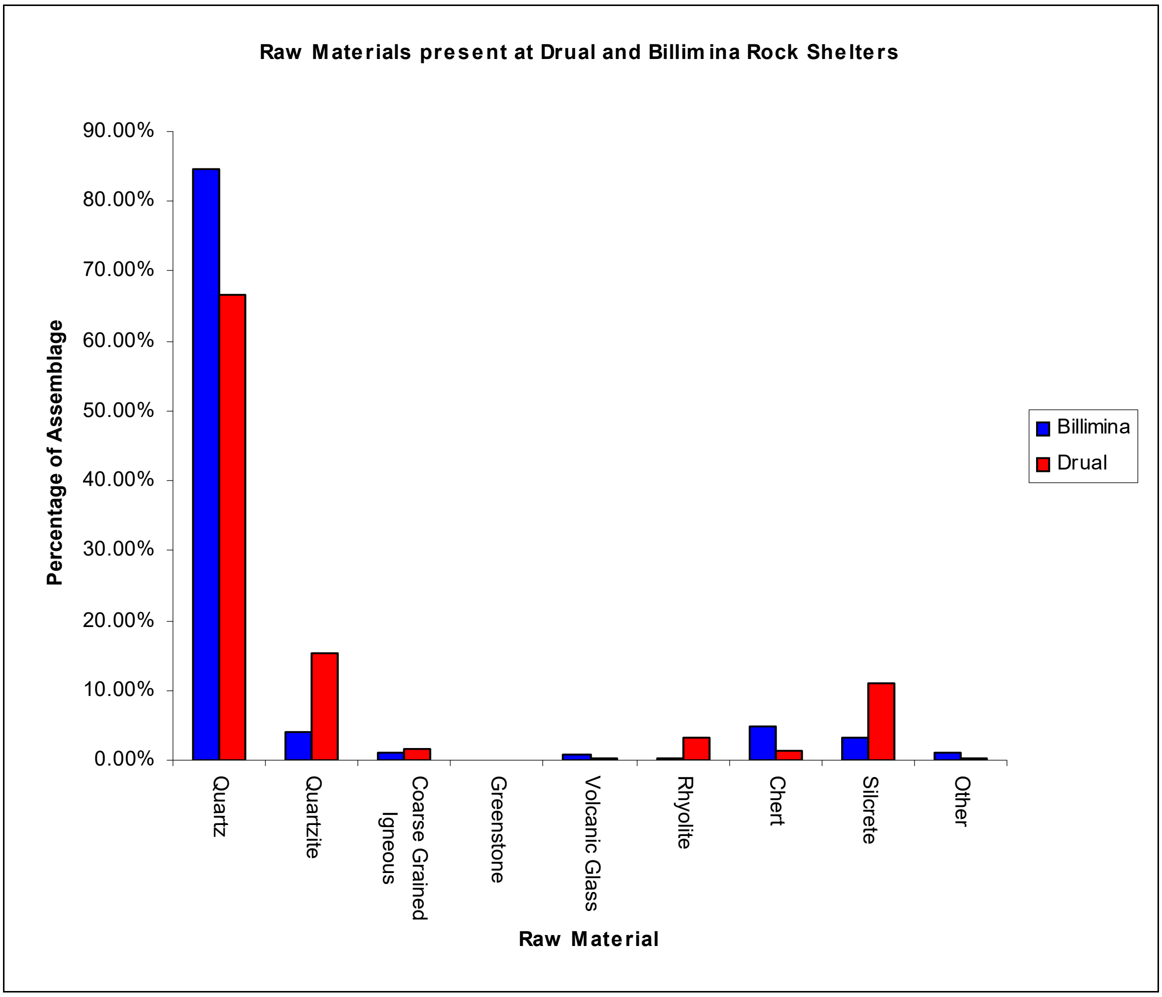


Figure 2-9: Percentage of raw materials present in the Drual and Billimina assemblages. The Drual assemblage exhibits far greater raw material diversity than the Billimina assemblage (Bird and Frankel, 1998:53).

The Billimina assemblage is generally more reduced than the Drual assemblage, indicating differential access or utilisation/scheduling of raw materials. The greater proportion of waste material and cores at Drual may also be indicative of wider ranging tool production activities (Bird and Frankel, 1998).

Lancefield Swamp

In 1975-76 excavations at the Lancefield Swamp, approximately 75 kilometres northwest of Melbourne, revealed a buried bone bed dated to 26,000 BP. This bone bed contained the remains of some 10,000 extinct animals, as well as 2 quartzite artefacts in association with the bone bed. A further 191 artefacts were found in sediments overlying the bone bed. This site provides tantalising evidence for the co-existence of humans and megafauna during the Pleistocene. Although there is a paucity of dated material from the lower levels of the excavations, the implications are that Aboriginal people and the megafauna coexisted in southern Victoria for a period of at least 7,000 years (Gillespie *et al.*, 1978; Horton, 1976; Horton and Wright, 1981; Orchiston, Miller and Glenie, 1977).

Summary of Pleistocene Archaeological Evidence in Victoria.

There are other sites in Victoria dated to the terminal Pleistocene. These sites include a coastal cave, (Bridgewater Cave- Discovery Bay) dated to between 10,760±10 BP (Beta-8465) and 11,390±310 BP (Beta-3923), freshwater shell middens on the Murray River dated to between 11,250±240(GAK-1062) and 19,980±220 (Beta-58969), and a hearth site at Lake Bolac containing kangaroo bone and quartz artefacts dated to 12,480±560 BP (SUA-1335). Although there are numerous sites dated from 22,000 BP to the beginning of the Holocene, there are few well-documented lithic assemblages on which to construct regional sequences (Bird and Frankel, 1998).

Bird and Frankel (1998) have discussed four regional Pleistocene sequences. They are:

- East Gippsland (Clogg's Cave and New Guinea II)
- Murray River Valley (Kow Swamp, Lake Victoria, Karadoc Swamp)
- Maribyrnong River Valley (Keilor and Green Gully)
- Far West Coast (Discovery Bay – Bridgewater Cave)

One unifying theme in all of the Pleistocene assemblages is the relatively small size of the recovered samples. As Bird and Frankel (1998:59) noted, quantitative comparison between artefact assemblages is challenging, as many results have not been published. The lack of a common artefact classificatory system is also problematic. The Pleistocene assemblages show a remarkable degree of variation across Victoria. The main variations are summarised in Table 2-6, below, adapted from Bird and Frankel (1998).

Area	Sites	Raw Material Availability	Technology	Tool Types
East Gippsland	New Guinea II Clogg's Cave	Diverse Intersite Variability	Freehand	Pebble Tools Large Scrapers
Maribyrnong	Three Open Sites	Silcrete and Quartz Intersite Variability	Bipolar Freehand	Large Scrapers Small Scrapers
Murray Valley	Numerous Floodplain Sites	Sparse Quartz	Bipolar	Small Scrapers
Discovery Bay	Numerous Open Sites Bridgewater Cave	Flint	Freehand	Large Scrapers
Gariwerd	Drual Billimina	Quartz and Quartzite's Intersite Variability	Bipolar Freehand	Large Scrapers Small Scrapers

Table 2-6: Regional Pleistocene assemblage trends identified by Bird and Frankel (1998).

Unfortunately, it is not possible to be more precise with much of the Victorian data. The data sets do not have the chronological resolution to allow finer grained analysis, thus blurring the relationships between older and younger materials at each site, and the inter-site relationships between sites of similar content and context.

What these various assemblages demonstrate is that a wide variety of geographically different parts of Victoria were being utilised by Aboriginal peoples well before the Holocene transition. There was related variations in stone tool raw material choices (or availability), manufacturing methods and usage, while the assemblages display greater regional diversity than has otherwise been claimed. This led Bird and Frankel (1998:61) to conclude that the unity of the 'Core tool and Scraper tradition' needs re-examination in light of emerging and more detailed regional studies.

Context of Pleistocene Sites in the study area

Apart from the dated archaeological sequences at the Keilor (Dry Creek), Brimbank Park, and Green Gully sites (all within 2-3 kilometres of each other), there is only one other radiometrically-dated site in the study area. Andrew Long and David Rhodes excavated an open site near Gisborne on a 'meander bend of the Kororoit Creek' (du Cros, 1993: 60). Two hearths were located and subsequently dated to 1,460±50 BP (Beta 45593) and 2,160±70 BP (Beta 61795) respectively. A total of 1,685 silcrete, quartz and basalt artefacts were recovered from the site. du Cros (1993: 60) has interpreted this site as a campsite functioning as a stopover point for groups travelling between Mount Macedon and the Maribyrnong Valley. The remainder of the vast quantities of archaeological evidence from the study area are undated. For example, the Mount William hatchet quarry, the Sunbury earth rings, several earth mounds, stratified artefact exposures, and vast numbers of surface artefact scatters and scarred trees, cannot readily be placed into a chronological sequence, as they remain for the most part undated (and unfortunately predominantly updateable). It is possible, however, to geomorphologically date some of the cultural material located on the alluvial terraces associated with the Maribyrnong River (and other alluvial watercourses).

The sedimentary sequences of the Maribyrnong River have been investigated in considerable detail (Anderson, 1972; Barlow, 1999; Bowler, 1969, 1970, 1987; Bowler *et al.*, 1967; Gallus, 1969), and shown to have differentially accumulated over the last 50,000 years. Fluvial activity has created a series of depositional terraces each distinct from overlying and underlying terraces, and indicating differing environmental regimes at the time of deposition. These terraces have been extensively dated, and provide a means of geomorphologically dating certain surface finds on the terraces. For instance, material appearing on Maribyrnong Alluvium, otherwise known as the 'GGM, GGL, an GGJ sediments' (Bowler, 1970:53) can be no more than about 5,000 years old. Materials located on the Upper or Intermediate zone of the Keilor Terrace (Doutta Galla Silt) could have been deposited at any stage over the last 10,000 years, but not before. The sediments underlying the intermediate zone are only rarely exposed, and were deposited between 10,000 years to at least 40,000 years ago (Bowler, 1970; Joyce and Anderson, 1976). The implications of these geomorphological constraints upon the chronology of archaeological materials located in or near alluvial terraces throughout the study area are significant. While the antiquity of archaeological sites is only one of many attributes used to determine scientific significance, it is nonetheless important. The geomorphic control over chronology in the alluvial sequences of the Maribyrnong provides us with a valuable tool to predict the location of other similar sites. This degree of chronological control is generally unavailable from any of the other archaeological data in the study area.

The sites discussed in the study area have provided some insight into human behaviour in the region throughout the late Pleistocene, demonstrating a continuous occupation of these valley environments for at least 30,000 years. There is also some tantalising evidence from the Lancefield Swamp site to suggest human interaction with megafauna 26,000 years ago, before the LGM. Human activity at this swampy site then appears to cease altogether until approximately 2,000 BP, when once again evidence of human activity in the form of stone tool discard is present. This evidence must be viewed cautiously however, as there has been only a very limited amount of research at the Lancefield site, thus the results are far from conclusive.

While Pleistocene evidence has been recovered from alluvial and swamp environments in the study area, the basalt plains are somewhat more problematic. At various stages throughout the human occupation of the area, the basalt plains have alternated from being virtually uninhabitable, to resource rich environments. For example, the environmental conditions prevailing on the plains 30,000 years ago were not altogether that different from contemporary conditions, yet during periods of maximum aridity (about 18,000-13,000 BP), the plains would have been quite inhospitable. While there is no evidence in the study area to support a recent human expansion (i.e. last 5,000 years) onto the plains for the first time and it is likely that the plains were intermittently utilised from the beginning of the human use of the region, and abandoned only at times of peak resource stress, the difficulty of chronological definition restricts our ability to determine any occupation sequences on the plains. The basalt plains sites generally do not possess the geomorphological markers of the alluvial sequences. It is not possible to postulate a *terminus post quem* for material appearing on sediments that cannot be dated either radiometrically or geomorphologically. Similarly, post-depositional processes will have disturbed the loose and very shallow sediments on the plains, irreversibly mixing any cultural materials present.

The stone artefact assemblages of the Pleistocene sites found in the alluvial terraces display an essentially localised 'Maribyrnong' industry. Bird and Frankel (1998) have described this industry in detail, and it is characterised by the occurrence of a limited number of formal tools, small overall artefact dimensions throughout, the predominance of silcrete and quartzite, and the use of both freehand and bipolar flaking methods. The 'Maribyrnong Industry' displays considerable intersite variability, and contains assemblages reflecting both specific knapping episodes, and long-term general accumulations of cultural materials (Bird and Frankel, 1998). What is clear from the various 'Maribyrnong Industry' sites is that 'older assemblages, like more recent ones, vary markedly in time and space' (Bird and Frankel, 1998:58-60). The Maribyrnong valley and environs can be considered as relatively stone rich, in terms of the geological variety and availability of raw materials for stone tool making. This diversity 'may account for the variability seen in the Maribyrnong Valley' (Bird and Frankel, 1998:58-60). The relative wealth of stone raw materials for tool making provides another very attractive reason for prehistoric populations to occupy the Maribyrnong Valley and surrounding areas. However, raw material availability may have changed significantly through time as land surfaces changed through geomorphic processes. There is no practical or economical way of determining if socio-cultural resource scheduling operated with regard to the stone of the Maribyrnong Valley as it did at Mount William short of a major petrological study. To summarise, Pleistocene archaeological evidence in the study area will be limited to those areas where deeply stratified alluvial deposits occur.

2.9. Wider Victorian Holocene Archaeology

The Holocene period, in general, has been characterised by several archaeological phenomena apparently unique to this period, which have become the subject of intense archaeological debate (Bird and Frankel, 1991a, 1991b, 1998; Frankel, 1995; Holdaway, 1995c; Lourandos, 1976, 1977, 1980, 1983; Ross, 1981, 1985; Williams, 1984, 1987). In contrast to the late-Pleistocene and early Holocene, the mid-Holocene (circa 5,000BP onwards) has been regarded as a period of rapid social, economic, technological and demographic change throughout Australia, commonly referred to as 'intensification' (Lourandos, 1983).

The transition from the Pleistocene to the Holocene in Australia is both a 'reality of climate history' (Frankel, 1995:649) and a contemporary intellectual construct. Single site or pan-continental analyses of stone tool technology in particular, have led to a '…consensus view that the Pleistocene-Holocene transition did not involve any significant change in stone tool manufacture' (Holdaway, 1995c: 795). This apparent lack of change in stone tool assemblages through time (until the mid-Holocene) has however been described as a product of archaeological method (Holdaway, 1995c) rather than a product of the material under analysis, inadvertently highlighting the apparent changes in stone tool technology in the mid-Holocene. A closer analysis of stone tool assemblages at regional scales dated to either side of the Pleistocene – Holocene transition is seen as one method of redressing the balance and archaeologically challenging the standard view of apparent cultural and technological homeostasis until at least the mid-Holocene (Frankel, 1995; Holdaway, 1995c).

Numerous perceived variations in the archaeological record upon which the intensification argument has been constructed were summarised by Bird and Frankel (1991b) as:

- Increase in the number of sites,
- Increased sedentism,
- Use of marginal environments,
- Development of facilities (i.e. fish trap complexes),
- Alliance and exchange systems, and
- Increased ceremonial activities.

Coincident with the supposed 'intensification' occurring in prehistoric Aboriginal society, many archaeologists have identified a pan-Australian stone tool industry emerging at about 4,500 BP. This industry emerging in the mid-Holocene is known as the 'Australian Small Tool Tradition' (ASTT) and is characterised by the presence of backed blades and geometric microliths in assemblages, and is commonly associated with the manufacture of timber hafted tools. This ASTT has come to serve as a chronological marker in Australian archaeological sequences, indicating the relative chronology of assemblages by the presence or absence of these supposedly diagnostic artefacts (i.e. backed blades). This 'chronology by association' is often utilised with surface artefact scatters, which are difficult (if not impossible) to date by any other means. The timing of the introduction of the ASTT is commonly held to be the mid-Holocene, at approximately 4,500 BP (Mulvaney and Kamminga, 1999). Alongside the introduction of new stone tool technologies, the raft of perceived changes in the mid-to-late Holocene archaeological record of south eastern Australia are seen by some as a 'package of related events' (Bird and Frankel, 1991a:1) occurring more or less simultaneously. A review of the available evidence however, draws into question many of the premises and relationships upon which the intensification arguments are based.

Many site chronologies have been built upon the dichotomous relationship between small tool type presence (< 4,500 BP) and small tool type absence (>4,500 BP) in artefact assemblages. This dichotomy is assumed to have specific chronological significance (Bird and Frankel, 1991a) and marks the pan-continental introduction of this technology (Hiscock and Attenbrow, 1998). Bird and Frankel (1991a) however, argue that this dichotomy is an artificial relationship, and is not suitable for the construction of chronological sequences based simply on the presence or absence of identifiable 'marker'[s] (Bird and Frankel, 1991a: 2-3). The validity of basing regional chronologies upon this dichotomous ASTT presence or absence has been demonstrated as erroneous by Hiscock and Attenbrow (1998). Evidence from the Upper Mangrove Creek for example, has revealed the presence of backed artefacts in deposits radiocarbon dated to between 5,500 BP and 8,500 BP at Mussel Shelter (Hiscock and Attenbrow, 1998:55) and '…older than 8,000 years BP' (Hiscock and Attenbrow, 1998:57) at Loggers Shelter.

A significant effect of the use of the ASTT as chronological marker may have been the artificial inflation of the number of sites thought to date to more recent periods, largely based on the presence of backed blades or geometric microliths. The sites where a typological chronology has been employed are typically surface artefact scatters where there is only a remote possibility of recovering radiometric dates (Bird and Frankel, 1991b). As these sites cannot be accurately dated, and the use of typological markers as the basis for chronologies is flawed, it is 'effectively impossible to fit these sites into a regional chronological framework' (Bird and Frankel, 1991b: 188).

An apparent increase in the number of coastal shell middens from the mid-Holocene onwards is also seen as a component of the intensification of regional prehistoric Aboriginal behavioural. However, this apparent increase in the number of shell middens is also a flawed premise upon which to construct models of regional change. Bird and Frankel (1991a: 3) argue that taphonomy, site survival, and research agendas have all played a part in creating a biased view of the archaeological database. For example, shell middens make up approximately 50% of the ^{14}C determinations of Bird and Frankel's (1991a) study area. Taphonomic and post-depositional processes along coastal margins are considered to artificially bias the archaeological database, inflating the number of younger sites. It is highly unlikely that many (if any) coastal shell middens older than about 6,000 years have survived the advance and stabilisation of sea levels at or near their contemporary mark. Early Holocene or Pleistocene shell middens that may have existed on early coastlines could not have survived the rising of the seas (Rowland, 1989). Similarly, research bias may have also favoured the selection of sites displaying better preservation (i.e. generally younger). The combination of these factors may have resulted in the chronological range of ^{14}C determinations being artificially truncated, While the overall number of ^{14}C determinations has been artificially inflated, suggesting a dramatic increase in the number and use of coastal sites.

Arguments in favour of increased sedentism in the Holocene, particularly after about 2,500 BP, are often based upon the emergence of a new type of archaeological evidence – earth mounds. A date of approximately 4,000 BP has been recorded at an earth mound site near the Wakool River in the Murray Valley (Berryman and Frankel, 1984) however the majority of other investigated mounds in Victoria are dated to about the last 2,000 years (Frankel, 1991a). In her study of earth mounds on the volcanic plains of Western Victoria, Elizabeth Williams concluded that the earth mounds were constructed as 'hut foundations, general camping places, and ovens' (Williams, 1987:317). Bird and Frankel (1991a: 7) however, argue that the archaeological evidence for deliberate construction of these earth mounds as hut foundations is tenuous, and residential use is most likely a secondary use of the mound features.

The notion that an aggregation of large numbers of earth mounds indicates increased sedentism is also flawed. Indeed as Bird and Frankel conclude 'mounds often appear as clusters but where adjacent mounds have been dated they may be separated in time by as much 1,000 years' (1991a:8). The construction of mounds is seen more as evidence of

localised responses to the wetter conditions of the last 2,500 years, than any increase in sedentism (Bird and Frankel, 1991a:8).
The emergence of 'stone houses' in parts of southeastern Australia, such as those at Lake Condah (Coutts, Frank and Hughes, 1978) has also been interpreted as evidence for increased sedentism in prehistoric Aboriginal populations, and associated with increases in local productivity (through fish traps), and population growth. It is implied in the literature (Coutts, Frank and Hughes, 1978: 42; Flood, 1989: 205-207) that these supposed village sites (complete with stone houses) were more or less permanently occupied, and in close association with the fish trap complexes, such as Lake Condah (Clarke, 1994: 11). There is however, no archaeological evidence to support this, nor is there any archaeological evidence demonstrating contemporaneity of occupation (Bird and Frankel, 1991a: 8; Clarke, 1994:11). It has subsequently been argued that the stone houses may represent 'post contact refuge areas' and were not part of a wider prehistoric settlement system (Bird and Frankel, 1991a:8). Although this view of European influenced post-contact housing construction (i.e. mimicry) is also somewhat problematic.

Two types of food procuring facilities have been identified in southeastern Australia that have played a significant role as archaeological evidence supporting the prehistoric Aboriginal 'intensification' (Lourandos, 1983) argument. These facilities are commonly referred to as 'fish traps', and extensive examples have been recorded at Lake Condah, Toolondo and Mount William in central Western Victoria. The Lake Condah example developed as a result of the hydrology along the edges of the basalt plains with human intervention (Bird and Frankel, 1991a; Coutts, Frank and Hughes, 1978), while the second type of facility recorded at Toolondo and Mount William consists of extensive systems of 'earth cut channels and ditches' (Bird and Frankel, 1991a:8). While it has been argued that these food-procuring systems are evidence for increases in productivity, populations and sedentism, the antiquity, utilisation history and construction sequencing of the features is entirely unclear. The Lake Condah system however, is geomorphologically constrained, and cannot be more than about 4,000 years old (Head, 1989). There is no archaeological evidence available to determine if this feature was gradually or rapidly constructed. Bird and Frankel (1991a:8) argue that these systems could have emerged over a long period rather than because of sudden demographic or environmental pressures or processes.

The development of trade in materials such as greenstone for hatchet heads (McBryde, 1978; 1979; 1984a; 1984b), and the remains of ceremonial sites such as stone arrangements and earth rings (Frankel, 1982b) have also been argued to be elements of a wider intensification and development of socio-economic alliance and reciprocity systems. While these phenomena are of undoubted archaeological significance, their place within debates of prehistoric Aboriginal intensification is unclear. None of these archaeological features (i.e. Sunbury earth rings or Mount William hatchet quarry) has been adequately dated. The best estimates available for the introduction of hatchet heads into the archaeological record in southeastern Australia is sometime after 4,500 BP (Mulvaney and Kamminga, 1999) and possibly as recently as 2,000 years ago (Frankel, 1991a). Whether this apparently recent introduction of hatchet heads proves to be the case, or it has been an artefact of research biases is yet to be determined. Bird and Frankel (1991a: 9) argue that it is difficult to include any of these types of archaeological phenomena into discussions of prehistoric change as none have been directly dated.

What emerges from a review of the evidence for late-Holocene intensification appears to be an over-reliance upon modern ethnographic analogues, a distinct lack of archaeological evidence for many of the perceived changes in prehistoric Aboriginal behaviour, and an over-reliance upon 'social' explanations (Bird and Frankel, 1991a) for archaeological phenomena poorly understood and often over-represented in the research database. While the intensification of Aboriginal prehistoric society is indeed possible, the current archaeological evidence does not offer unequivocal support for this position. Of greater concern is the perceived need to argue that Aboriginal society was intensifying and advancing towards an agricultural state as Williams, for example, has argued (Williams, 1987:320). The supposed cumulative long-term structural changes in prehistoric behaviour culminating in the intensification of Aboriginal society and the eventual emergence of agriculture is rooted within a social evolutionist paradigm (Bird and Frankel, 1991b) that is not demonstrated by the archaeological evidence in Australia, and is generally not supported by the archaeological evidence of hunter-gatherer societies anywhere in the world. The emergence of agriculture was by no means inevitable nor indeed necessary (Rowley-Conwy, 2001) –nor should it be viewed as so.

Context of Holocene Sites in the Study Area

Central to the construction of models of changing Aboriginal behaviour and land use in prehistory is the vast quantity of surface material that is to be found in the form of artefact scatters across the study area. The fundamental issues of chronology and the timing of the introduction or local development of new technologies remain largely unanswered for this region. At present, the timing of the initial development or use of certain parts of the study area simply cannot be determined. Mount William hatchet quarry for example, cannot be easily located within a regional model of cultural change as the chronology of the quarry is unknown. The ethnoarchaeological and scientific significance of the quarry can be discussed at length, but the timing of the first use of the quarry remains elusive (see next section for further discussion regarding the Mount William quarry).

The vast quantities of stone artefacts distributed across the land surface of the study area constitute the overwhelming majority of the archaeological record. Despite the quantity of material present, establishing pattern, change and/or chronology from these assemblages is particularly elusive, as the application of geomorphic dating is geographically restricted and typological chronologies are not appropriate. The widespread utilisation of typological dating in the study area may have artificially inflated the number of sites thought to be of mid-to-late Holocene antiquity, based on the presence or absence of supposedly diagnostic chronological markers (i.e. backed blades or geometric microliths). As well as the inadequacy of typological dating, earlier industries present in the study area are not necessarily distinctive from later industries (within the same regional, technological and resource 'bloc') rendering the utilisation of typological dating methods even more suspect.

The dating of surface scatters will always remain problematic unless the materials are found in direct association with dateable sediments or features (Holdaway *et al.*, 1998: 16), or the material is directly dateable using methods such as obsidian hydration (Jones and Beck, 1992: 180). This latter method is not without its limitations either, and is obviously inappropriate if no obsidian is present within the assemblage. Essentially, the construction of chronologies and the identification of change are the cornerstones of archaeological research. Where these constructions are (in part) based upon highly differentiated and disturbed surface scatters, the establishment of any chronological association is, and will remain, problematic (Jones and Beck, 1992:188).

2.10. Significance and Representativeness

> 'In all areas of heritage management, the assessment of significance is held to be the central, most important and most immediate task' (Bowdler, 1984: 1).

The central philosophical pillar of cultural resource management is the conservation of those items or places considered worthy of preservation for future generations. The CRM profession is charged with determining which of those items or places are significant enough to warrant conservation. CRM professionals traditionally arrive at this decision through the application of a multi-criteria significance assessment process. The purpose of this section is to discuss how the concepts of significance and representativeness are dealt with in the predictive modelling process. It will be argued that although the predictive modelling process appears to be a valuable tool in assessing significance and representativeness, there are certain methodological and theoretical constraints in many modelling endeavours that hinder the creation of a representative sample of the archaeological record, potentially biasing the sample of archaeological sites preserved for future generations.

Significance

The assessment of the significance of an item or class of items is a fundamental component of the cultural resource management process. The assessment process is utilised as a means of determining which items are considered 'valuable' enough to warrant conservation. Importantly, it is widely recognised that not all items or classes of items can be conserved; hence the need for a process identifying those items which are believed worthy of conservation. In Australia, the framework that this assessment of cultural significance is based upon is known as the Australia ICOMOS 'Burra Charter' (Marquis-Kyle and Walker, 1992). The Burra Charter defines cultural significance as 'the aesthetic, historic, scientific, social or spiritual value of a place or item for past, present or future generations' (Marquis-Kyle and Walker, 1992: 21). While it is explicitly recognised that the assessment of cultural significance is based upon several core elements (i.e. social, historic, aesthetic, scientific or spiritual values), the purpose of this section is to discuss the assessment of the scientific significance of pre-contact archaeological materials within the current study area and Victoria in general. This in no way diminishes the importance of the other significance attributes wherever they may be applicable. In particular, contemporary Aboriginal populations have the right to determine the significance of cultural material as they see fit. The right to self-determination and the ownership of cultural property are not at issue here.

What is at issue however, are the ways in which scientific significance is assessed at the individual site level, and whether this is the most effective means of conserving significant sites or classes of sites. The significance assessment procedure is a multi-layered process that must address and incorporate the often-competing values of various stakeholders and the various attributes of different types of cultural resources. For this reason, contemporary Aboriginal groups are an essential component of the significance assessment process, and inclusive cultural resource management decisions cannot be made without consulting the relevant indigenous community(s). Predictive modelling should never be used as a means of avoiding or fulfilling the requirements of a complete cultural heritage assessment. It is a tool for flagging those areas of higher likelihood of locating additional archaeological material. Similarly, models of this nature cannot be regarded as fulfilling Aboriginal community consultation requirements in any way. Aboriginal community consultation and participation are not optional extras (Langford, 1983) in predictive modelling practice.

Assessing Scientific Significance

There has been considerable debate in the archaeological and CRM literature concerning the assessment of the scientific significance of archaeological materials and/or sites (Bowdler, 1984; Flood, 1984; Sullivan and Bowdler, 1984; Tainter and Lucas, 1983; Vinnicombe, 1984; Witter, 1984). Scientific significance is generally assessed according to two themes – (1) representativeness, and (2) relevance to 'timely or specific research questions' (Bowdler, 1981). Bowdler (1984) comments that the level of sophistication of the research questions generated for any area is inversely proportional to the level of understanding of the prehistory of that area. When assessing whether or not a particular site or class of sites can answer specific research questions Bowdler outlines three questions that should be asked of the item: -

- 'Can this site contribute knowledge which no other site can?
- Can this site contribute knowledge which no other resource, such as documents of oral history or previous research can?
- Is this knowledge relevant to specific or general questions about human history or behaviour or some other substantive subject' (Bowdler, 1984: 1-2).

While this is a relatively straightforward process, there are problematic issues using criteria such as these to assess significance. The major criticism is the tendency to treat each site in isolation, and not as a part of a wider landscape or suite of sites. A single artefact scatter, for instance, may not appear to be very significant, however if the scatter forms a small part of a larger landscape scale distribution of material, then the significance of the components of that landscape scale system must be viewed differently. The assessment of scientific significance is not a 'static' (Bowdler, 1984: 1-5) process, nor should the possibility of improved techniques or technology in the future be ignored. In a contemporary Victorian CRM context, assessing the research potential of an archaeological site or item has come to be an assessment of the content, structure, and integrity of the relevant archaeological material. The greater the integrity of the site; the more material present in a stratified and undisturbed state, then the more likely it is for the item to be considered of high significance. The process has been 'codified' to a certain extent by practitioners who utilise a numeric system to substantiate their significance assessments. For example, if all elements are assessed using a cumulative numeric system, then a site can be rated depending upon the final 'score' the site is given. The higher the item scores, then the greater the scientific significance, and vice versa.

Representativeness

The second major component of the scientific significance assessment process is that of representativeness. In essence, representativeness refers to the overall regional distribution of a particular archaeological site type, and is determined by assessing whether a particular site or class of sites is common, occasional or rare in a particular locality.

Assessing Representativeness

Representativeness is assessed based on whether a site is:

- Common – site type is common both locally and regionally
- Occasional - site type is an occasional occurrence within the local area or region, or
- Rare – A rare or previously unknown site type within a region.

The assessment of the representativeness of a site (or sites) should also take into account the context and condition of the individual site. For instance, there may only be a small number of sites across a region that have suffered only minimal disturbance since European settlement. It would be prudent to rate these sites as more significant than other more disturbed sites, even if they are a commonly occurring site type regionally.

Representativeness assumes greater importance in predictive modelling discourse as the term assumes slightly different meanings depending upon the context of use. Not only is the conservation of a representative sample of archaeological sites a central pursuit in contemporary CRM; it is essential for the future of both CRM and archaeology in general. A continuing failure to conserve a representative sample of the archaeological record would result in a severely biased view of the past, and ultimately a debased cultural record upon which archaeological research ultimately depends. Existing archaeological databases have become the most popular data source for agencies or archaeologists wishing to pursue predictive modelling in either (or both) pure research or CRM contexts (Church, Brandon and Burgett, 2000:136). While the advent of GIS technology has made this appear simpler, the outcomes of many GIS based models are somewhat disturbing. In regions where the archaeology is relatively unknown, or the existing database is heavily biased the representativeness of the existing data is unknown, as is the type and amplitude of any of the biases present. If the database used to construct models (particularly the statistical-correlative type) is not representative of the archaeological record then the predictive model constructed will be dangerously flawed. The resulting model will be based upon biased data, and it will become a self-perpetuating series of erroneous predictions, resulting in an even more unrepresentative view of the archaeological record, a phenomena illustrated in Figure 2-10.

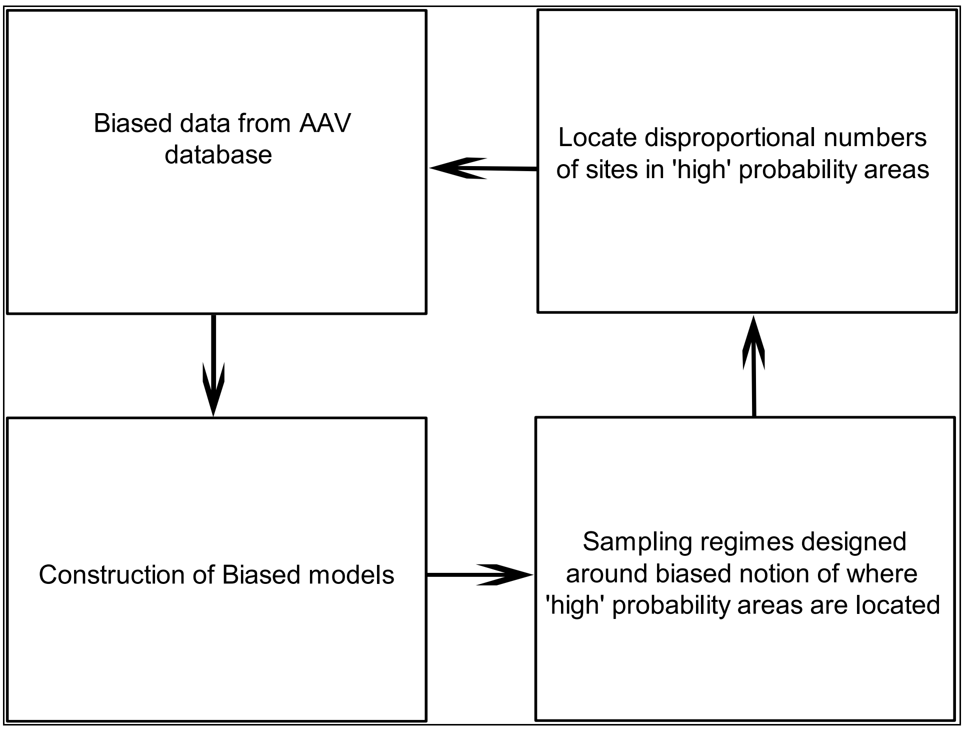


Figure 2-10: The circular nature of model building from biased datasets, perpetuating unrepresentative samples of the archaeological record. After Wheatley, D (In Press).

This is by far the gravest error that can be made in predictive modelling. Predicting that individual sites do not exist when in fact they do is problematic. However, systematically perpetuating the construction of an unrepresentative view of the archaeological record is infinitely more destructive in the long term. This is the primary motivation for creating sensitivity overlays for this thesis, rather than attempt to create formal predictive models based upon spurious statistical inferences drawn from biased data (Thomas, 1978:231-244). Surveying for archaeological sites in areas 'predicted' to have a high probability of containing undiscovered sites can only serve to further bias the archaeological record if the predictions were based initially upon flawed data (van Leusen, 2002: 5-9).

2.11. Statutory Planning Mechanisms

In Victoria, a codified system of planning provisions applies to all planning and development decisions made by local government authorities (LGA's). Many of the Victorian Planning Provisions (VPP) have specific requirements, prohibit certain types of developments, or contain specific environmental constraints. Each municipality within the state has its own planning scheme that is based upon the requirements of the VPP and the *Planning and Environment Act (Vic) 1987*. The Department of Infrastructure administers the *Planning and Environment Act (Vic) 1987.* The VPP contains a series of standard 'zones' and 'overlays'. Zones refer to the nature of the land use permitted in a specific area (i.e. industrial, rural, business, commonwealth), while the overlays are used to 'provide additional protection for specific purposes' (Bowman, 2001: 4). For instance, there are specific overlays for 'Salinity Management' areas, 'Heritage' areas, and areas containing 'Significant Landscapes' (Bowman, 2001). The level of protection offered to areas included in planning scheme overlays is considerably higher than areas otherwise excluded from overlay protection.

The example in Figure 2-11 shows the various land use areas (zoning) for the township of Kilmore in the Mitchell Shire (northern extremity of the current study area). Superimposed over this is part of the shire's 'Heritage Overlay', (shown in red). In general, when an area or item is included in an overlay, the responsible LGA must follow prescribed statewide guidelines when assessing development applications that may impact upon that area or item. The statewide guidelines may preclude all activity in an overlay area, or simply require the LGA to issue a special permit with conditions allowing specific activities to occur (i.e. subdivision, building, or clearing).

The State Planning Policy Framework (SPPF) outlines the objectives of the Heritage Overlay, for example, as follows:

> 'Planning and responsible authorities should identify, conserve and protect places of natural or cultural value from inappropriate development. These include:
>
> - Places of botanical, zoological or other scientific importance, including national parks and conservation reserves and the habitats of rare or endangered plants and animals.
> - Places and sites of geological, palaeontologic or other scientific importance, including rock formations and fossil sites.
> - Places of Aboriginal cultural heritage significance, including historical and archaeological sites.
> - Sites associated with the European discovery, exploration and settlement of Victoria.
> - Important buildings, structures, parks, gardens, sites, areas, landscapes, towns and other places associated with the historic and cultural development of Victoria, including places associated with pastoral expansion, gold mining, industrial development and the economic expansion and growth of Victoria.
>
> Planning and responsible authorities should take account of the findings and recommendations of the Victorian Heritage Council and the provisions of the Heritage Act 1995. Planning and responsible authorities must take account of the requirements of the Victorian Archaeological and Aboriginal Relics Preservation Act 1972, the Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984 and the views of local Aboriginal communities in providing for the conservation and enhancement of places, sites and objects of Aboriginal cultural heritage value' (Department of Infrastructure, 2000: 15-1-3).

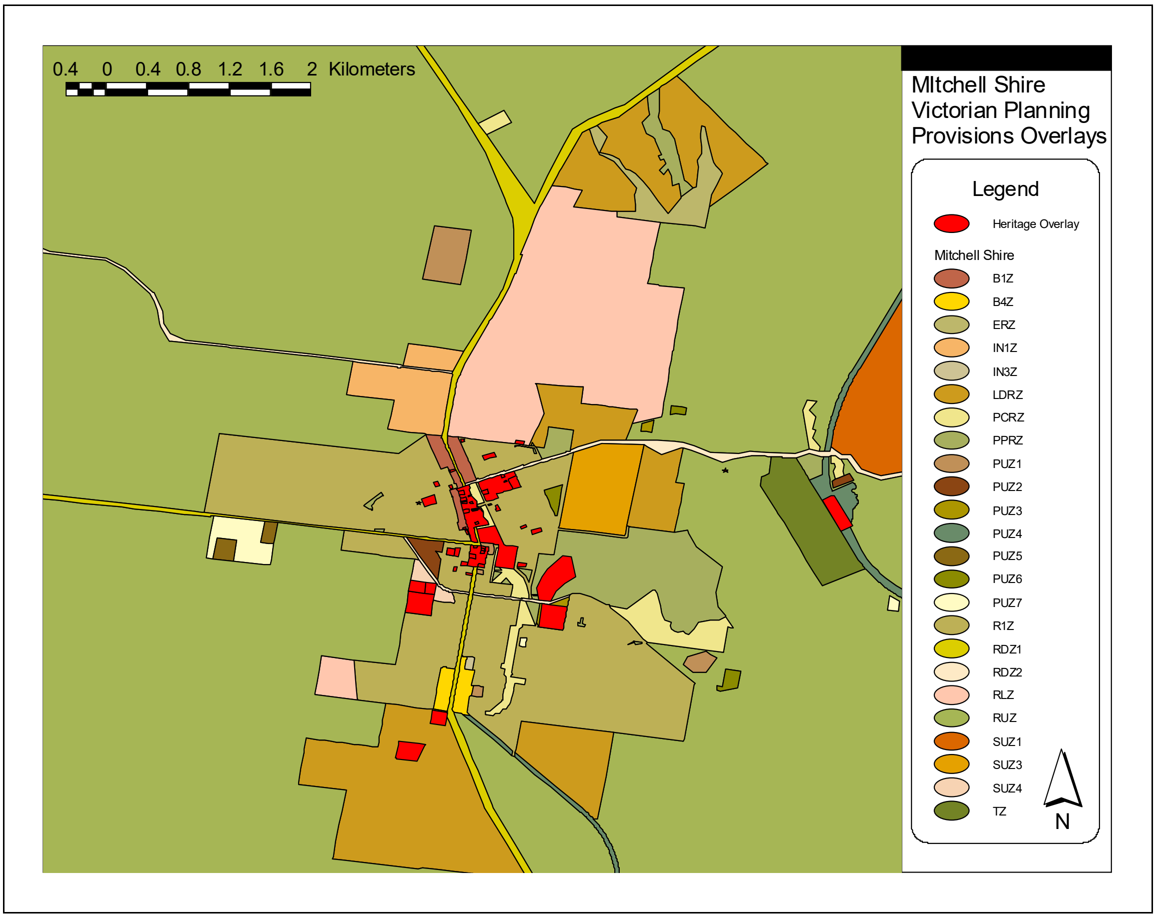


Figure 2-11: Mitchell Shire Zoning GIS Layers, showing the current Heritage Overlay for the town of Kilmore in red with other colours representing various zoning restrictions.

This codified system of planning regulations makes the incorporation of an overlay of archaeological sensitivity relatively simple. However, the requirement to implement an overlay of archaeological sensitivity would need to be implemented as part of the overall State Planning Policy Framework to ensure a unified approach to archaeological zoning across the state. The implementation of an archaeological sensitivity zone overlay within each LGA planning scheme would then need to take place on a shire-by-shire basis, as the zone(s) of archaeological sensitivity are not uniform across the state, and would need to be constructed to reflect the diversity of the local archaeology.

Models, Management and Planning

> 'AAV has doubts about the accuracy of older location information in their sites database. Such information could prove misleading if used as too rigid a guide…AAV is finding it more beneficial to encourage planners to see archaeological sites as a zone or dimension in the landscape…' (du Cros and Rhodes, 1998: 4).

Cultural resource management agencies have become the driving force behind the development of a huge number of predictive modelling projects all over the world. While this trend has been seen as positive by some practitioners and negative by others (Woodman and Woodward, 2002: 22), the pace of the development and the scope of predictive models continue unabated. There are certain issues that need to be addressed in order to determine if the modelling approaches being advocated in particular applications are the most appropriate methods available, or if the development of new methods and techniques has taken precedence over the ultimate aim of conserving the archaeological record. Indeed, many predictive modelling attempts have been derided as 'method in search of theory' (Church, Brandon and Burgett, 2000: 135-155), where it appears that the creator(s) of the model were perhaps more interested in pioneering a new modelling method than ensuring the conservation of the archaeological record.

In order to address the issue of model purpose and the suitability of the methods used to the questions being asked, it is necessary to explicitly recognise the ultimate purpose of the model. Is the model purely a research tool, or is it to be applied in a management context? If the model is to provide data on the approximate location of archaeologically sensitive areas to planners before and during development activities, then the archaeological sensitivity approach is a superior CRM tool. If the desired outcome of the model is principally to generate new research directions or questions (Woodman and Woodward, 2002: 22), then the modelling approach and methods used may be entirely different to the sensitivity method, and entirely unsuited to the CRM purposes highlighted. In administrative environments where the outcomes of any modelling process are oriented towards conservation rather than on-going research questions, as little margin for error and misinterpretation as possible is highly desirable, particularly if the model(s) are to be utilised by non-archaeologists. The archaeological sensitivity method provides planners or cultural resource managers with an immediate 'red flag' (Altschul, 1990) option over sensitive areas, allowing the relevant authority to arrange further archaeological survey or to allow site mitigation to take place.

In this instance, the outcome of this thesis requires that any model developed should be suitable for use by local government authority (LGA) planners. The almost ubiquitous use of GIS in local government means that it is a relatively straightforward process to develop archaeological sensitivity overlays for a required area. Once developed, the layers can be directly incorporated into the relevant LGA's planning scheme as a digital overlay or series of digital overlays.

This chapter introduced the thesis study area, and more specifically its geomorphological, environmental and cultural and archaeological background. The following chapter reviews the extensive cultural resource management literature from the study area.

Chapter Three

3. Cultural Resource Management Surveys

Over the last 25 years, there have been a steadily increasing number of reports and studies devoted to the archaeology or cultural heritage of the Melbourne Metropolitan area. These documents originate for a variety of reasons, are of differing quality and utility, and are utilised by a variety of audiences. As part of this project, 93 reports dealing with the study area and held by Aboriginal Affairs Victoria have been examined (reports completed prior to December 2000). These reports vary in length from a few pages to several hundred, with similar variations in intent, content, and quality. Some are the result of work commissioned by the former Victoria Archaeological Survey (VAS), or Aboriginal Affairs Victoria (AAV). Many others are consultancy reports conducted on behalf of private organizations. In this chapter, I will review and discuss the collection of regional archaeological reports, small-scale studies and consulting reports for the thesis study area.

These reports are relevant to the overall research aims in several ways. Firstly, they are a major source of primary archaeological data. Secondly, one of the required outcomes of this thesis is a review of the quality of the data held by AAV, and these reports are the major source of this data. Thirdly, one of the major academic outcomes of the thesis is the construction of predictive models based predominantly upon this AAV data. Finally, another of the major academic outcomes of this thesis is the writing of a prehistory of the Melbourne region.

A thorough review of the reports was considered necessary. In doing so, it became quite apparent that the little, if any, of the archaeological data produced by consultancies is ever used in the academic world. Indeed, two of the more recent texts on Australian prehistory (Lourandos, 1997; Mulvaney and Kamminga, 1999) contain a combined 1,563 bibliographic references to archaeological papers and associated scholarly documents. Less than 1% (n=14) of these refer to contracted archaeological reports. In other words, despite the vast number of reports completed throughout Australia (the ‘grey literature’) only a tiny proportion are used to write regional or continental prehistories.

3.1. Regional Archaeological Studies

It is essential to offer a brief review of the regional reports before discussing the more focussed and constrained consultant’s reports. The regional studies constitute the ‘templates’ upon which virtually all reports have since been based. These regional reports were all funded by VAS/AAV. The survey projects initiated in the early 1980s by VAS/AAV were directed at addressing the perceived threats to the archaeological record caused through unprecedented urban expansion (Presland, 1983).

The earliest archaeological survey projects for the general region were conducted by Denise Gaughwin (1981), Hilary Sullivan (1981) and Jim Rhoads (1986). Gaughwins' (1981) study area was the 2,000km^2 Westernport Catchment; Sullivans' (1981) study area covered some 70,000 ha of the Mornington Peninsula, while Rhoads' (1986) study covered approximately 50,000 ha of the Bellarine Peninsula. Between the three reports, 637 sites were located and recorded. While these three early reports do not relate directly to the present study area, they are the early benchmark in archaeological survey for the region. The three reports were severely restricted by limited human resources, poor visibility, low survey intensity and very large study areas. Formal sampling methods were not utilised in any of the three projects.

Presland, G (1983)

In 1981, recognising serious threats to the archaeological resource base through rapid urban development, the VAS initiated a pilot study to investigate the archaeology of greater Melbourne. Gary Presland was appointed to undertake the archaeological survey of the Melbourne region (1983). Presland nominated the goals of the project as:

- 'To develop a practical and economical strategy for surveying prehistoric archaeological sites in the area.
- To identify areas of potential archaeological importance in the study area.
- To identify those parts of the study area where survey can be conducted effectively.
- To implement a pilot survey programme and evaluate its effectiveness.
- To prepare comprehensive proposals for future surveys of prehistoric archaeological sites in the study area' (1983: 2).

Presland's study area was extremely large, covering some 374,000 hectares, and included 445 kilometres of watercourses and 72 kilometres of coastline. Presland identified 40 new sites, bringing the total number known in the region to 180.

Presland stratified his study area into five landscape units: -

Unit 1 – Alluvial plains, terraces and the valleys of the Maribyrnong and Yarra rivers.

Unit 2 – Undulating plains.

Unit 3 – Low hills with elevation of less than 100 metres.

Unit 4 – Hills with elevation of between 100 and 300 metres.
Unit 5 – Eastern foreshore of Port Phillip bay.

Presland noted a variety of factors that would affect his survey design (1983:42-47). These impacts or constraints included the immense size of the study area, enormous environmental diversity, the heavily urbanised nature of much of the study area, a general lack of visibility, a shortage of available field assistance, and a shortage of time to complete the project. Presland was aware that even under optimal surveying conditions, and given the six months allocated for fieldwork, he could 'not hope to cover adequately all of the study area'. Presland was forced to resort to a largely opportunistic survey design and field strategy and focus his attentions on areas that he regarded as having a suitable level of surface visibility.

Presland's survey located 40 previously unrecorded sites – 27 surface scatters, 12 scarred trees, and a freshwater shell midden. Presland spent a total of 76 days in the field, largely surveying alone. This duration in the field makes this the longest running survey yet to take place in the region. He did not record isolated artefact occurrences, and he collected only 107 artefacts. This collection was intended to enable Presland to investigate regional patterning, although the sample size was simply too small to allow such an analysis. Despite the length of time in the field, Presland only recorded 111 artefacts from all landscape units. This very small number could be a function of either visibility, or a lack of staff in the field, or prior activities of collectors. Presland concluded that the data collected 'point to at least a general use by Aborigines of all parts of the study area' (1983:69) and that further research should be initiated (1983:92). Presland recognised that the huge task of trying to survey 3,740 square kilometres was always going to be problematic – it was simply too large an area, and recommended that any future studies should have at least four field crewmembers and that much smaller areas should be tackled (1983:93).

du Cros, H (1989)

The Western Region survey is the second stage of the survey program initiated by Presland's study. The project was supervised by the Victoria Archaeological Survey, which provided Hilary du Cros with equipment, vehicles and logistical support. The Victorian Government nominated du Cros' study area as a residential growth-corridor; and as such, the aim of the study was to investigate the Aboriginal archaeology of the

Western Plains before urban expansion. du Cros'165-page report details the results of 32 days of archaeological fieldwork conducted between the Werribee River and the Calder Highway in 1989. du Cros and her field assistants located 96 previously unrecorded sites. It is not clear how many individuals actually participated in the survey, but three names are included as being volunteers for at least part of the time. du Cros recorded 916 stone artefacts in 57 scatters, 9 scarred trees, 4 in-situ exposures, 2 sets of axe-grinding grooves, one stone arrangement, one freshwater shellfish midden, a contact period campsite and 21 isolated artefacts. The assemblage recorded by du Cros contained silcrete (48.7%), quartz (32.7%) and quartzite (13.4%). Other materials accounted for 4.7% of the total material analysed. The artefact types recorded for this study included formal tools (8.4%), flakes (47.3%), flaked pieces (36.8%) and cores (7.5%).

du Cros notes that the survey area was not 'intensively surveyed due to its size' (1,349 km^2) (1989: 31). du Cros utilised a stratified non-random sample of some 1,312 hectares within the study area to constitute a 'representative sample'. This sample was selected from within the four main geomorphic units of the study area – 617 hectares of volcanic plains, 384 hectares of water frontages (creek lines), 285 hectares of hills, and 26 hectares of mountain ranges. du Cros non-randomly selected '89 survey sample units' (1989: 32) from within these four geomorphic units. This non-random sampling strategy was considered a necessity to 'minimise the effects of poor visibility in some areas by choosing open eroded areas' (1989: 32).

Since 1989, the content and structure of this report has become the unofficial benchmark in Victorian archaeological survey reporting. There are great similarities between this report and most that have followed. Indeed, of the 84 contracted archaeological reports reviewed for this project, just over half (45) were completed by du Cros and Associates. Spennemann (1995) noted that du Cros and Associates had completed 46.8% of survey reports during a review conducted for the year 1993.

From fieldwork experience and the type of sites recorded, du Cros (1989) developed a series of predictive statements for the western region, which she numbered as follows:

1. 'Burials, artefact scatters, isolated artefacts, and scarred trees will be found on river or creek flats, terraces or slopes within 100 metres of a major water course.
2. Artefact scatters are also likely on points of vantage such on the volcanic plains, such as eruption points (or extinct volcanoes or rises).

3. Artefact scatters; isolated artefacts and scarred trees are likely to be found close to large or permanent swamps and lakes on the volcanic plains.
4. Sources or outcrops of silcrete and metamorphic stone are likely to have been quarried by Aboriginal people if they were exposed more than 150 years ago.
5. Shell middens are likely along the terraces of major rivers (i.e. Little River and Werribee River) in places where no ploughing or disturbance has occurred.
6. Stone arrangements are likely in areas, which have suffered little in regard to rural activity in the west of the study area. These areas are also likely to contain well-preserved examples of artefact scatters, quarries, and other archaeological sites that have not been disturbed by ploughing or clearing.
7. Axe grinding grooves are likely elsewhere in the Werribee Gorge and possibly in nearby sandstone areas dissected by creeks.
8. The ridge tops of the mountain ranges and saddles in particular where people could travel over the ranges are the most likely places for sites. Any water sources such as local springs, soaks, major rivers and creeks are the most probable places for site occurrence.
9. Sites with extensive sub-surface archaeological deposits containing burials, hearths, faunal remains, and artefacts are likely in the areas with the best preservation. That is, in some sections of the major rivers where material has been covered by successive deposits of alluvium and in caves or rock shelters where soil is preserved from surface erosion.
10. Contact sites are most likely to be located close to old homesteads or provisioning points. However, it is not unlikely that some Aboriginal groups wanting to avoid European contact camped away from these places in remote or isolated places' (du Cros, 1989a: 69)

du Cros, H. (1990)

This archaeological study follows on from du Cros' 1989 Western Region study. The major difference between the two studies is the extent of the area surveyed. In this project, du Cros non-randomly sampled 45 km^2 between Kororoit Creek and the Maribyrnong River, selecting 192 hectares (4.2% of study area) for survey. du Cros and Annette Xiberras conducted the survey over a 5-day period, recording 19 previously unrecorded sites to add to the 40 sites previously recorded in the Sydenham corridor area. The 19 new sites recorded during this survey consisted of 15 artefact scatters, two isolated artefacts, one quarry and one eroding exposure in a creek bank. From these 19 sites, du Cros analysed 252 artefacts. Flakes and flaked pieces dominated the assemblage (85.3%), the remainder being 12 formal tools (4.7%) and 25 cores (9.9%). Silcrete was the dominant raw material (61.5%), followed by quartz (26.5%), quartzite (5.1%) and other materials (3.1%), including eight glass artefacts.

du Cros (1990) included a 'cut-down' version of the predictive model discussed in the Western Region study of 1989. Instead of a ten-point model, the one offered in this report is a smaller, six-point version, listing only Points 1,3,4,5,9 and 10 from the 1989 Western Region model. du Cros goes on to comment that the 'Western region site prediction model was tested successfully during the fieldwork, despite poor visibility in some areas. Sites occurred in much the same general locations as predicted' (1990:29). The area surveyed for this report has undergone intensive development since this report was prepared.

du Cros, H. (1991)

This third regional report by du Cros concentrated on the area known as the Werribee growth corridor, an area of about 210 km^2 surrounding the township of Werribee. The area is geologically and geomorphologically similar to the areas studied in both of the preceding du Cros reports. Here she sampled approximately 1.07% of the study area (225 hectares) using a non-random stratified method, over a period of ten days. Thirty previously unrecorded sites were located. These sites included 12 artefact scatters, 11 isolated artefact occurrences, three scarred trees, two exposures, one stone arrangement and one 'other' site type. du Cros analysed 231 artefacts during the course of this study. There were 11 formal tools (4.8%), 119 flakes (51.5%), 86-flaked pieces (37.2%) and 15 cores (6.5%). The raw materials were quartz (40.0%), quartzite (28.0%), silcrete (28.0%), glass (0.55%) and 'other' (3.5%). The western region predictive model is once again utilised in this report, with points 1,2,3,5,6,9 and 10 from the original Western Region Report (du Cros, 1989) included verbatim.

Ellender, I. (1991)

Although not strictly within the study area for this project, the area covered during Ellender's (1991) survey falls just outside the eastern boundary of the study area, and so was included in this review. Ellender surveyed 104 hectares during this project, locating 70 previously unrecorded sites. These sites were 16 artefact scatters, 20-scarred trees, 33 isolated artefacts, and an historic Aboriginal grave. Ellender analysed 382 artefacts of which 36.1% were made on chert, 31.4% on quartz, and 29.3% on silcrete. Artefact types recorded included flakes (33.7%), cores (6.2%), blades (5.2%), scrapers (3.4%), and fragments (49.7%).

Approximately 1.1% of the study area was surveyed, with visibility averaging less than 20% for the entire survey. The survey area was selected using a stratified non-random method. The study area was divided into five 'landscape units' from information contained in available regional maps. There is no elaboration on how the individual areas to be surveyed were selected from the study area, other than commenting that areas with less dense vegetation cover were selected from aerial photographs. Ellender (1991) concludes by acknowledging the limitations of this survey particularly in regards to visibility constraints.

3.2. Summary of Regional Reports

The five regional reports summarised represent the collective efforts of archaeological surveying funded by VAS/AAV in, or very near, the study area. Virtually every subsequent survey in the region has been based upon these 'baseline' surveys. Despite the limitations of these reports (i.e. visibility constraints), they represent a valuable source of information to be incorporated into any models developed for the region. The data in Table 3-1 (below) revels that 35.1% of all sites were located within major rivers and creeks landform. 92.7% of all sites located in these five reports were either artefact scatters, scarred trees or isolated artefact occurrences.

Two hundred and thirty-four sites were recorded during these surveys, in numerous landform types, and with differing visibility conditions. These 234 sites were reported as new discoveries, however it is not clear from the reports if previously recorded materials were re-recorded or re-located. The extent to which previously recorded data was incorporated into these reports is also unclear. Four of the reports list known sites before the relevant fieldwork, but do not provide any further information. Presland (1983) mentions that some sites were revisited and re-recorded, but does not quantify this data.

It is only possible to ascribe a visibility figure to eleven of the observed site occurrences in Table 3-1. Five of the site recording occurrences do not have an estimate of visibility for the particular landform element or site area in which the recording took place. As such, the visibility figures are not particularly useful as a means of estimating any parametres for the other areas where visibility figures were not given. Table 3-1 shows that over a third of all sites occurred in the 'major rivers/creeks' landform class. There is every possibility that the landform classes 'gorge' 'valley' and 'alluvium' are also features in the river or creeks category but have been given a different name by the relevant recorder. Figure 3-1 shows the percentage of sites recorded in each of the identified landforms.

	Regional Survey																													
	Presland (1983)					Du Cros (1989)					Du Cros (1990)					Du Cros (1991)					Ellender (1991)					Total				
Landform	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	Total Sites
Major Rivers/Creeks	0	0	0	0	0	32	3	0	6	35	13	0	1	2	?	11	7	3	4	15	0	0	0	0	0	56	10	4	12	82
Sedimentary	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	5	17	1	24	9	5	17	1	32
Volcanic Plains	0	0	0	0	0	15	4	0	1	45	1	0	2	0	?	1	0	4	0	15	0	0	0	0	0	17	4	6	1	28
Undulating Plain	18	4	5	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	4	5	0	27
Gorge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2	10	0	30	6	2	10	0	18
Hills/Uplands	0	0	0	0	0	9	2	0	2	45	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	9	2	2	2	15
Basalt Plains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	3	0	4	0	11	3	0	14
Flat Plain	4	6	0	1	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	6	0	1	11
Alluvium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	24	1	2	0	0	3
Low Hills	0	2	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Mountain Ranges	0	0	0	0	0	1	0	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Valley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1
Totals	22	12	5	1		57	9	0	9		14	0	3	2		12	7	7	4		17	20	32	1		122	48	47	17	234

Table 3-1: Summary of sites found in each of the landform types mentioned in the five regional reports. Key: AS = Artefact Scatter, ST = Scarred Tree, IAO = Isolated Artefact Occurrence. Other site types and % Visibility are self-explanatory.

Material	Sydenham	%	Werribee	%	Western Region	%	Melb. Metro	%	Plenty Valley	%	# Artefacts	Overall %
Silcrete	155	61.51	65	28.14	447	48.80	70	63.06	112	29.32	849	44.87
Quartz	67	26.59	92	39.83	300	32.75	0	0.00	120	31.41	579	30.60
Quartzite	13	5.16	65	28.14	122	13.32	0	0.00	0	0	200	10.57
Chert	0	0.00	0	0	0	0	26	23.42	138	36.13	164	8.67
Glass	8	3.17	1	0.43	19	2.07	0	0.00	0	0	28	1.48
Other	9	3.57	8	3.46	28	3.06	15	13.51	12	3.14	72	3.81
Total	252	100	231	100	916	100	111	100	382	100	1892	100
Tool Type	Sydenham	%	Werribee	%	Western Region	%	Melb. Metro	%	Plenty Valley	%	# Artefacts	Overall %
Formal	12	4.76	11	4.76	77	8.41	20	18.02	20	5.24	140	7.40
Flakes	104	41.27	119	51.52	433	47.27	8	7.21	129	33.77	793	41.91
Flaked Piece	111	44.05	86	37.23	337	36.79	0	0	0	0	534	28.22
Core	25	9.92	15	6.49	69	7.53	7	6.31	24	6.28	140	7.40
Scraper	0	0	0	0	0	0	0	0	13	3.40	13	0.69
Fragment	0	0	0	0	0	0	76	68.47	190	49.74	266	14.06
Other	0	0	0	0	0	0	0	0.00	6	1.57	6	0.32
Total	252	100	231	100	916	100	111	100	382	100	1892	100

Table 3-2: Table summarizing the artefact analysis from the five major regional studies conducted in or near Metropolitan Melbourne. These figures are all derived directly from the reports themselves, and as such will contain any errors from the original recording programs.

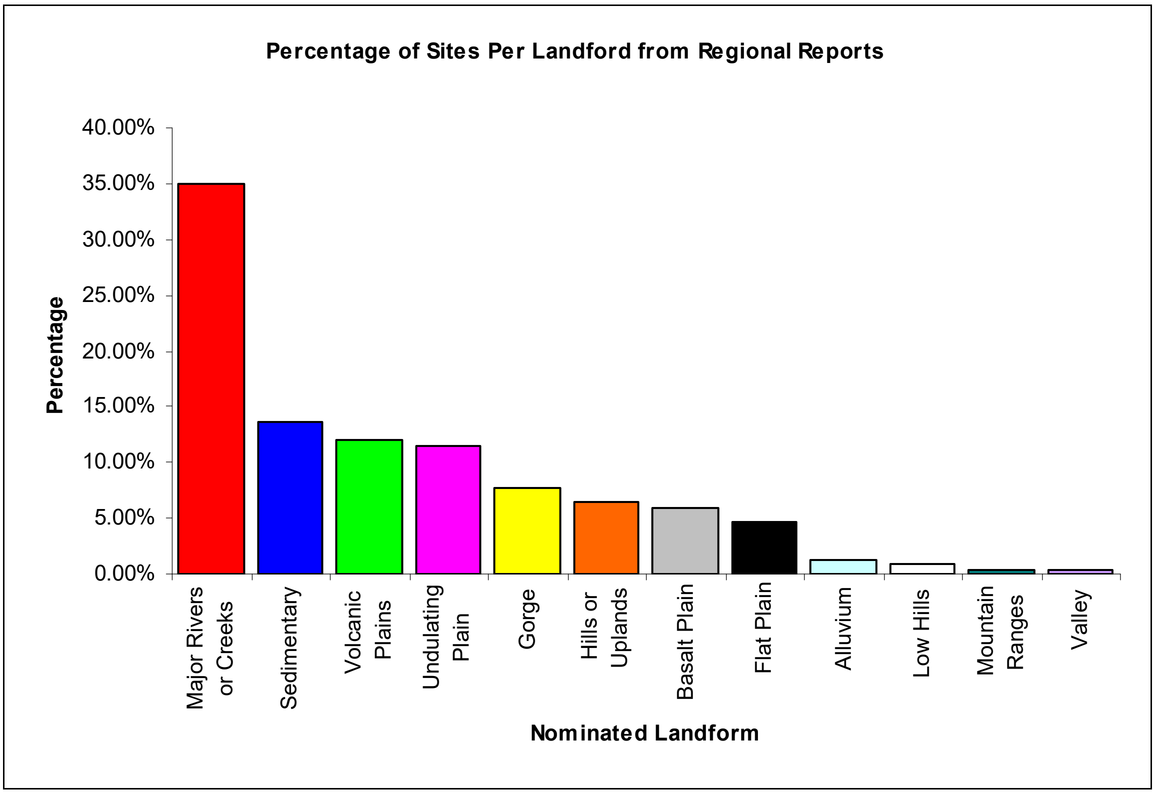


Figure 3-1: Percentage of sites per landform class collated from the five major regional survey reports.

	Regional Survey																	
	Presland (1983)			Du Cros (1989)			Du Cros (1990)			Du Cros (1991)			Ellender (1991)			Total		
Landform	Area Available (km2)	Area Surveyed (km2)	% Surveyed	Area Available (km2)	Area Surveyed (km2)	% Surveyed	Area Available (km2)	Area Surveyed (km2)	% Surveyed	Area Available (km2)	Area Surveyed (km2)	% Surveyed	Area Available (km2)	Area Surveyed (km2)	% Surveyed	Area Available (km2)	Area Surveyed (km2)	% Surveyed
Major Rivers/Creeks	0	0	0	107.5	3.8	3.6	4.5	0.7	16.0	60.0	0.9	1.5	0	0	0	172.0	5.4	3.2
Sedimentary	0	0	0	0	0	0	0	0	0	0	0	0	23.8	0.4	1.7	23.8	0.4	1.7
Volcanic Plains	0	0	0	945.0	6.2	0.7	40.5	1.1	2.7	150.0	1.4	0.9	0	0	0	1135.5	8.7	0.8
Undulating Plain	1025.0	201.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	1025.0	201.8	19.7
Gorge	0	0	0	0	0	0	0	0	0	0	0	0	6.8	0.2	3.0	6.8	0.2	3.0
Hills/Uplands	247.0	65.4	0.3	143.5	2.9	2.0	0	0	0	0	0	0	14.8	0.1	0.5	405.3	68.3	16.9
Basalt Plains	0	0	0	0	0	0	0	0	0	0	0	0	22.0	0.3	1.4	22.0	0.3	1.4
Flat Plain	1051.0	161.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	1051.0	161.5	15.4
Alluvium	0	0	0	0	0	0	0	0	0	0	0	0	17.0	0.1	0.4	17.0	0.1	0.4
Low Hills	1301.0	153.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	1301.0	153.2	11.8
Mountain Ranges	0	0	0	152.5	0.3	0.2	0	0	0	0	0	0	0	0	0	152.5	0.3	0.2
Totals	3624.0	581.9	0.8	1348.5	13.1	6.4	45.0	1.8	18.7	210.0	2.3	2.4	84.3	1.0	6.9	5311.8	600.1	-

Table 3-3: Total study area, area sampled and actual percentage surveyed from the five regional reports. Approximately 11.3% of the total area available for the relevant study areas was claimed to have been surveyed.

The data presented in Table 3-2 provides a summary of the artefacts recorded and analysed as an integral part of the major regional studies. This table clearly shows that there is diversity in raw material types present in the different assemblages across the region in question. There are some doubts, however, about the raw material category ‘chert’. This material may in fact be a form of silcrete that has been erroneously recorded as ‘chert’ or sometimes as quartzite (Webb, 1995). Nevertheless, silcrete is still the dominant raw material in the assemblages, accounting for nearly half of all recorded artefacts (44.9%). Quartz (30.6%) and quartzite (10.6%) also feature predominantly in the assemblage. The raw material ‘chert’, which may be misreported as mentioned above, accounts for 8.7% of material recorded. Glass appears in three out of the five surveys, and accounts for 1.5% of the total. The remaining 3.8% is all ‘other’ material types recorded during the survey projects (i.e. mudstone or ochre). None of the reports indicates what sampling procedure (if any) was used when selecting the artefacts for analysis from the lithic materials located during the field surveys.

Table 3-3 shows the breakdown of areas surveyed for the five regional reports. Approximately 600 km^2 was reported to have been surveyed (11.3% of the total area) but the actual amount of land physically inspected is much less than the claimed 600 km^2. When allowance is made for variables such as visibility the actual area surveyed could be as little as 10% of the 600 km^2. Interestingly, the major rivers and creeks landform is underrepresented in the total of areas surveyed (3.2%), while it is the landform in which 35.1% of sites were located.

In these reports, there is some variance in the percentage quantity of each raw material recorded. For instance, in the Sydenham Corridor study du Cros (1990) recorded that 61.5% of the assemblage was made on silcrete; while Ellender (1991) recorded that 29.3% of the Plenty Valley assemblage was made on silcrete (if the chert figures are added to the silcrete figures, then the silcrete total would be 65.4%). Quartz varies between 0% of the Melbourne Metropolitan survey (Presland, 1983) to 39.8% of the Western Region Melbourne Metropolitan study (du Cros, 1989). Quartzite also varies between 5.2% and 28.1% of the relevant assemblage. The raw material distribution is comparatively uniform across the areas represented by these five studies, particularly when the potential problem of correctly identifying silcrete is taken into account (Webb 1995). Presland’s (1983) raw material classifications for the Melbourne Metropolitan area may also be erroneous. Presland (1983) records no quartz or quartzite in the material he recorded, while silcrete (63.1%), chert (23.4%) and 'other' (13.5%) are recorded. Four out of the five regional surveys record that quartz was present, while three out of five record that quartzite was present in the various assemblages.

The total assemblage of 1,892 artefacts has been placed into a series of typological categories used by the report authors. Formal tools include geometric microliths, backed blades and scrapers (Presland, 1983), while blades are generally defined on morphological characteristics, as being a piece twice as long as wide. The data from Table 3-2 shows that the number of formal tools recorded is generally quite low, accounting for only 7.4% of the overall total. The proportion of formal tools on each survey ranges from 4.8% in the Sydenham and Werribee reports to 18.0% for the Melbourne Metropolitan area survey. Material defined simply as 'flakes' constitutes the largest single artefact category, accounting for 41.9% of the total assemblage. The proportion of 'flakes' ranges from 7.2% in Presland's Melbourne Metropolitan Study to 51.5% in the Werribee Corridor study (1991). 'Flaked Pieces' are the next most numerous of the artefact categories, accounting for 28.2% of the total. 'Flaked Pieces' ranges from 0% in the Melbourne Metropolitan and Plenty Valley studies to 44.0% in the Sydenham Corridor study. 'Cores' account for 7.4% of the total, and are in generally consistent numbers throughout the five regions surveyed. Ellender recorded the only occurrences of the artefact category 'scrapers'. These 13 scrapers represent only 0.7% of the total. The other four studies either recorded scrapers as formal tools, or did not record any of this artefact type. The remainder of the assemblage is mostly described as 'fragments'. This category includes those pieces recorded in the field that were considered to be flaking debris or débitage. This category accounts for 14.1% of the total. Although it is unclear exactly what the category 'other' represents, this category accounts for the remaining 0.3% of the total assemblage. Variance in the composition of the assemblages may also be the result of individual sampling biases or the result of prolonged amateur artefact collectors removing particular classes of materials from sites.

The assemblages described here are a combination of the work carried out for five different field surveys conducted by three different archaeologists and various assistants. Although there will be inherent differences in these results – simply because such as range of individuals has been involved – the assemblage shows reasonable homogeneity across the Melbourne region. Although there are some differences in the structure of the individual assemblage samples, these differences appear largely superficial. The main source for the apparent variation may simply be the differences in raw material identification between the relevant archaeologists as discussed by Webb (1995).

3.3. Major Consulting Reports

While the regional reports discussed above were conducted as commercial activities, they were fully funded by VAS or AAV, and not by a third-party client, such as a developer. As such, these projects were not conducted under the same type of commercial pressure that applies to the non-VAS/AAV funded reports that are described below, and which constitute the second major source of archaeological information for the region. These reports are most often conducted at the instigation of a non-archaeological proponent, such as a local council, land management agency or developer. Consultant archaeologists carry out the archaeological survey and reporting on behalf of the relevant client. These activities are not funded by AAV, and there are minimum reporting standards to which consultants are asked to comply. These reports are not subject to peer review or editorial input from AAV (Stewart Simmons, Personal Communications, 2000). There is hiatus of some 13 years between the first two reports in this section. This is because no major commercial survey appears to have taken place in the current study area between 1977 and 1990. There are many minor surveys that were undertaken, and these are addressed in the minor consulting reports section below.

Bell and Presland (1977)

This short report was one of the very earliest archaeological surveys conducted in the region. It outlines the results of a small-scale opportunistic survey conducted in the area now known as 'Brimbank Park'. Bell and Presland (1977) recorded 12 sites within the park environs (nine scarred trees and three artefact scatters), noting that visibility was uniformly poor (0-10%). The authors note archaeologically 'sensitive' areas within the park as being (a) the edge of the basalt plain (escarpment) and (b) the confluences of creeks or rivers.

Rhodes, D (1990)

This survey aimed to provide information regarding areas of 'archaeological sensitivity' within the boundaries of the City of Keilor. Rhodes opportunistically sampled 12 areas that were under imminent development pressure. Within these 12 areas, Rhodes recorded 12 new archaeological sites. These sites consisted of three artefact scatters, four isolated artefacts, four quarries and one scarred tree. During the course of the survey, Rhodes noted that visibility conditions were consistently poor. Rhodes also noted that the quarries are located on the incised river valley slopes. Rhodes constructed five generalized predictive statements regarding the archaeology of the upper Maribyrnong Valley, which generally concur with those proposed by du Cros (1989). The predictive statements proposed by Rhodes limit site occurrence to the incised river valleys common throughout the region, and the junction of the basalt plain and these valleys – the escarpment (1990:46). Rhodes concludes that 'there is a greater range of sites occurring in the incised valleys. This and the higher number of sites occurring in the valleys may suggest that there was more intensive Aboriginal land use in these areas, largely associated with quarrying activities. The limited range of sites on the plains…and their close proximity to water in most cases indicates a series of transient short-term campsites' (1990:43).

Sutherland and Richards (1994)

This well-constructed report outlines an archaeological survey conducted in the Shire of Bulla. The authors opportunistically sampled approximately 200 ha of the shire, locating 20 previously unrecorded sites (10 artefacts scatters and 10 isolated artefacts). This report includes a comprehensive discussion of the various archaeological survey methodologies appropriate for regional or large-scale surveys. Although the authors chose to opportunistically sample their study area, they note that the use of such biased survey strategies is inherently problematic. Sutherland and Richards conclude that 'biased survey sampling, [the] uncritical acceptance of unproved predictive modelling results, [and the] absence of standardised archaeological practice, especially evident in the content of reports' are all causal factors in the archaeology of the area being 'best described as poorly known' (1994: 28-29).

Brown and Lane (1997)

This comprehensive CRM document includes an outline of an archaeological field survey covering approximately 64 hectares near Keilor. The Brimbank City Council local government area (LGA) included Brimbank Park (the former Maribyrnong Valley Park), and parts of the Organ Pipes National Park (the Green Gully burial site is located within Brimbank Park). Brown and Lane (1997) opportunistically sampled 10 separate locations within the City of Brimbank LGA during nine days of field survey. Brown and Lane (1997) located 27 previously unrecorded sites, consisting of six artefact scatters and 21 isolated artefacts. The authors note that visibility was generally poor throughout the areas surveyed, and that deep 'cracking' of clay soils within the region may result in the downward movement of stone artefacts into these cracks. The effects of this phenomenon are poorly understood in the region (1997:40). Brown and Lane (1997) generally adhere to the du Cros (1989) model of site distribution in this study. The authors predict that the areas of greatest archaeological potential will be located within the incised valleys of the major rivers and creeks. They conclude however, that ‘as with many surveys in the region before the present study…the survey areas are biased towards the river and stream valleys in comparison to areas of volcanic or basalt plain’ (1997:41).Figures 3-3 and 3-4 present the artefact raw material and type data for Brown and Lane’s (1997) study.

Large Area Consulting Reports																									
	Bell and Presland (1977)					Rhodes (1990)					Sutherland and Richards (1994)					Brown and Lane (1997)					Total				
Landform	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%	AS	ST	IAO	Other	VIS%
Alluvium/ Terrace	2	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	-
Basalt Plains	1	0	0	0	25	1	0	1	0	20	0	0	1	0	?	0	0	1	0	5	2	0	3	0	-
Major River/Creek Valleys	0	9	0	0	10	4	0	2	4	20	10	0	9	0	?	11	0	17	0	20	23	9	28	4	-
Totals	3	9	0	0	-	5	0	3	4	-	10	0	10	0	?	11	0	18	0	-	27	9	31	4	-

Table 3-4: Summary of results from the four major consulting reports conducted in the study area. The landform categories from the Sutherland and Richards (1994) report were simplified for the purposes of analysis. The original report made use of three sub-categories for the Major River and creek valley class. These three were combined into one category.

The major consulting reports outlined above are more management-oriented documents than the regional reports, and as such have no significant research intent. Table 3-4 presents the quantifiable data from these reports. These four reports documented comparatively few sites – 71 in total, compared with 234 sites from the regional reports. The major limitation in using the data collated from these reports is the lack of quantification of visibility. While all authors discussed visibility, the manner in which these data are presented renders it impossible to extract comparable information. Describing visibility as 'good' or 'bad' or between'0% and 80%' is inadequate. Of similar concern, only Brown and Lane (1997) provided a section detailing the assemblages identified and recorded during their survey. The artefact and raw material data from this report is presented below. The figures given by Lane and Brown (1997) are a sample of the total assemblage, and not the entirety of material present at each recorded site. The method of sampling the assemblages used by Brown and Lane (1997) is unknown. Figure 3-2 shows the distribution of the recorded sites per landform identified.

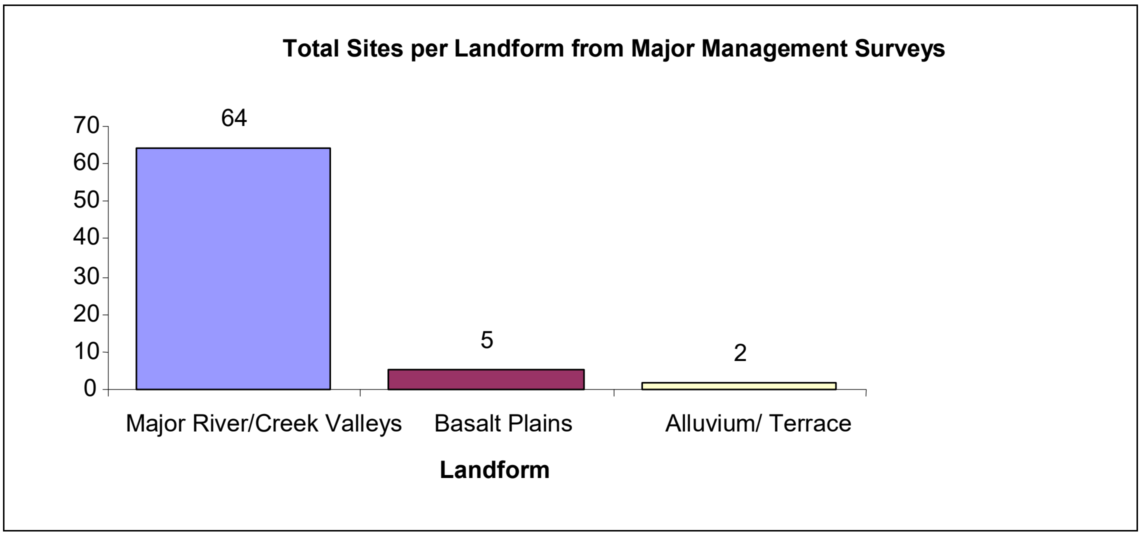


Figure 3-2: Sites per landform from the major management oriented survey reports for the study area.

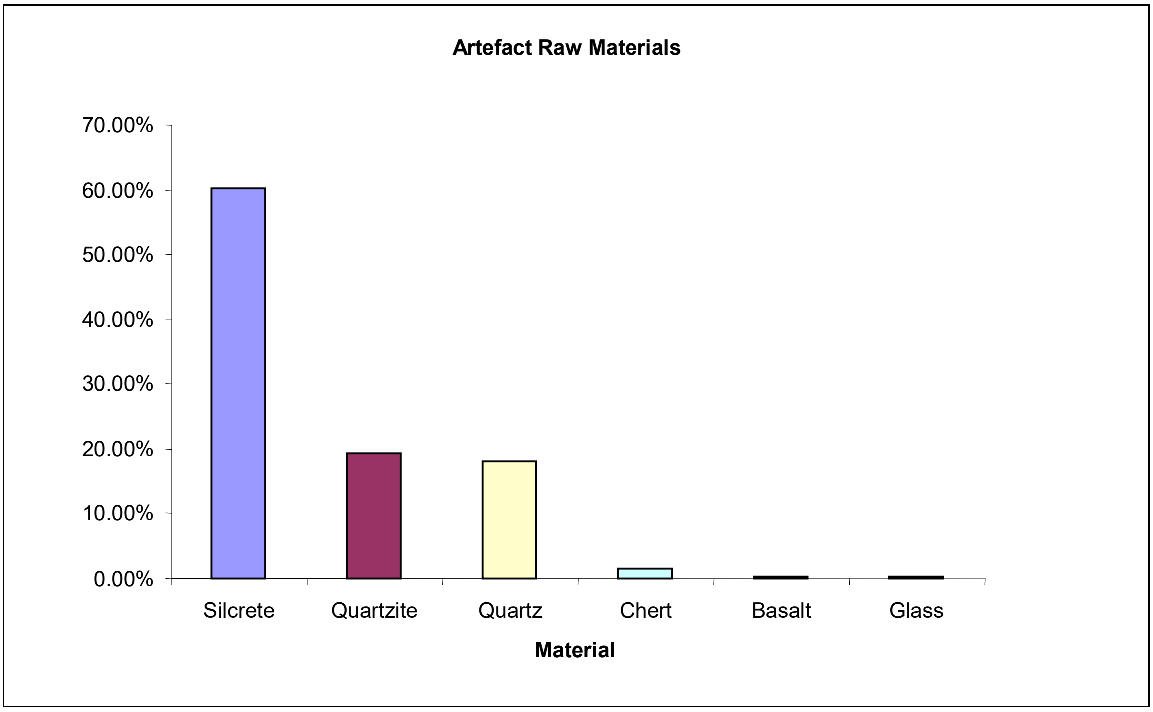


Figure 3-3: Raw material analysis from Brown and Lane (1997). Silcrete dominates the assemblage recorded during this survey (n=559).

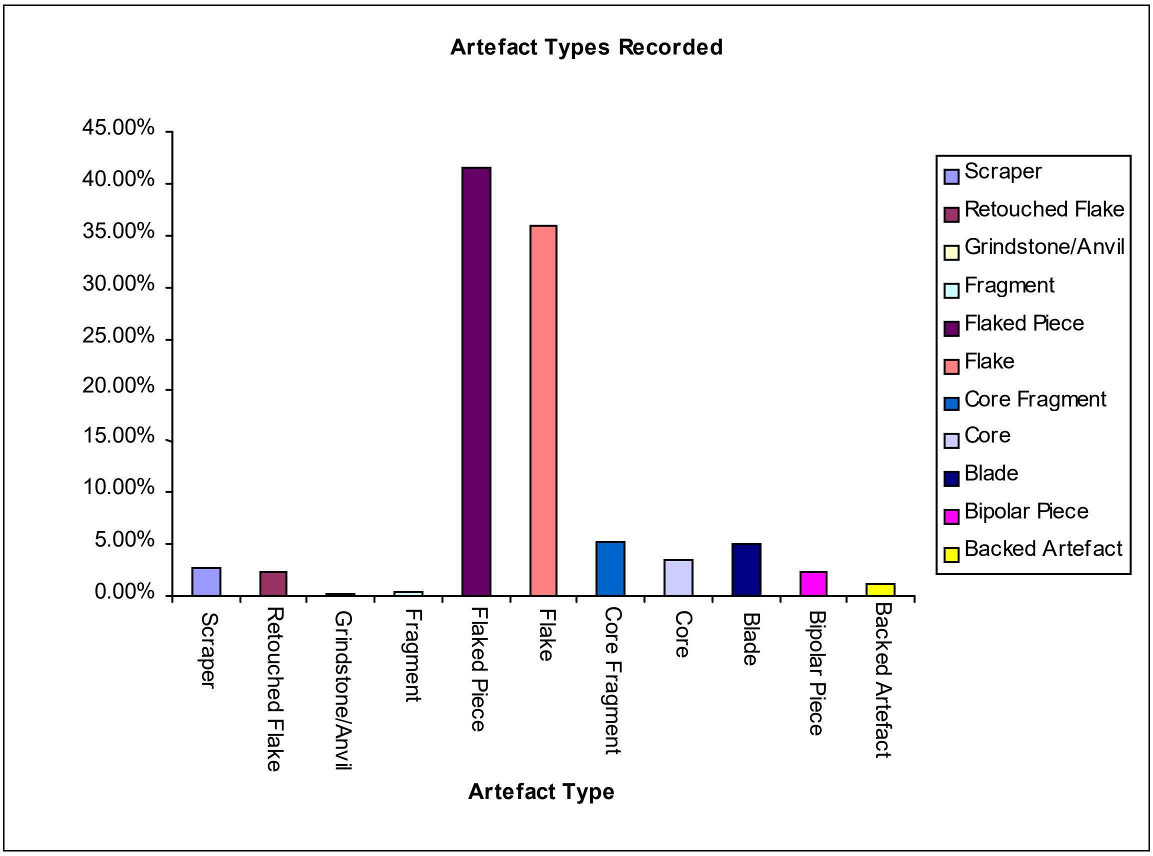


Figure 3-4: Artefact analysis from Brown and Lane (1997). Flakes and Flaked Pieces dominate the assemblage recorded during this survey (n=441).

Minor Consulting Reports

Eighty-Four smaller consulting projects have been carried out in the study area before December 2000. These smaller reports tend to be surveys conducted before land altering development, and are carried out by consulting archaeologist(s) on behalf of a client. Not all reports completed in the study area have been reviewed for this section. Some have been reviewed elsewhere in this thesis, while others were excluded completely. Desktop studies (i.e. contained no actual field survey component) were excluded from the analysis. The material presented here has been tabulated from the eligible reports. These reports may be considered as a 'primary' data source. The selection criteria for reports were straightforward. All those reports for the study area containing archaeological fieldwork components that were not reviewed in previous sections are included in the following analysis.

Numerous firms, individuals and associations of individual practitioners completed the 84 reports. The various individuals and groups responsible for the completed reports are shown in Table 3-5 (below).

Report Author/Firm	Number	% of Total
Biosis Pty Ltd	3	3.6
Brennan G, and Marshall, B	1	1.2
Brennan, G	2	2.4
Clark, N	2	2.4
du Cros and Associates	45	53.6
Fullagar, R	1	1.2
Hall, R	1	1.2
Kinhill Pty Ltd	1	1.2
Marshall, B	4	4.8
Marshall, B and Webb, C	1	1.2
Muir, S and Newby, J	2	2.4
Murphy, A	1	1.2
Richards, T and Sutherland, P	1	1.2
Schell, P	1	1.2
Vines, G	7	8.3
Vines, G and Ward, G	1	1.2
Weaver, F	7	8.3
Webb, C	2	2.4
Xiberras, A	1	1.2
Total	84	100

Table 3-5: Firms or practitioners responsible for the completion of survey reports in the thesis study area. du Cros and Associates has completed the overwhelming majority of survey reports (53.6%).

Of all of those involved in the completion of survey reports for the thesis study area, du Cros and Associates have been by far the most prolific, completing over half (45). As noted above Spennemann (1995) reported a similar figure for du Cros and Associates

(46.9%) when he analysed one years (1993) worth of Victorian consulting reports held by AAV. Ironically, du Cros' (2002) recent book on Australian archaeology makes no mention or use of her extensive consulting work conducted throughout the Melbourne region.

Sites Recorded

597 sites were recorded in these 84 reports (Table 3-6).

Site Type	Number	%
Artefact Scatters	255	42.7
Isolated Artefact	292	48.9
Other	22	3.7
Scarred Trees	28	4.7
	597	100

Table 3-6: Table showing the breakdown of the 597 sites recorded in 82 small consulting reports between 1988 and 1998. These small-scale reports were all conducted within the study area of this thesis. The category 'other' includes the small number of less common site types that I have classified in this thesis as Site Type 3.

Artefact data was not provided in 37 of the 84 reports (44%), while the remaining 56% of reports provided at least basic artefact data on each site or site type located during the respective survey.

The average duration of fieldwork for the various projects was 2.44 days. The average number of people involved in each study was 2.11, and the average number of sites recorded by each study was 7.1. Each report averages approximately 52 pages. The average study area size from the 84 reports is approximately 49,040 hectares, however, this is heavily skewed by two reports that have a total study area of 2,520,000 hectares between them. If these two reports are disregarded, the average study area is reduced to 602.32 hectares per report. This is the average study area calculated by dividing the total area calculated from the reports (30,116.2 hectares) by the number of reports (50). As such, it is not a true reflection of the real average report area, as thirty-two of the reports do not state the actual extent of the area being examined (38.1%). The median survey area (again disregarding the two larger surveys mentioned above) is 40 hectares.

Claimed Coverage %	N	%
0.17%	1	1.2
1.00%	2	2.4
1.07%	1	1.2
3.0%	1	1.2
5.0%	4	4.8
14.0%	1	1.2
50.0%	1	1.2
70.0%	1	1.2
100.0%	11	13.0
Not Stated	61	72.6
Total		100

Table 3-7: The percentage of claimed coverage from the reports where this was provided. 72.6% of reports did not provide this data.

Only 23 of the reports include a calculation of the actual percentage of ground physically surveyed. Interestingly, 11 of the reports indicate that the authors claimed to have surveyed 100% of the study area. It should be noted that the 11 reports mentioned here have an average study area of approximately 52 hectares, and the authors spent an average of 1.7 days in the field with 2.3 people — making 100% coverage extremely unlikely (see Table 3-7).

The manner in which visibility was recorded across the 84 reports differed so widely that it is impossible to quantify visibility to any meaningful degree. Ideally, visibility data from each of the reports should have been tabulated in a manner that allowed direct comparison between the reports and report areas. For example, a simple quantification of the square metres surveyed and the visibility per square metre would allow such a direct comparison. Each report should ideally provide a tabulation of the total area surveyed in square metres, an estimate of the percentage of ground surface visibility per square metre, the number of sites located in each of the visibility ranges, and the landform upon which the sites were located. For example, see Table 3-8.

Landform Type	Area Surveyed (M^2)	Visibility Range (%)	Actual Area Surveyed (M^2)	Sites Located	Site Type
Basalt Plains					
		0-10			
		10-20			
		20-30			
		30-40			
		40-50			
		50-60			
		60-70			
		70-80			
		80-90			
		90-100			
Total					
Incised Valleys					
		0-10			
		10-20			
		20-30			
		30-40			
		40-50			
		50-60			
		60-70			
		70-80			
		80-90			
		90-100			
Total					

Table 3-8: Example of a standardised reporting format that would allow for the direct comparison of survey results, providing all relevant data is supplied.

Visibility can be measured as the percentage of bare ground visible per square meter. This approach may appear to be overly prescriptive to some, however, in the interests of future researchers, this type of simple table would allow the necessary data compilations and comparisons that cannot be made here. Standardised artefact identification and recording procedures are also necessary.

Calculating an overall visibility figure therefore, is somewhat problematic and is best avoided, as it would simply be an average of averages. It is only appropriate (given the available data) to tabulate the various classes of visibility conditions from each report, rather than try to impose quantification on an already problematic and subjective series of calculations performed in the field. Dennis Byrne (1983) attempted a similar method in his survey of Wandella-Dampier forests, where average visibility ratings were ‘scored’ on a scale from 1 to 6 (1=0%, 2=20%, 3=40%, 4=60%, 5=80%, 6=100%). Where this method is problematic here is that many of the reports presented a series of visibility ranges (i.e. between 40% and 100%) rather than quantifying each survey area independently. This means that many of the visibility figures cannot be assigned to a discrete ‘range’ as Byrne’s method utilised. Figure 3-5 presents the numerous visibility ranges collected directly from the study area reports.

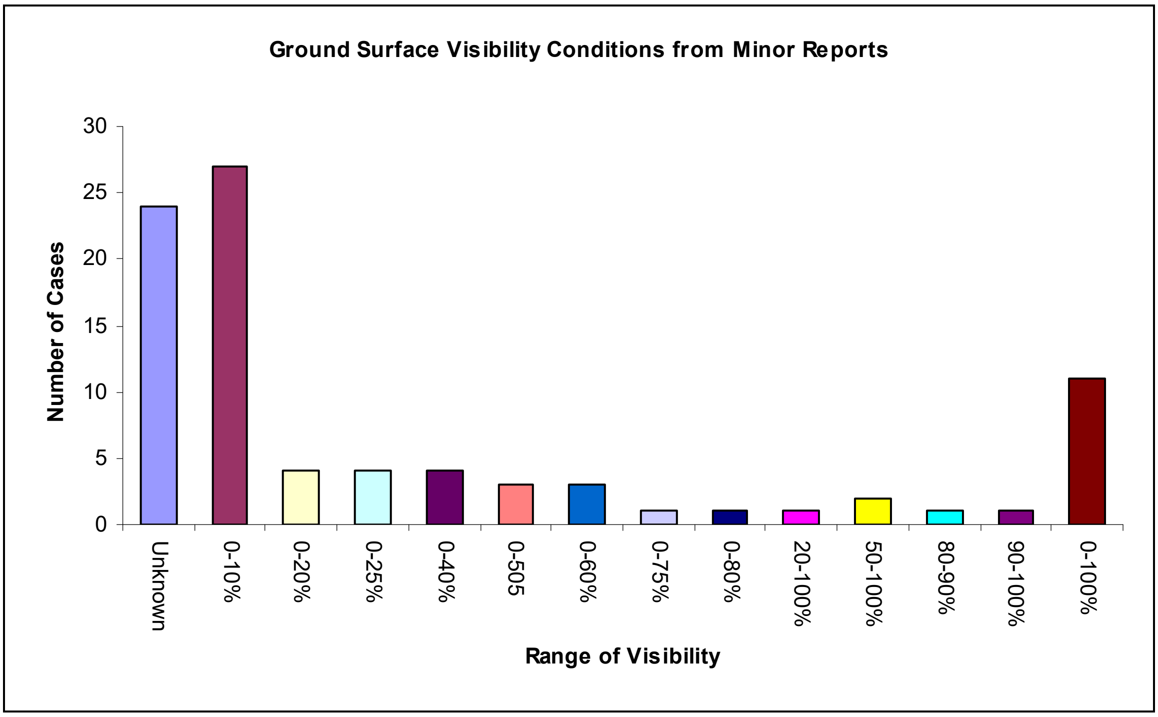


Figure 3-5: Graph showing the range of ground surface visibility figures extracted from the minor survey reports.

Figure 3-5 reveals that many of the reports were completed under less than desirable field conditions. For example, 36.9% of these reports were completed in areas with less than 20% visibility prevailing. There are also a large number of reports that did not include any data on surface visibility (28.5%). Figure 3-6 shows the percentage of sites recorded in each of the visibility ranges.

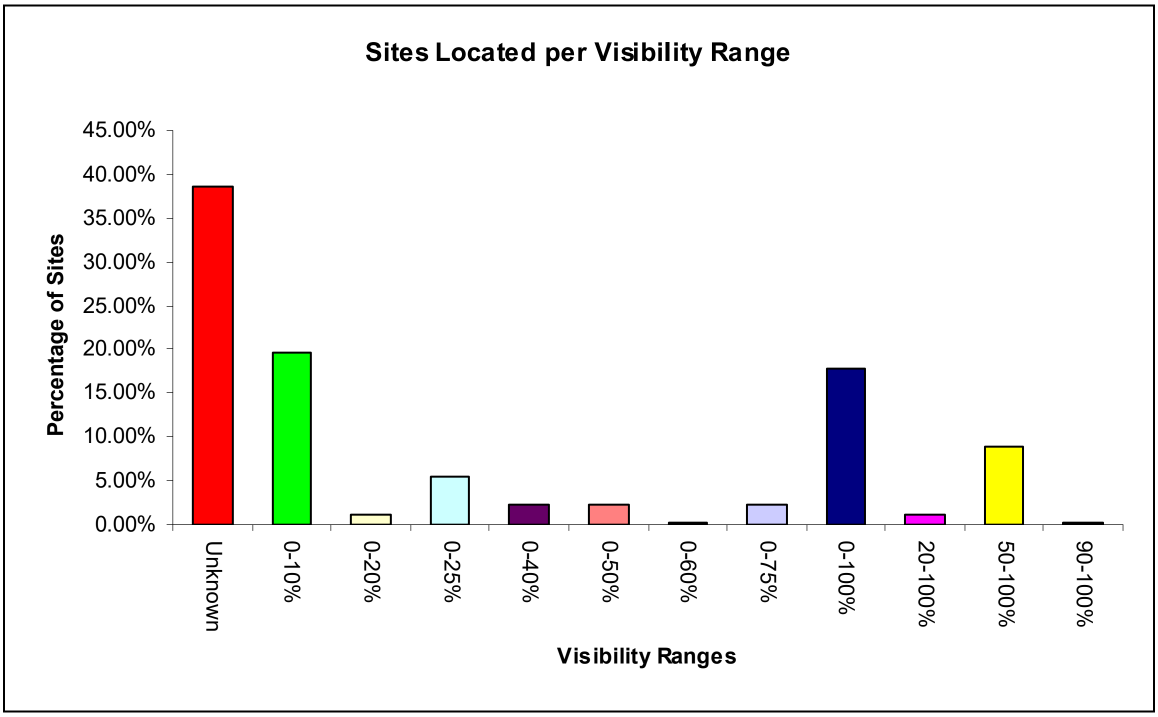


Figure 3-6: Percentage of sites located in each of the identified visibility ranges.

In general, the reports have all encountered limited visibility conditions. This seems to be one of the common denominators of archaeological work in the region. It is somewhat problematic that this phenomenon does not receive more attention in the reports, and is almost treated as a given. It should be communicated to the report's intended audience that the individual survey recovery rates (the amount of material recorded during a survey) are dramatically affected by visibility considerations. A serious lack of visibility can render any survey completely ineffectual. If the survey team cannot see the ground, then it cannot locate archaeological material. It is questionable if surveys conducted with ground surface visibility of less than 20% are effective at all that (Simmons and Djekic, 1981: 25). If the survey is conducted with less than 20% visibility, then at least 80% of the area in question cannot be adequately assessed for archaeological materials. If this is indeed the case, then we need to consider if it is actually worth conducting archaeological survey at, or below, this level of visibility. In addition, it should be noted that even when visibility is excellent and no surface artefacts are located, there remains the possibility of subsurface material existing at any given location.

Critique of Minor Reports

There are certain bias-producing flaws in the methods used to select surveyable areas before field survey. Many of the consultanting reports make mention of using aerial photographs to select areas in the proposed study area with good ground visibility. This method of survey area selection introduces another form of bias into survey samples. Areas of land in these photographs that appear to have less dense vegetation, and are thus more suited to surveying, may not be the same areas that were favoured by Aboriginal people in prehistory. There is no correlation between modern seasonal vegetation pattern changes, and the use of the landscape by Aboriginal people through time. Since the arrival of Europeans, the impacts of questionable land use practices coupled with introduced plant and animal populations have rendered certain areas more vulnerable to erosion, and thus less vegetation. Erosion induced vegetation loss is in no way randomly distributed, and will be apparent in different areas with different intensities, dependant upon the season. Basing part of a survey on aerial photographs that may show this type of 'patterning' introduces bias. Some possible solutions may be to conduct intensive survey campaigns during times of drought or after the area in question has been burnt off. The latter is a relatively easy method of increasing the level of ground surface visibility, and does no great harm to the environment or the surface archaeological material (excepting scarred trees of course, which are at risk from fire).

Although shovel testing has been postulated as one possible response to the visibility dilemma, it is still not the most efficient or effective means of archaeological data recovery. If surface visibility is low, thus reducing the chances of intersecting an archaeological site utilising foot transects, then the chances of intersecting an archaeological site using a series of small shovel test pits is perhaps even lower. There is a considerable body of literature arguing that shovel test pitting (STP) is a limited field method and should be used with caution (Krakker, Shott and Welch, 1983; Lightfoot, 1989; Lynch, 1980; Shott, 1985, 1989; Stone, 1981). STP is discussed in more detail in Chapter 5. In three-quarters of the reports summarized here, an opportunistic approach to sampling was used (see Figure 3-7). Only 7.1% of reports attempted a more formalised sampling approach, and 11.9% do not state a sampling method. The vast majority of the archaeological data generated from the survey projects of the region are based on a sampling method that is inherently biased, and is not conducive to hypothesis testing. Although this method of basing samples upon expert opinion is useful and valid in certain research endeavours, it is not particularly suited to gathering quantitative results from field-based pursuits (Neuman, 1997).

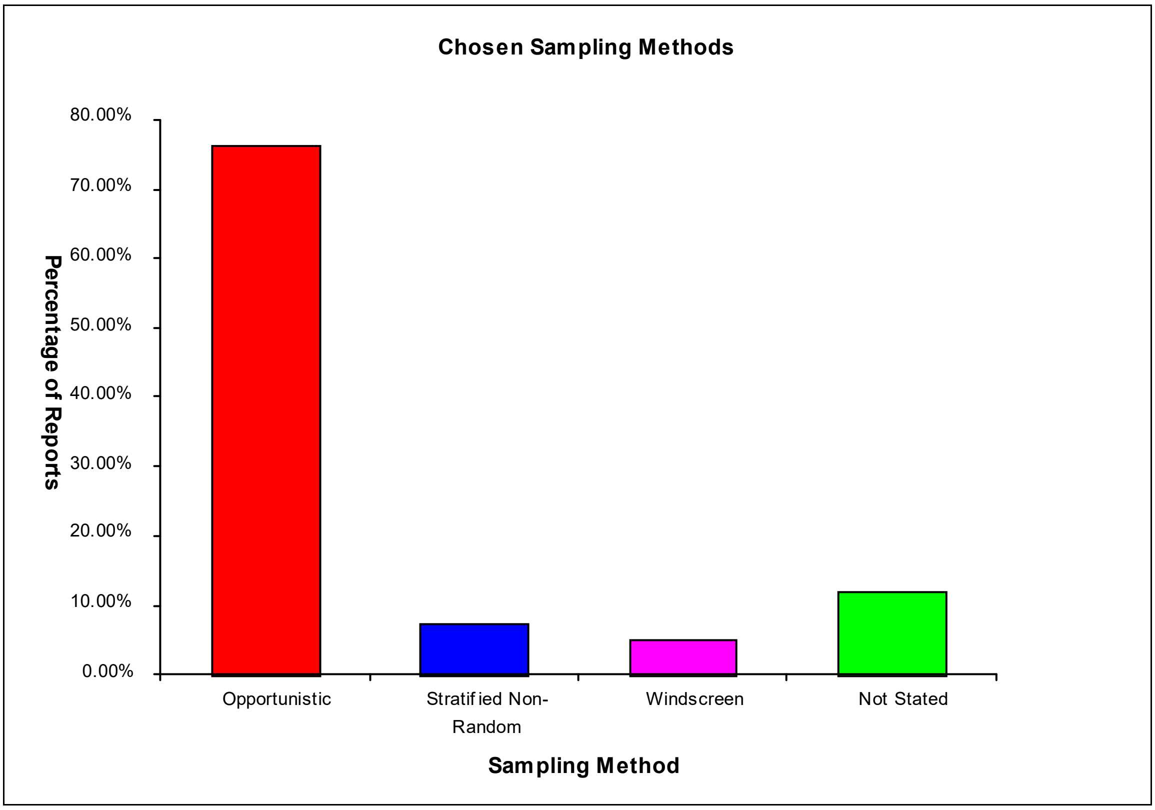


Figure 3-7: Sampling methods chosen for the field survey component of the reports reviewed.

Four (4.8%) of the reports made use of a sampling method known as 'windscreen' sampling, or surveying from a moving vehicle. This is a method that should be avoided in any serious archaeological pursuit. Aboriginal Affairs Victoria should discourage the use of this method at all times.

Intensity

There is considerable variation in the 'intensity' of survey in the study area. I use the term 'intensity' in the same way as Orton who defines survey intensity as 'the amount of effort devoted to inspecting field areas' which has a 'profound effect on discovery probabilities' (Orton, 2000: 75). Survey intensity can be measured by calculating the spacing between survey transects and the effective visibility, or if no other means are available, intensity can be derived from the number of person-days per unit of area surveyed (Orton, 2000). For example, surveys may be of five days duration with two people who attempt to cover 192 hectare (du Cros, 1990), while another may cover 104 hectares with six people over 19 days (Ellender, 1991). The intensity of survey coverage has an enormous effect on the rate of data recovery from field surveys, and our ability to infer from the sample to the whole. The importance of survey intensity is often over-looked in Australian CRM and archaeological literature. In general, the intensity of surveys in the study area is very low. For example, from the 84 minor consulting reports, 178 people were involved in 205 days of survey (36,490 person-days). The total area in question from these 84 reports was 2,550,116.2 hectares.

Therefore, the following calculations can be made: -

$$\frac{2{,}550{,}116.20 \text{ hectares}}{36{,}490 \text{ person Days}} = 69.88 \text{ hectares per person per day}$$

If the study area is a regular square shape (which of course most are not), a 69.88-hectare area is the equivalent of an area 835.94 m^2 (i.e. 835.94m x 835.94m= 69.88 ha). If we alter the above equation slightly to calculate the person days per hectare, then the result is 0.014-person days/ha. If this hypothetical area were to be surveyed utilising a 10 metre wide transect method, then the following can be calculated: -

$$\frac{835.94 \text{ metres}}{10 \text{ metres}} = 83.59 \text{ transects of 10 metres width.}$$

This means that a field worker would be required to walk 83.6 transects 10 metres apart to survey this sized study area. This equates to walking approximately 67 kilometres per day (assuming that 'only' 80 transects were to be walked – i.e. 80 x 835.94m = 66.8 kilometres). Even with 4 field personnel (well above the average here), then each member of the field crew would be required to walk somewhere in the order of 17 kilometres per day.

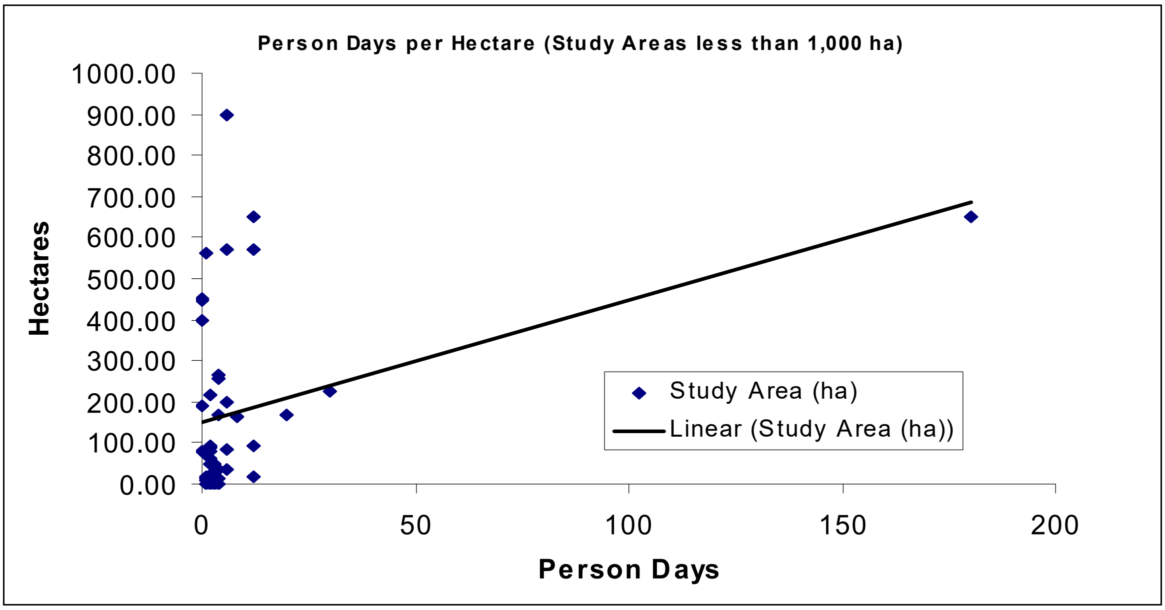


Figure 3-8: Person days per hectare of area inspected (study areas less than 1,000 ha). The largest study areas were excluded to avoid unnecessarily skewing the results.

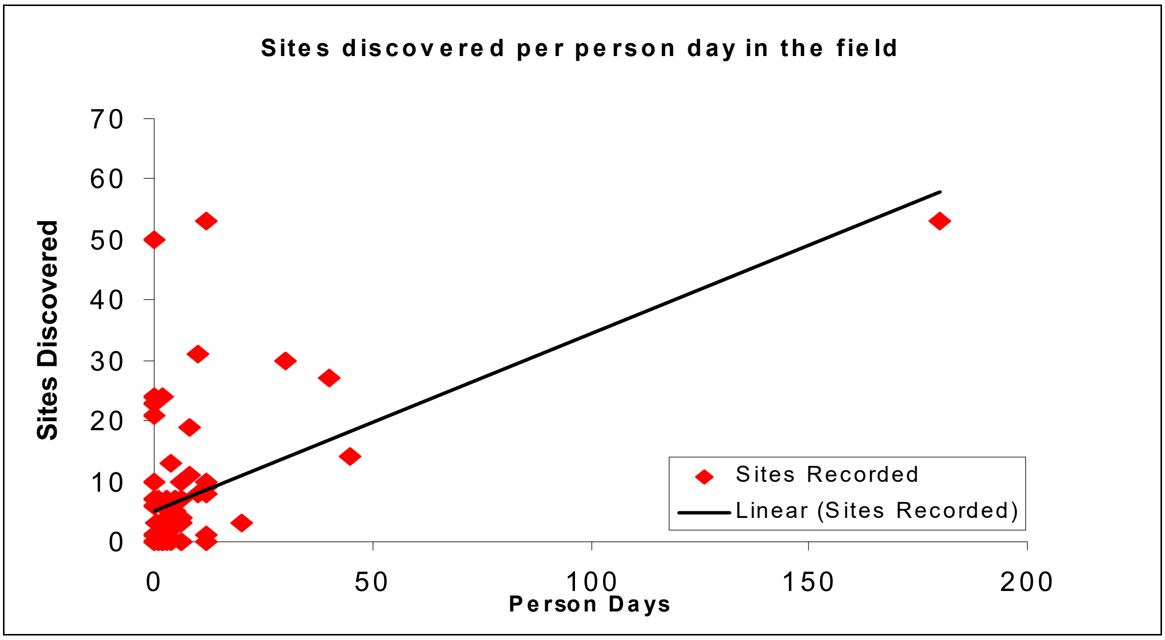


Figure 3-9: Sites discovered per person day. A linear relationship exists between the length of time spent in the field, and the number of sites discovered. The largest study areas were excluded to avoid unnecessarily skewing the results

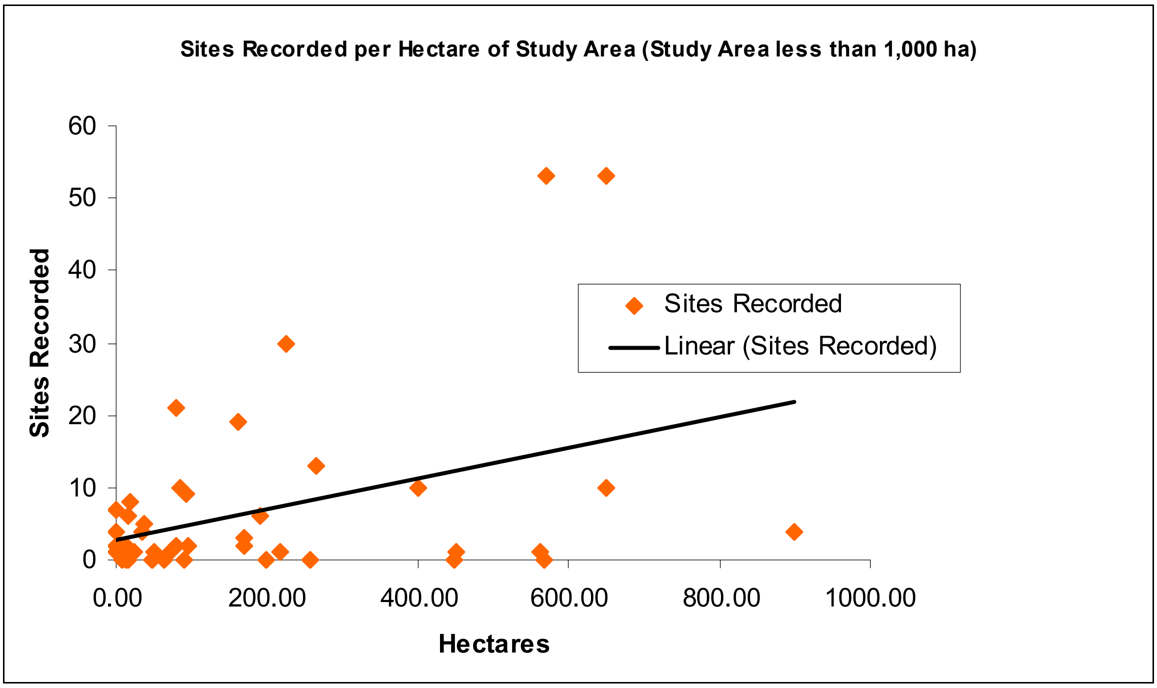


Figure 3-10: Sites recorded per hectares inspected. Study Areas less than 1,000 ha. The largest study areas were excluded to avoid unnecessarily skewing the results.

As would be expected in a field-based survey discipline, Figures 3-8, 3-9, and 3-10 show that relationships exist between the length of time in the field, the size of study areas, and the number of sites recorded. Logically, the more time spent in the field the more archaeological sites are recorded. The level of intensity of survey however remains very low. Although the level of intensity of surveying required will differ for any given area, as a general rule, field crew spacing of less than 10 metres apart when walking transects is considered ideal (Schiffer and Wells, 1982: 352). As a comparison, in a study of survey intensity (or level of effort) of archaeological projects from the southwestern United States, Schiffer and Wells (1982) determined that the survey intensity of the projects under scrutiny (n=12) was 0.1 person days/ha. This surveying intensity is 7.14 times greater than that exhibited in the Melbourne region. When we take into account that visibility conditions in the arid southwest of the United States are generally far more conducive to archaeological survey than those found in the Melbourne metropolitan area, the disparity between surveying intensities becomes even greater.

Connolly and Baxter (1983) outline a method to estimate the amount of actual ground covered in any given survey. For the purpose of the calculation, we assume that a field crew are spaced consistently at 10 metre intervals, and the survey transect width was 50 metres (six field crew members spaced at 0, 10, 20, 30, 40 and 50 metres from the point of origin). We also assume that the field crew could see 2.5 metres either side of them, thus a five-metre wide swathe per crewmember. Ten 50 metre wide transects are walked to cover a 500x500 metre quadrat. From this information, we can calculate the following:-

$$\frac{5 \text{ metres (view per crew member) x 500 metres x 10 transects}}{500 \text{ metres x 500 metres}} = \frac{25{,}000 \text{ metres}}{250{,}000 \text{ metres}}$$

=0.1

= 10% coverage (assuming 100% visibility).

Assuming 100% ground surface visibility, the transect method of survey with the stated assumptions would only provide about 10% coverage of each quadrat. If poor visibility is taken into account, then far less than 10% of the actual surface will have been inspected. For instance if visibility is only 10%, then as little as 1% of the area in question can be said to have been inspected. This is true of all surveys, and highlights the impossibility of ever achieving a true 100% surface survey. In many survey situations, far less ground has actually been covered than we might think.

There is little sense of consistency in the survey coverage of the study area. This is to be expected when reports are instigated by non-land managing agencies. The most consistency seen in the reports appears to be that parallel transects are utilized for ground survey; however the spacing of these transects is highly variable. With GPS and GIS it is now possible for field surveyors to map in great detail where transects have and have not been placed. We still, however, see boundaries drawn around large areas that are subsequently termed ‘surveyed’. This provides no means of quantifying the actual area surveyed, or the visibility effects on this ‘surveyed’ area. The actual amount of ground physically surveyed will always be far less than the area identified in the reports as the total ‘study area’. The two are vastly different entities. As most of the reports (86.9%) do not provide any way of calculating the area that was surveyed, there is no way of calculating the relative intensity of each survey. As such, we are forced to rely upon less powerful measures of surveying intensity such as the person-days per hectare method outlined above.

Summary of Minor Reports

Most of the better quality reports contain a similar, well developed, structure. This structure has been largely derived from previous studies and an AAV guidelines document produced some time ago (Aboriginal Affairs Victoria, 1997). These guidelines provide a structured approach to the production of a report, but little else. There is no recommendation as to the types of survey strategy that should be employed other than to state that the survey strategy should 'be suitable for achieving the aims of the brief' (Aboriginal Affairs Victoria, 1997: 8). A definition of a 'site' is included in these guidelines. This definition simply states that a 'site' will be defined as an occurrence of 'five (5) or more items of cultural material within an area of about 100 square metres' (Aboriginal Affairs Victoria, 1997: 1). Lithic materials located with a lower density than this are referred to as isolated artefacts. The standardisation of report structure is also largely a product of one consulting firm (du Cros and Associates) producing over 50% of all the reports analysed.

This formulaic report structure brings a certain standardisation to the consulting archaeology literature. However, where this is problematic is in the institutionalisation of weak methodological requirements. The AAV survey guidelines do not specify how surveys should be conduced in Victoria, and thus a situation has developed where consulting archaeological survey is an opportunistic or judgemental exercise, rather than a methodologically rigorous data-collecting program. Without any sense of an over-arching research prerogative, the vast majority of the information collected through the consulting industry is of no real value in archaeological research. This is of no fault of the consulting community who are not, and should not, be in the business of setting research agendas. Consulting archaeologists are subject to real commercial pressures, and as such cannot afford the luxury of trialling different field methodologies and strategies. Consultants generally use methods that have delivered results for them in the past, based on the methods used by their predecessors. These methods also provide the requirements demanded by consultant's clients – timely risk management advice. Methodological refinement is an area where the client of a consultant will seldom show any concern or financial interest. That these methods may not be the most appropriate or the most archaeologically productive is not entirely the responsibility of the consulting community. In an ideal world, the academic community would be developing and testing new and improved methods of conducting rigorous field survey in various geographic settings based on a range of timely research questions. AAV would refine the required survey standards to incorporate any new developments, and impose a series of overarching (perhaps generic) research questions which must be addressed in each CRM project (scale dependant). While the consulting community will continue to utilise the methods that deliver results, the majority of consultants are also conscientious archaeologists attempting to deliver those results in as rigorous and methodologically appropriate manner as commercial constraints allow.

The past two decades of management archaeology have produced a vast corpus of material regarding the archaeology of the study area for this project. The data collected through these reports is part of a cumulative inventorying process, whereby each occurrence of a site type is recorded wherever it occurs. The effect of this cumulative growth in the AAV sites database has been to represent the region as a 'pinboard of disarticulated, discrete archaeological locations' (Tunn, 1998:35), without any real sense of the overall picture of the regions archaeology. This is partly due to the lack of an over-arching research paradigm imposed or required by the responsible authority, in this case AAV. As a result, the archaeological data contained in the dozens of field reports tends to be one-dimensional and offers little more than the archaeological stamp collecting approach identified by Orton (2000). The results from the analyses undertaken here show that the vast majority of archaeological sites of all types were located and recorded as part of a commercial archaeological exercise. Indeed, of the 1,005 sites registered in the study area, 902 (89.8%) were located as the result of commercial archaeological projects.

Each of the reports reviewed has fulfilled the requirements of the organization requesting the work, such as a developer or utilities company. The on-going lack of a regional research program and serious methodological flaws reduces the utility of the AAV database for analysis. The continued reliance on biased survey sampling strategies, the general lack of standardised archaeological field procedures, and the uncritical reliance on untested predictive models (Sutherland and Richards, 1994: 29) such as the 'du Cros Model' (1989), severely limits the utility of any archaeological data collected or disseminated. The major limiting factor of the AAV data however, is the inability of the majority of the data to make any meaningful contribution to the overall understanding of the prehistory of the region. The survey data is predominantly mono-dimensional, in that the surface finds recorded throughout the area do not allow for in-depth contextual analysis or chronological interpretation. The majority of the AAV database for the region can provide little more than approximate locational information, and in some cases assemblage composition.

3.4. Distribution of Registered Archaeological Sites

Registered AAV Sites

There were 1,011 Aboriginal archaeological sites in the AAV site registry for the study area as of December 31st, 2000. Details of 1,005 are given in Tables 3-9 and Figure 3-11. Six sites were excluded from analysis because they are contemporary 'Aboriginal Places' (such as the 'Ronald Bull Mural' at the now defunct Pentridge Prison).

Site Type	N	%
Surface Scatters	469	46.7
Isolated Artefacts	339	33.7
Scarred Trees	106	10.5
Exposure in Bank*	38	3.8
Quarry or Stone Source	29	2.9
Mounds	8	0.8
Burials	6	0.6
Earth Rings	5	0.5
Grinding Grooves	2	0.2
Hearth	1	0.1
Art Sites	1	0.1
Stone Arrangement	1	0.1
Total	1,005	100

Table 3-9: Known AAV registered archaeological sites in the study area.* Exposure in Bank refers to occurrences of artefacts exposed *in situ*.

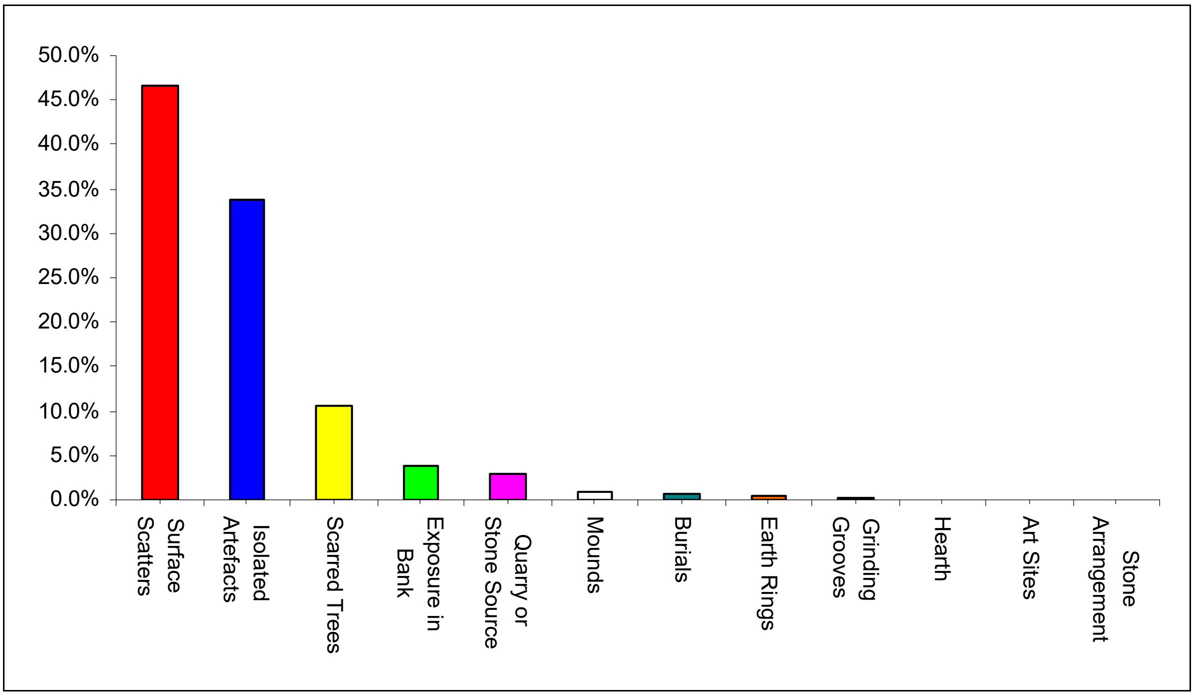


Figure 3-11: Percentage breakdown of the total number of known AAV site types in the study area. 90.9% of all sites are common surface material or scarred trees. Rare or more scientifically significant sites are only a small proportion of the total.

Interpretation

For the purposes of interpretation and discussion throughout this thesis, the 1,005 registered sites have been re-classified into three site classes. The three-tiered site classification system has been developed independently of the cultural significance of each site, and is introduced here as an analytical tool reflecting their contemporary scientific significance. Consultant archaeologists undertake cultural significance assessments during most survey activities that incorporate a variety of issues and criteria. To simplify the analysis of data for this thesis, a three-tiered classification of sites based upon the scientific or archaeological significance has been used (Table 3-10), rather than the numerous other significance criteria (i.e. social, educational or aesthetic values). This manner of classifying the existing sites database allows for some comparability across the study area. Comparability between the numerous original recorders would otherwise be impossible. Notions of individual or collective significance of sites or classes of sites cannot be ignored, and this analytical system does not address contemporary social or cultural significance from an Aboriginal perspective. Social or cultural significance is an entirely separate area of investigation, beyond the scope of this thesis. The major reason for the development of this classificatory system is to allow for the comparison of certain classes of sites across the wider region, and to assist in the predictive modelling process. Aboriginal concerns and involvement in the management process of archaeological sites is considered in more detail in Chapter 6.

Site Type	Description	Defined	Number
Type 1	Isolated Artefacts	Have little interpretative utility if regarded in isolation. Little excavation potential. Low scientific significance. Common.	339
Type 2	Artefact Scatters Scarred Trees Grinding Grooves Quarries	Have some interpretative potential if site contents, context, and density are known. Should be viewed as component of wider site distribution. Limited excavation potential. Medium scientific significance, depending on the structure of the individual site. Relatively Common. Some may be of high enough significance or rarity to be considered as a Type 3 site.	606
Type 3	Burials Mounds Exposures in Bank Hearths Earth Rings Art Sites Stone Arrangements	Sites, which do, or have the potential to, contain stratified deposits. Comparatively few known across the study area High scientific significance, and greater interpretative value. Only type of sites for which fine grained chronological information can be determined in certain cases. Predominantly rare site types.	60

Table 3-10: Known AAV sites for the study area re-classified into three site classes. These classes are for modelling scientific significance only, and are not an attempt to create a new or different significance assessment process.

The following figures present the number of sites per site class in each of the geomorphic units (GMU) present in the study area. The GMU's were introduced and defined in Chapter 2 (Table 2-2).

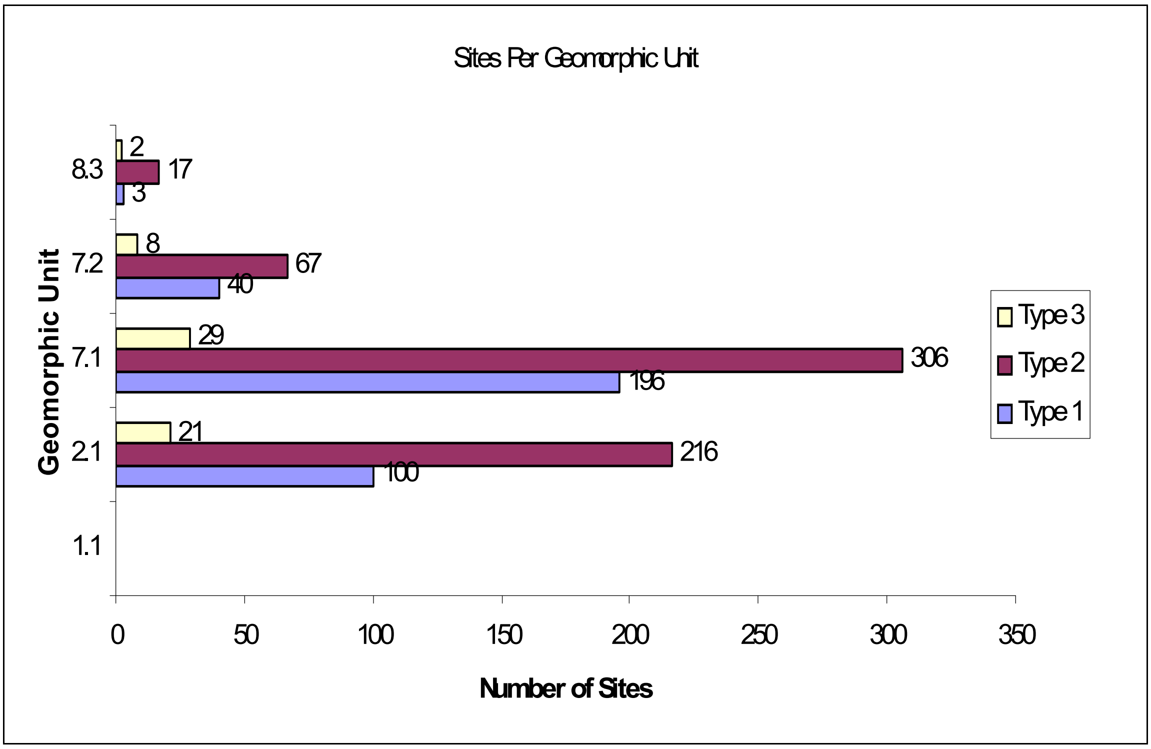


Figure 3-12: Number of AAV registered sites per geomorphic unit within the BPAP study area.

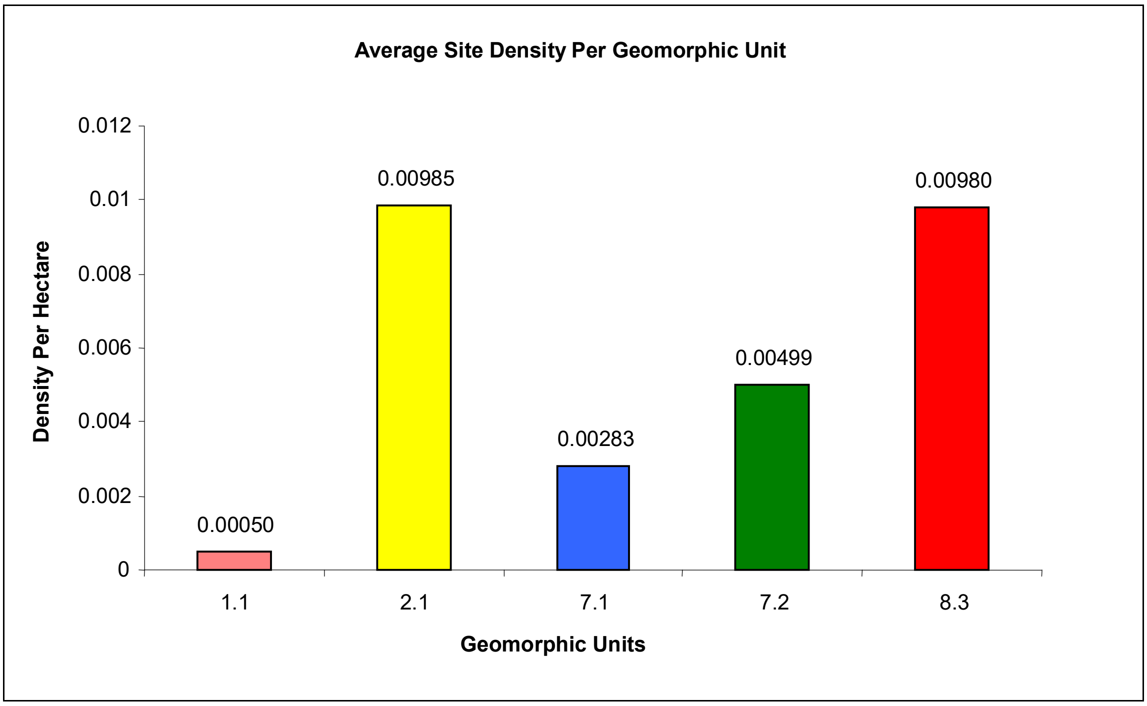
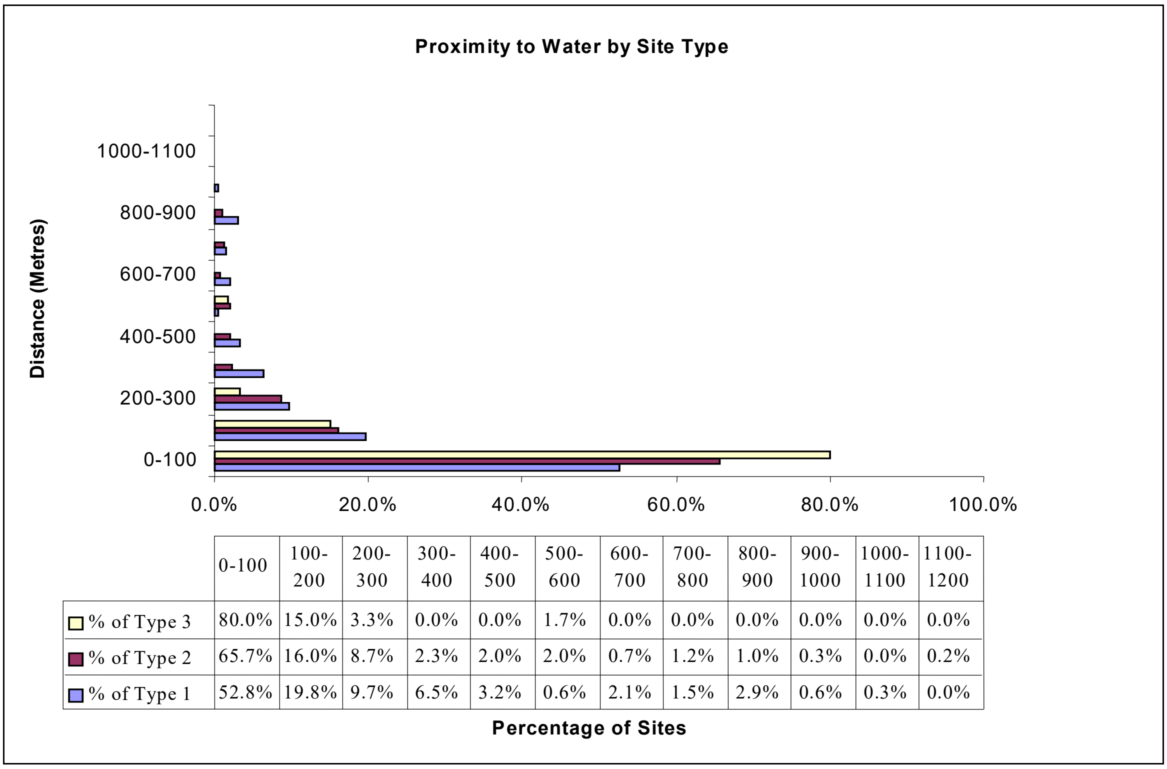


Figure 3-13: Average density of sites per hectare of AAV registered sites in each of the geomorphic units within the study area. The site density for GMU 1.1 is inferred from AAV data from the wider region.



	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200
% of Type 3	80.0%	15.0%	3.3%	0.0%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% of Type 2	65.7%	16.0%	8.7%	2.3%	2.0%	2.0%	0.7%	1.2%	1.0%	0.3%	0.0%	0.2%
% of Type 1	52.8%	19.8%	9.7%	6.5%	3.2%	0.6%	2.1%	1.5%	2.9%	0.6%	0.3%	0.0%

Figure 3-14: Average distance to water of type classified known AAV sites. The 1:25,000 hydrology layer used in *ArcView 3.2* for these calculations was modified to remove all modern water features such as dams, reservoirs or drains.

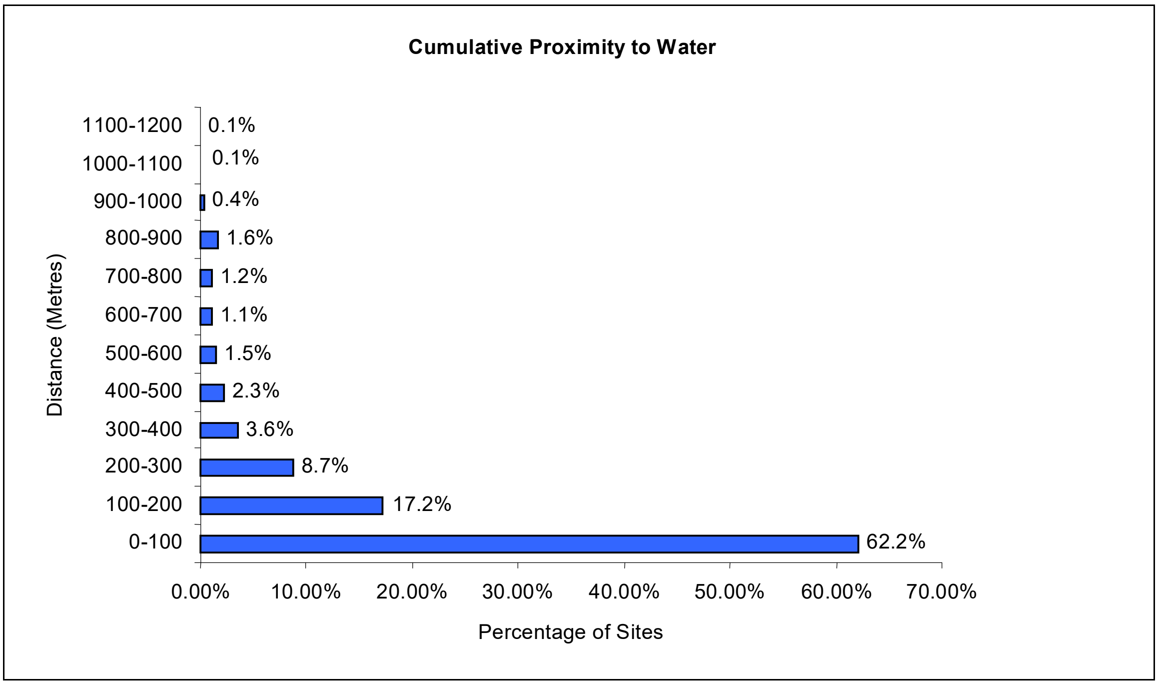


Figure 3-15: Distance to water for all known AAV sites types. The graph shows that 62.2% of all known AAV sites within the study area occur within 100 metres of a fresh water source. The 1:25,000 hydrology layer used in *ArcView 3.2* for these calculations was modified to remove modern water features such as dams, reservoirs or drains

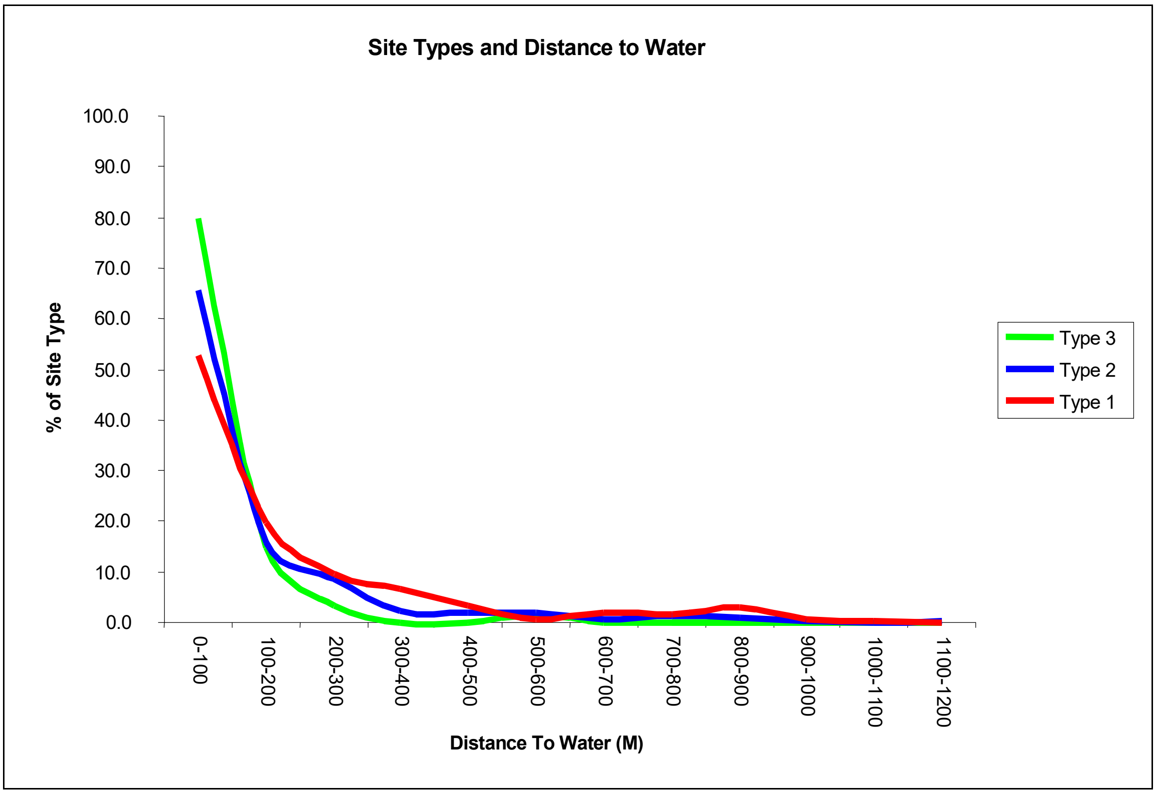


Figure 3-16: Graph of the distance to water of each site type. This is the same data as shown in Figure 3-14, however, presented in this manner, the data highlights that the aggregate of Type 3 sites are distributed closer to water, while the aggregate of Type 1 sites are distributed further away from water.

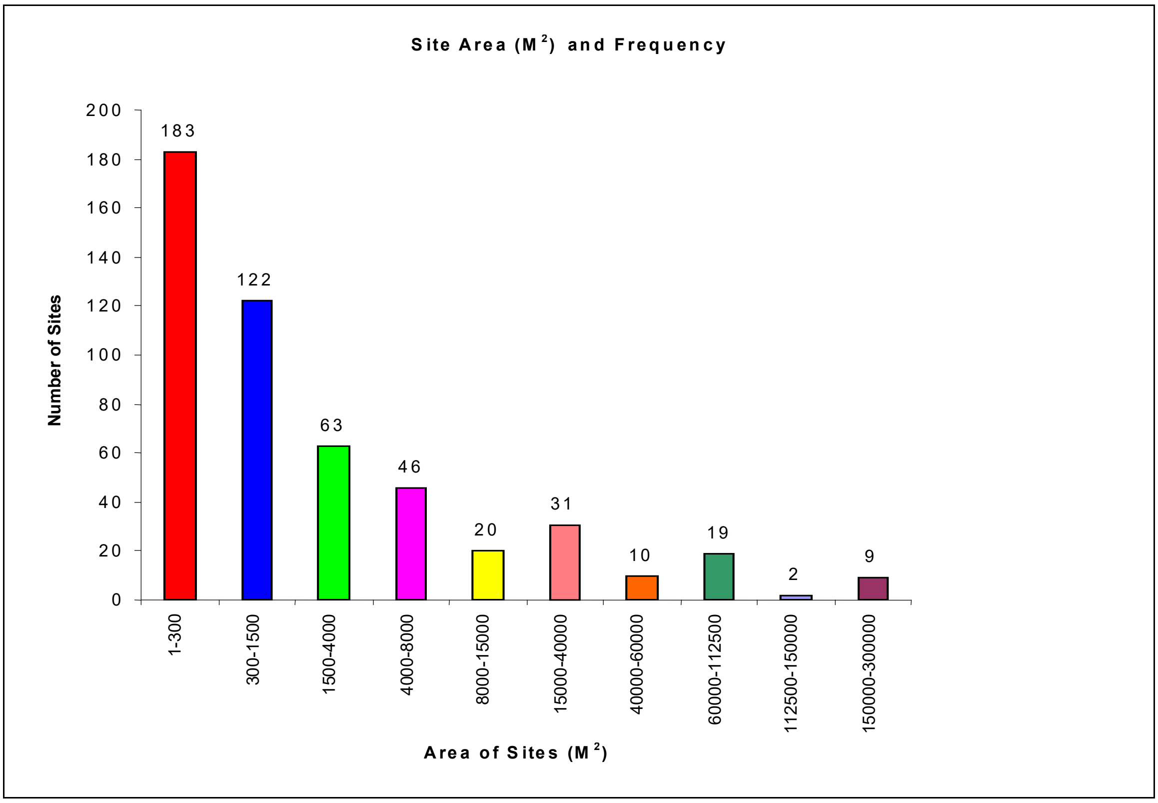


Figure 3-17: Site area calculated for the 505 sites with length and width figures. It was possible to calculate the site area figures for 50.2% of the total number of sites in the sample (n=1,005). The AAV database contains records of sites covering as much as 30 hectares.

The site area data contains records of sites as large as 30 ha. While this is possible, given that the majority of sites are stone artefact scatters, and the manner in which they were recorded, this data is problematic and cannot be readily accepted as useful or accurate.

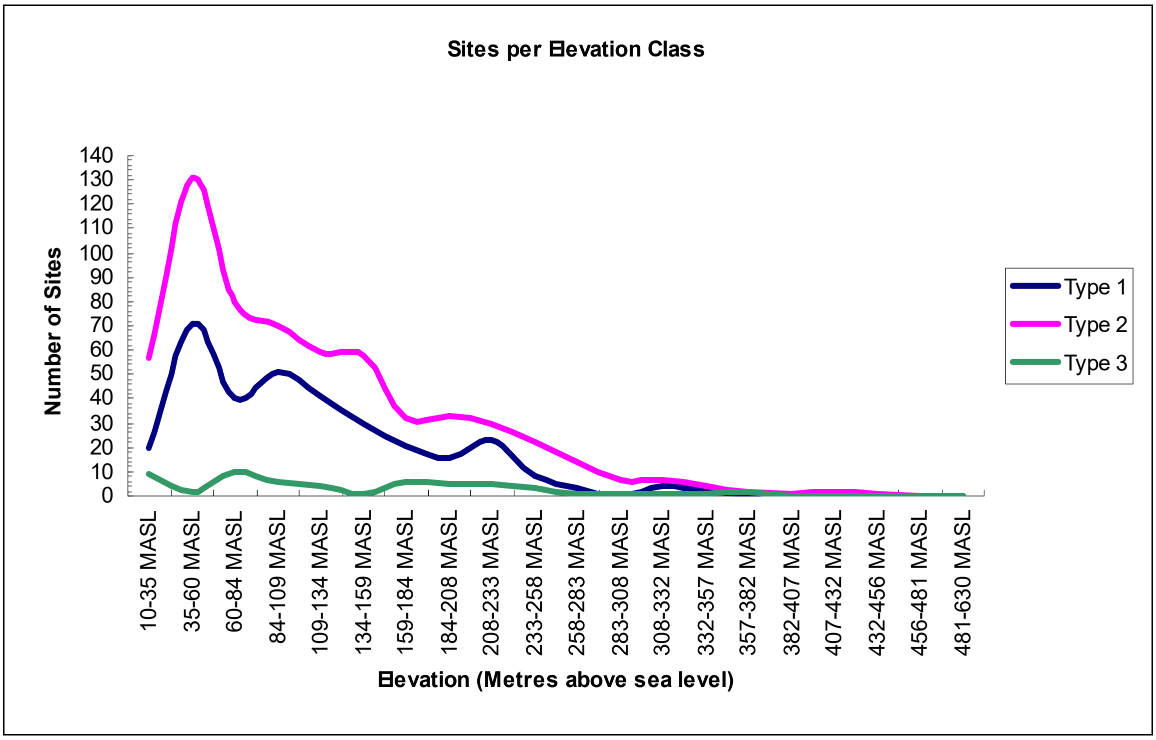


Figure 3-18: Graph of known AAV sites per elevation class. This data shows skewing towards the parts of the study area at lower elevations, which is a function of where surveys have been conducted too date.

Compass Direction	Degrees
Flat Ground	-1
North	315°-45°
East	45°-135°
South	135°-225°
West	225°-315°

Table 3-11: Data derived from *ArcView 3.2* used to calculate the aspect of the study area from topographic map data. Flat Ground returns a result of –1, while all other values correspond to a compass bearing. These are then grouped as north, south, east, or west.

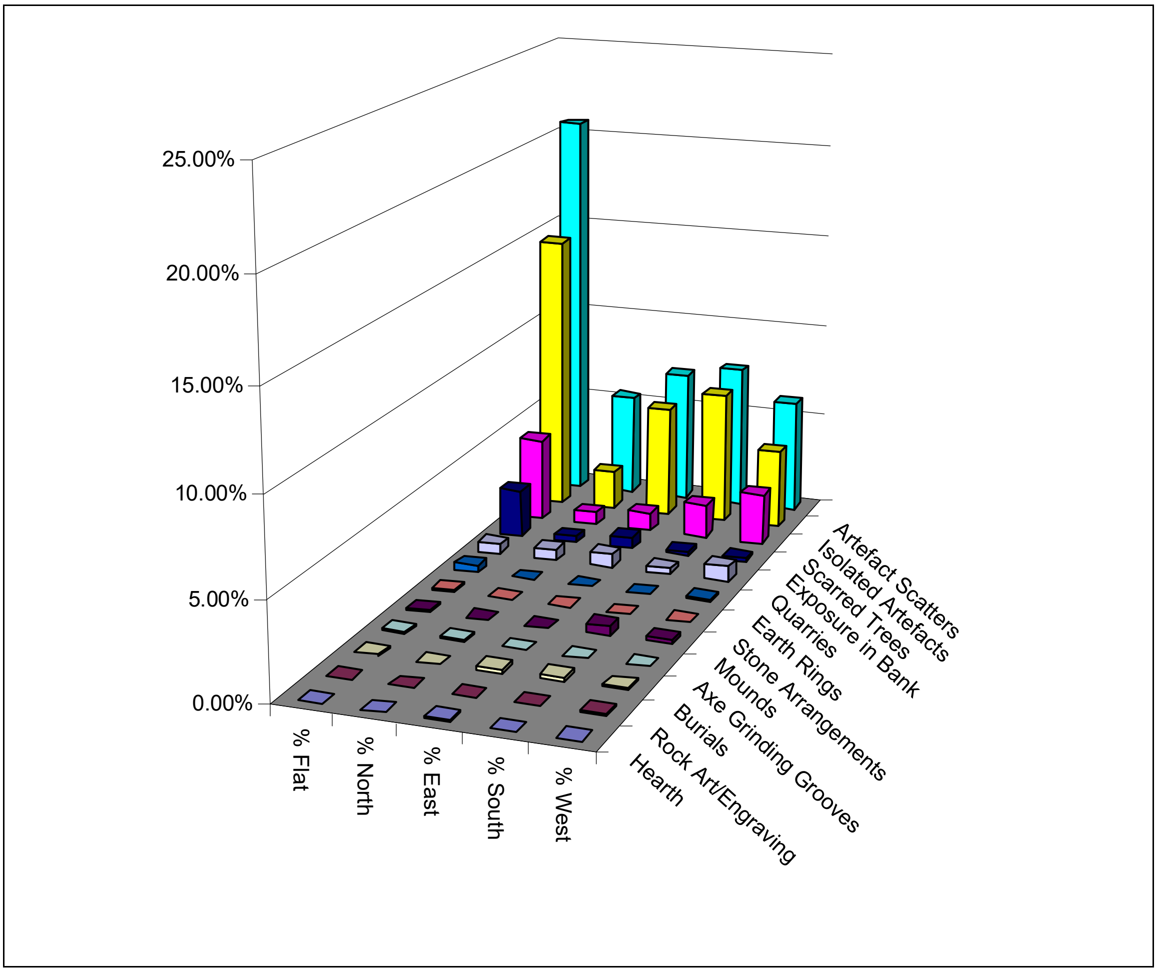


Figure 3-19: Percentage of each site type falling into the five classes used to determine aspect. As the graph clearly shows, north appears to be the least favoured site aspect, while flat ground is most favoured.

Site Type	% Flat	% North	% East	% South	% West	Total
Isolated Artefacts	14.7%	2.0%	5.9%	7.0%	4.2%	33.7%
Burials	0.1%	0.0%	0.2%	0.2%	0.1%	0.6%
Exposure in Bank	2.5%	0.3%	0.6%	0.2%	0.2%	3.8%
Axe Grinding Grooves	0.1%	0.1%	0.0%	0.0%	0.0%	0.2%
Hearth	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%
Mounds	0.1%	0.0%	0.0%	0.5%	0.2%	0.8%
Earth Rings	0.4%	0.0%	0.0%	0.0%	0.1%	0.5%
Rock Art/Engraving	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Quarries	0.5%	0.6%	0.7%	0.3%	0.8%	2.9%
Stone Arrangements	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%
Artefact Scatters	20.7%	5.4%	7.0%	7.6%	6.0%	46.7%
Scarred Trees	4.4%	0.7%	1.0%	1.8%	2.7%	10.6%
Total	43.6%	9.1%	15.5%	17.5%	14.4%	100.0%

Table 3-12: Aspect data from the 1,005 sites in the study area. This is the data plotted in Figure 3-19, above.

Characteristics of Known AAV Sites

There are certain site characteristics that can be determined from an analysis of the data held by AAV. However, there are as many characteristics or trends that cannot be explained as a result of prehistoric Aboriginal land use patterns or preferences. For instance, Figure 3-18 shows that there is a heavy skewing of site distribution toward the lower elevations of the study area. Part of this may be indicative of certain land use decisions made by Aboriginal people, however it is more likely that this is a result of uneven survey coverage throughout the study area. If more survey activity has been concentrated in areas of lower altitude, then obviously this is where the majority of recorded sites will occur.

The following characteristics have been extracted from the AAV database using *ArcView 3.2: -*

- The overwhelming majority of recorded sites are either surface scatters (46.7%), isolated artefacts (33.7%), or scared trees (10.5%). The remainder of site types account for less than 10% of the total in the study area (Table 3-9 and Figure 3-11).
- 88.2% of all sites in the study area occur at slopes of between 0° and 10°.
- Site density per geomorphic unit ranges between 0.05 sites /100m^2 to 0.985 sites/100m^2 (or between 5 sites/ha and 98.5 sites/ha) (Figures 3-12 and 3-13).
- 62.2% of all sites are within 100 metres of a source of fresh water (Figures 3-14, 3-15, and 3-16).
- 79.4% of all sites are within 200 metres of a source of fresh water (Figures 3-14, 3-15, and 3-16).
- 60.4% of all sites cover less than 1,500 m^2 (Figure 3-17).
- 18.1% cover an area larger than 8,000 m^2 (Figure 3-17).
- The largest sites in the data set cover between 15 and 30 hectares (Figure 3-17).
- Aspect appears to have limited influence over the location of the 1,005 sites analysed. The majority of sites (45.6%) are on level ground not favouring one direction over another. Northerly aspects appear to have been the least favoured, with only 9.1% of sites featuring a northerly aspect (Table 3-11 and Figure 3-19).
- Sites appear skewed towards the lower elevations (Figure 3-18) of the study area. This however, is likely to be the result of survey bias and not cultural choices.

Summary of Chapter Three

The study area for this thesis has been the subject of intensive archaeological scrutiny over the last 25 years. The quantifiable results of the completed CRM reports reveals much about the conduct of archaeological surveying in this part of Victoria, and more importantly, the nature of the archaeological record, and the collected archaeological data.

Dan Witter first raised many of the findings of the analyses presented here as 'issues of concern' nearly 25 years ago. Indeed, as early as 1977 Witter commented that opportunistic survey methods produced archaeological data that was essentially 'useless in analysis' (1977: 80). Witter called for specific research frameworks to be established throughout Victoria, alongside the use of quantitative survey and data collection methods, which would allow both regional and longitudinal analysis of survey results (1977:80). Most importantly, Witter cautioned that the site card system utilised by AAV (and still the primary data source) could not be considered as a research tool. Twenty-five years ago, Witter believed that the research potential of the AAV database was 'exceedingly limited' (1977:100). Various iterations, alterations and software upgrades later, the AAV database is still exceedingly limited in terms of the amount and quality of research data that it can reveal. This is essentially symptomatic of the different agendas of CRM and research archaeology. The data collection has been directed towards the goals and objectives of a CRM organization, and not an archaeological research agenda. As such, the AAV database is an inventory of what sites are located where—not why (Rhoads, 1992: 198). The lack of detail identified in the CRM reports greatly hampers the research potential and comparability of this body of literature, and renders the quantification of many of the survey variables impossible. While this is a problematic situation, it must be noted that this lack of detail is not restricted to this particular area, and is indeed a widespread phenomena in Australian CRM (Boot and Kuskie, 1996: 27).

This chapter has exhaustively reviewed the various forms of cultural resource management data available for the current study area. The following chapter introduces the theoretical and methodological perspectives employed throughout the fieldwork stages of this project.

Chapter Four

4. Methodology

A significant component of this project was the collection of 'baseline' archaeological data for the construction of predictive models. This data was also to be collected to allow comparisons to be made with the data held by AAV. The data was to be collected in a controlled and well-planned manner to minimise bias. The main purpose of the data collection is to determine the spatial attributes of Aboriginal archaeological material, not the functional or typological attributes of the lithics present in each location. The level of detail recorded however, does allow for certain typological and functional analyses. In this chapter, the overall field methodology employed is introduced and discussed. Theoretical constructs and methodological constraints are discussed, and the rationale for the type of sampling approach chosen will also be discussed. This is followed by a consideration of the actual field operationalisation of the survey methodology.

4.1. The Archaeological 'Site'

> '…[L]ike a pair of worn suspenders, the site concept can be stretched so far that it fails to carry any weight at all' (Thomas, 1975: 63)

The construction of the concept of archaeological 'site' in contemporary discourse is seldom questioned. Until relatively recently, definitions of the term 'archaeological site' were considered so obvious as to be unnecessary. The concept of archaeological site was 'so ingrained into the conventional wisdom of archaeology' (Thomas, 1975:61) that its meaning and implications were seldom considered. More recently, however, practitioners have begun to question the utility of the traditional notion of the archaeological site (Dunnell, 1992) and have proposed a variety of new methods to address the perceived shortcomings of orthodox archaeological site definitions.

There are a great many definitions of the term archaeological 'site'. At times arbitrary, at times precise, the notion of archaeological 'site' is central to virtually all-archaeological and cultural resource management pursuits. However, the assumptions associated with the term archaeological 'site' are seldom explicitly questioned. Nor is the appropriateness of the 'site' concept in archaeological or cultural resource management arenas questioned (Thomas, 1975). It is almost as if the notion of 'site' is the one central, unifying unit of analysis that links all archaeological endeavours, regardless of the appropriateness of this often uncritically applied and accepted epiphenomena (Dunnell and Dancey, 1983).

The Collins Dictionary of Archaeology defines an archaeological 'site' as 'any place where there is evidence for past human activity' (Bahn, 1992: 460), while the McMillan Dictionary of Archaeology offers no definition of the term (Whitehouse, 1983). The definition of 'site' from the former publication is so all encompassing as to include virtually anything that humans have done since the dawn of time, while the lack of a definition in the latter implies that the term 'site' is something that is obvious, self-explanatory, and readily understood by all archaeologists (Dunnell, 1992; Witter, 1977). The first example from the Collins publication is an example of what Gallant (1986: 408) has termed the 'correct but vague approach' to defining a 'site', while the second example from the Macmillan publication illustrates the 'benign neglect' approach (Gallant, 1986:408). Defining what is, or is not, an archaeological 'site' is central to the pursuit of both cultural resource management and academic archaeology. Definitions of the 'site' are considered paramount in cultural resource management in order to manage the resource in question. While in archaeological research, defining the 'site' is essential if we are to extract, analyse and compare typological, taxonomic or functional attributes or occurrences at inter or intra-site levels. However, the range of 'site' definitions is almost limitless. Indeed, 'one of the crucial decisions we must face if we are to develop survey data with an iota of comparability is the question of what is and what is not a site' (Plog, Plog and Wait, 1978: 385). This is one of the fundamental steps in designing any survey or scientific experiment – determining the unit of analysis.

The definition of the term archaeological 'site' often depends (by necessity) upon the individual project or the practitioner(s) involved in the research activities. However, in a cultural resource management application definitions of what are or are not a 'site' are often prescribed. Definitions may vary from 'archaeological sites represent the activity loci of cultural systems' (Judge, Ebert and Hitchcock, 1975: 83) – Gallant's (1986:408) 'correct, but vague' definition – too the highly formalised and rigid definition adopted by the Southwest Anthropological Research Group (SARG) in the early 1970s. Members of SARG defined a 'site' as being 'any locus of cultural material, artefacts, or facilities with an artefact density of at least 5 artefacts per square meter' (Plog and Hill, 1971: 8; Plog, Plog and Wait, 1978: 387). While the first definition is ambiguous, and in reality almost meaningless in a field survey situation, the second definition can lead to the introduction of severe systemic bias, or at least the exclusion of certain classes of prehistoric cultural activity from the archaeological record (Plog, Plog and Wait, 1978). In either case, the fundamental requirement of comparability between the data sets collected (assemblages) is severely compromised.

As an example of possible systemic bias, Figure 4-1 illustrates a simulated lithic scatter covering a considerable area. If the material is recorded using an artefact density method (say 0.05 artefacts per hectare), then it may be that four discrete sites are recorded. If on the other hand, a lower artefact density was used (say 0.02 artefacts per hectare) then all of the material might be regarded as part of the same site. This example illustrates that the arbitrary prescription of an archaeological 'site' can be problematic.

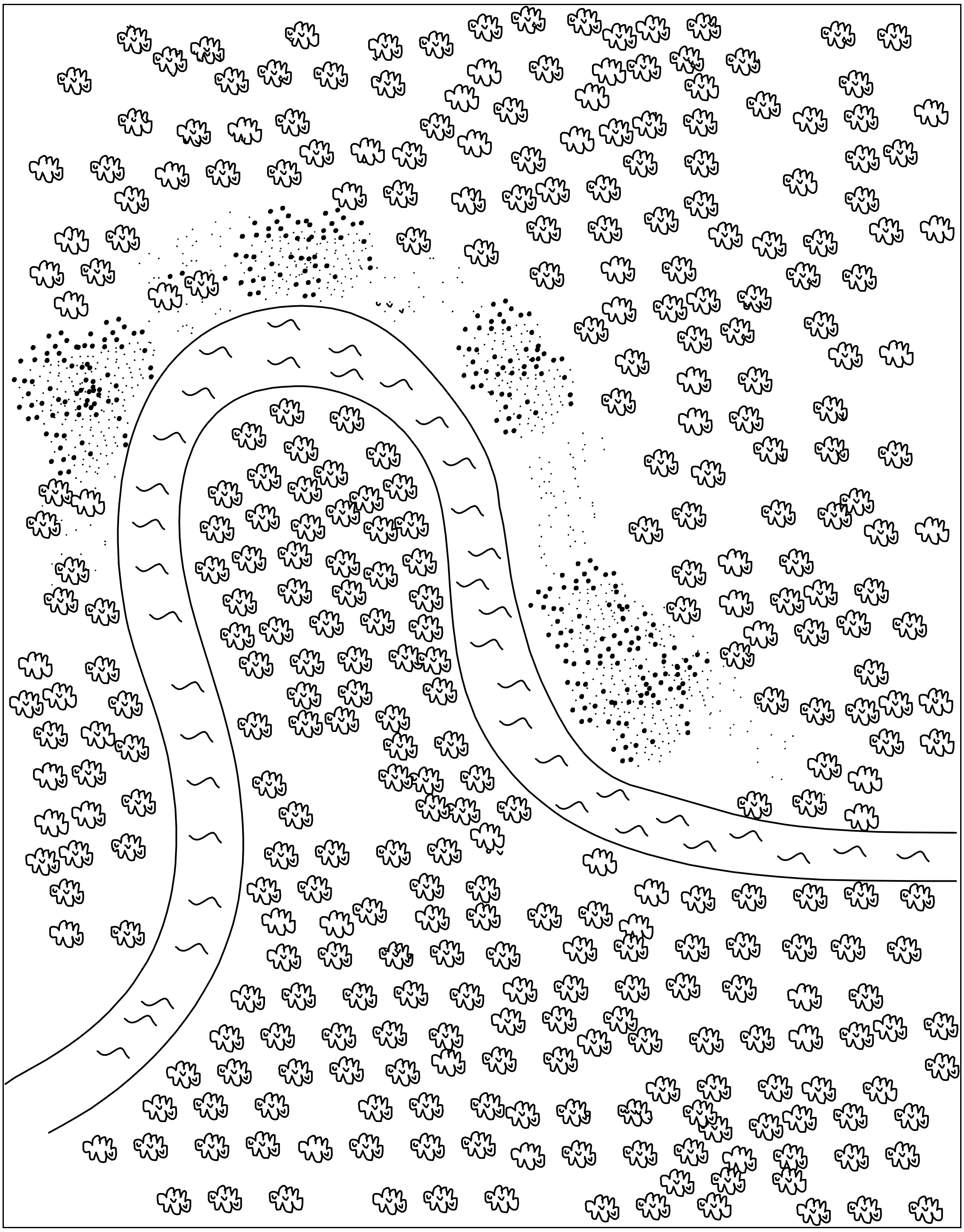


Figure 4-1: Does this diagram represent four discrete sites or one larger site of variable density along the banks of the hypothetical waterway?

In Australian prehistoric archaeology there are essentially two classes of phenomena investigated – sealed sites and non-sealed sites (Ebert, 1992). Sealed sites include any archaeological occurrence with sub-surface deposits, which have been sealed by geomorphic or cultural processes, and display a certain degree of stratigraphic and chronological integrity. These are the class of site favoured by the majority of prehistorians' for academic research, as opposed to less 'important or interesting' (Rhoads, 1992: 202) site types. Sealed sites include cave and rock-shelter deposits, shell middens, and alluvial deposits (i.e. Keilor, Brimbank Park and Green Gully sites). Non-sealed sites are all those sites that do not exhibit deeply stratified sub-surface deposits, and commonly occur at, or on the contemporary land surface. This site class includes stone artefact scatters without stratigraphy, scarred trees, fish traps, and stone arrangements.

The second site class (stone artefact scatters and scarred trees in particular) are common in many Australian environments (Holdaway *et al.*, 1998). It would not be possible however, to construct the prehistory of any region without the research conducted on those sites that display the necessary chronological and stratigraphic integrity – the sealed sites. The vast majority of dateable cultural material is recovered from this class of site, while virtually no dateable material is exhibited in the non-sealed class of sites. For example, Bird and Frankel (1991b: 182) show that stone artefact scatters comprised 37% (n=3,500) of the archaeological record in a study area of Western Victoria. Of these sites (approximately 1,300 sites), only four had been subjected to radiometric dating (0.3%), while approximately 15% of rock shelters (approximately 70 sites) in the same region had been dated. The overwhelming majority of archaeological material presents itself to archaeologists as the ever-present surface scatter of lithic materials. For a variety of political and economic reasons, excavation has now all but given way to the survey of non-sealed surface sites in contemporary cultural resource management applications (Ebert, 1992). The two dominant classes of archaeological site encountered in Australia discussed above fit comfortably into the three-tiered 'Site Type' classificatory system developed earlier in Chapter 3. The non-sealed sites, which constitute the bulk of the archaeological record, are identified here as either Site Type 1 or 2 and have limited interpretative potential. The sealed site class discussed here correlate to the Type 3 sites discussed in Chapter 3, and are those rare sites with greater interpretative potential.

The difficulties encountered in defining the archaeological 'site' (particularly in hunter-fisher-gatherer archaeology) have led to the development of a body of method and theory designed to overcome the perceived shortcomings of the 'site' concept. By the early 1970s, many archaeologists had come to question the utility of the 'site' notion. Many practitioners were seeing the archaeological record as a more or less continuous phenomenon across landscapes, rather than as discrete or bounded 'sites' (Ebert, 1992). The difficulties encountered by these practitioners led to the development of 'non-site'

(Thomas, 1975), 'off-site' (Foley, 1981c), 'site-less' (Dunnell, 1992; Dunnell and Dancey, 1983) 'distributional' (Ebert, 1992) or 'spatial' (Holdaway *et al.*, 1998) archaeology. The terms are often used interchangeably (Van de Velde, 2001). For the sake of consistency, the term 'off-site' archaeology will be used here. Primarily concerned with archaeological processes and patterning at regional scales, an off-site approach is one in which the archaeological record is viewed as a spatially continuous phenomena and not arbitrarily delimited into the more commonly applied archaeological 'site' types (Ebert, 1992; Foley, 1981c; Thomas, 1975). The following section will examine the development and application of the 'off-site' archaeological approach, and its relevance to this thesis.

4.2. Theoretical Development

> 'There is a mode of archaeological research in which the site concept is not only inessential, but even slightly irrelevant. I specifically refer to regional sampling procedures, which take the cultural item (the artefact, feature, manuport, individual flake or whatever) as the minimal unit, and ignore traditional sites altogether' (Thomas, 1975:62).

In the late 1960s, David Hurst Thomas began a series of investigations in the Reese River Valley of Central Nevada aimed in part to test Julian Steward's (1938) ethnographically derived model of prehistoric Shoshonean settlement patterns and land use and concept of 'stable, yet flexible transhumance' (Thomas, 1975: 64). Thomas constructed a very specific sampling strategy. Steward (1938) had theorised that certain 'techno-economic' (Thomas, 1975: 64) activities would have taken place in the past within a series of microenvironments. Thomas designed a sampling strategy, which would allow the artefactual evidence of these 'techno-economic' activities to be recovered from each of the identifiable microenvironments, independently of all others, which would allow him to compare and contrast the materials recovered from each of the identifiable microenvironments.

Thomas constructed a stratified random sample of the Reese River Valley by superimposing a 500x500 metre grid over a map of the entire study area (resulting in nearly 1,400 25-hectare grids). These grids were stratified according to the identified microenvironment, and a 10% random sample was then drawn from each of the identified biotic communities (Thomas, 1975). Thomas made use of a computer-simulated model to predict the distribution of certain resources available to the prehistoric population. Three environmental zones were analysed, and three resource types were modelled. Then, Thomas deduced a variety of 'tool kit units' (Thomas, 1972: 696) for each environmental zone. This simulated model was then run 1,000 times to simulate 1,000 years of occupation of the Reese River Valley study area (Thomas, 1972).

The artefact served as the minimum unit of analysis during the extensive fieldwork carried out for the Reese River Valley project. Artefact attributes such as edge angles and functional classifications were utilised to delineate assemblages as belonging to butchering, hunting, plant processing or living activity areas (Ebert, 1992). From the survey work, Thomas recovered approximately 3,500 formal tools, and 180,000 flakes (Ebert, 1992). The overall results of the Reese River Project broadly agreed with ethnographic models constructed by Steward (1938) in the 1930s. The distribution of archaeological materials associated with winter habitation sites were expected to be 'clumped' (Ebert, 1992:59), and the distribution of materials discarded during foraging activities was expected to be 'dispersed' (Ebert, 1992:59).

Before the Reese River Valley project, the majority of archaeologists who had worked in the Great Basin area had concentrated their efforts on 'cave sites and a few large open sites' (Ebert, 1992:58). Thomas believed that the investigation of these site types was biased toward sites that had been utilised for extended periods of occupation (i.e. winter habitation sites), and were not representative of the entire prehistoric Shoshonean settlement system. By utilising the sampling approach outlined, Thomas was able to collect a more representative and unbiased sample of the archaeology of the Reese River Valley. In addition, by utilising the artefact as the minimum unit of analysis, Thomas was able to ignore the traditional 'site' notion altogether.

Robert Foley made significant advances in the development of 'off-site' archaeology in his fieldwork in the Amboseli Basin of Southern Kenya during 1976-1977 (Foley, 1981b). Foley used strictly controlled methods, emphasizing 'efficient sampling'(Foley, 1981a: 174) techniques, in a manner similar to that of vegetation ecologists. He utilised the artefact as the unit of analysis, and conducted stratified random sampling across his study area, followed by opportunistic sampling to address specific research questions.

Foley's fieldwork was specifically designed to test his 'off-site' concepts, and to develop new field methods to collect the appropriate data. The culmination of this fieldwork led Foley to identify patterns of archaeological phenomena 'tending towards continuous rather than discrete artefact distributions' (Foley, 1981c: 161) across various components of the landscape, and regard the traditional site concept as somewhat lacking in analytical or interpretative value (Foley, 1981c).

Foley's methods were largely based upon methods developed and employed by vegetation ecologists, and the economically derived site catchment analysis theories developed by Claudio Vita-Finzi and Eric Higgs (Higgs and Vita-Finzi, 1972). Foley theorized that if a prehistoric economy could be reconstructed, then it would be possible to identify how a particular human group would utilise a particular environment. Ecological reconstructions should then reveal spatial or behavioural (or both) patterning at the resource demand – vs. – energy cost interface of the human system within that systems 'home-range'. There is an assumption that 'archaeological data relate primarily to long term gross behavioural characteristics, and ecological theory may be used to predict their structure' (Foley, 1981a: 1).

Aside from contributions to 'off-site' archaeological theory, Foley also made significant contributions towards the incorporation of taphonomic processes in the analysis of spatial patterning at regional scales. Foley cautioned that off-site archaeology, as both a method and theory, must attempt to take account of taphonomic processes through the analysis of various pre and post-depositional processes operating on any given archaeological material. These processes include artefact discard, burial rate of archaeological material (aggradation), exposure rates (degradation), artefact oscillation rates, artefact movement(s), artefact destruction, and visibility factors (Foley, 1981a; 1981c).

Glynn Isaac is arguably the best known of the trio of archaeologist's discussed in this section. Isaac was a prominent archaeologist who worked extensively in the rift valley of eastern Africa, particularly at Koobi Fora, East Rudolf, and Olorgesaille. Isaac's investigations centred on 1.5 mya Pleistocene deposits in east Africa. From analyses of these deposits, Isaac attempted to address questions of the origin of modern *Homo sapiens*, and the development of modern human behaviour and technology.

Isaac's major contribution to the development of 'off-site' method and theory was his explicit recognition that archaeological materials occurred across landscapes and chronological units at varying densities, from concentrated patches (sites) to the less highly concentrated 'scatters between the patches' (Isaac and Harris, 1975). From their fieldwork Isaac and Harris (1975) recognised that there was probably more archaeological material lying between the patches they had observed as 'sites' than was actually present in these sites. Hence, an empirical method was deemed necessary to identify and quantify the material occurring outside of the recorded sites.

Isaac and Harris devised a geologically stratified sampling scheme whereby sample strata were systematically laid out from the top of the particular escarpment in question, proceeding down slope to the floor of the given valley. These areas were then surveyed on foot utilising common pedestrian survey techniques – i.e. transects. The chronological structure of the landscape was comparatively well known, so that the location of each site and artefact could be placed into a relatively secure dating schema without having to specifically date each site. The specific aim was to identify areas of variable artefact density, differences in tool types in each transect, and any difference in the utilisation of raw materials (Isaac and Harris, 1975).

From these surveys, Isaac and Harris concluded that there was indeed evidence of differential density of archaeological material across the landscape. Isaac and Harris (1975) identified three different levels of artefact density in their east African study area:

- Low Background Level – Large areas of low artefact density. Between 0-3 artefacts in 25m^2 sampling units.
- Intermediate Level – More isolated artefacts and small scatters, density of between 2-3 artefacts up to 10-20 per 25m^2 sampling unit.
- Peak Levels – High-density concentrations of artefacts in localised concentrations. Between 20-30 artefacts up to 100 artefacts per 25m^2 sampling unit (Isaac, 1989: 262).

While this experiment yielded clear evidence of differential artefact discard and accumulation across various geographic blocks within the sampled area, the results did not explain the cause of the observed phenomena. Indeed, 'determining what factors led to frequent artefact making and discarding in some areas rather than others remains a major challenge' (Isaac, 1989:262).

Summary

Since the late 1960s and early 1970s, numerous practitioners have adopted an off-site approach to conducting archaeological fieldwork (Dunnell and Dancey, 1983; Foley, 1981b, 1981c). While this is not a new method of survey, it does not appear to have enjoyed a great deal of popularity in Australian archaeology or CRM. There are however some notable exceptions. For example, recent work at the Currawinya Lakes in southwest Queensland by Richard Robins (Robins, 1997), Jim Rhoads' survey of southwestern Victoria (Rhoads, 1992) and Simon Holdaway's (Holdaway *et al.*, 1998) project in Sturt National Park are three contemporary Australian examples of off-site field methods at work.

The greatest challenge facing practitioners utilising an off-site approach is still one of chronology, not methodology (Jones and Beck, 1992). While Isaac (1989) believed that identifying causal relationships between tool making, discard rates and landscape utilisation would prove one of non-site archaeologies biggest challenges, he had the relative luxury of operating with a degree of chronological certainty. In an Australian context, Isaac's (1989) observation is equally pertinent, however at the surface site level; there is normally very little chance of establishing any chronological resolution unless excavation and radiocarbon dating can identify a minimum underlying age of the sediments.

Sampling

> 'Archaeology…is the discipline with the theory and practice for the recovery of unobservable hominid behaviour patterns from indirect traces in bad samples' (Clarke, 1973: 17).

Since the mid-1960s, sampling discourse has been a key feature of archaeological and CRM literature internationally. In virtually all areas of archaeology and CRM practitioners are constantly manipulating or seeking samples. This sample may be as ubiquitous as a stone tool scatter, as diverse as rock art motifs, or as distinctive as culturally modified trees. Indeed, the archaeological record itself is only a small component of the totality of past human activity available to archaeologists as the surviving sample. The development of modern sampling method and theory has been predominantly driven by the needs of business, science and social researchers (Orton, 2000). The realisation that it is seldom possible to check, test or observe every item or member of a population of objects, things or individuals created the need to test a small 'sample' of the given population, which could then be taken to be representative of the whole. Statistics are the means of supplying the descriptive characteristics or parametres of that sample (Judge, Ebert and Hitchcock, 1975).

The 'sample' then, constitutes the basis upon which decisions are made, or inferences are drawn, that affects or reflects upon the entire population(s) under observation, while statistics are the tools with which it is possible to summarise and generalise information about that population(s) (Judge, Ebert and Hitchcock, 1975). While the origin of the ideas behind sampling are lost (Orton, 2000), the majority of the developments in statistics, sampling methods and statistical theory have occurred in the 20th Century. Although statistical method and theory are often seen as fixed, immutable mathematical rules, development and innovation within the statistical sciences is constant. Bayesian method and theory, for instance, has only recently been utilised in archaeology (Shennan, 1997), and continues to hold great promise for the archaeological researcher (Delicado, 1998; Orton, 2000). The availability and continual development of high-powered computers has also aided these developments.

Classical statistical inference is mainly concerned with making informed decisions or choices possible from a position of relative uncertainty (Shennan, 1997). Uncertainty exists, because we do not know, or cannot quantify, everything about a given population. The relative degree or level of uncertainty can be established however, using probability theory and method (of which sampling is a key component). Usually, statistical method and theory are employed either to test particular hypotheses or to estimate particular sets of parametres from a given sample. The ability to make informed inferences in the face of relative uncertainty makes probability-based statistical methods particularly suited to many archaeological questions.

Archaeologists seldom have access to 100% of the population of the items or objects they study. This is particularly true of data recovered through field survey, where the amount of data recovered is dependant upon a litany of uncontrollable variables such as surface visibility, post-depositional processes, or artefact destruction. Thus, for the archaeologist, to be able to construct a rigorous sampling scheme to collect a portion of the extant data and infer results from the part to the whole is of enormous benefit.

Until the 1960s, the majority of archaeological sampling was based upon intuitive or opportunistic methods. Advances in statistical method and theory however, led to the wider adoption of formal statistical and sampling methods in both archaeological research and CRM (Orton, 2000). Lewis Binford's (1964) paper entitled 'A Consideration of Archaeological Research Design' is generally regarded as the turning point in the application of formal statistical and sampling techniques in archaeology and CRM, particularly in the U.S and the U.K. (Orton, 2000). Binford (1964) called for archaeologists to develop overt research designs, and to make use of formal statistical inference through the application of probability-based sampling techniques. This emphasis on statistical theory and scientific method was to form much of the basis of the emergent ‘New Archaeology’ (Trigger, 1989). The application of formal statistical and sampling methods in CRM had become almost ubiquitous in the U.S. by the early 1980s and in the U.K. by the early 1990s (Orton, 2000). Formal sampling methods utilising probability techniques are not common in Australian CRM however (Attenbrow, 1988), thus limiting the interpretative value and overall representativeness of much of the data collected. Where these types of analyses have been used (Veth, 1993), the results are often erroneous or misleading (Holdaway, 1995a: 43-45; 1995b: 137-138).

Sampling is of central importance in most archaeological applications, primarily as a means to either reduce costs, or to manage the vast quantities of data that can be generated through archaeological survey or excavation. Not only is it imperative to collect the appropriate type of data (relative to the question being addressed), it is essential to know when enough data has been collected, or when it is necessary to modify the sampling scheme. A formal sampling design allows practitioners to set limits on the amount and type of data required for a given question. In this context, a formal sampling scheme provides the archaeologist with the boundaries within which to gather the required data. Once these boundaries are reached, collection of new data can cease, and the analysis can proceed. A good sampling design should help avoid what Orton (2000: 7) described as ‘archaeological stamp collecting’– or, the collection of data for the sake of collecting data.

Sampling and sampling design has been the subject of an enormous (and expanding) body of archaeological literature during the 1970s and 1980s. The majority of this literature, particularly in regards to CRM, has emanated from the United States, Canada and the United Kingdom (Binford, 1964; Chartkoff, 1978; Cowgill, 1990; Dancey, 1974; Dunnell and Dancey, 1983; Foley, 1978; Gallant, 1986; Hasenstab and Lacy, 1984; Hoffman, 1993; Judge, Ebert and Hitchcock, 1975; Kintigh, 1990; Krakker, Shott and Welch, 1983; Lightfoot, 1986; Lovis, 1976; Matson and Lipe, 1975; Nance, 1981; Nance and Ball, 1986; Nicholson, 1983; Orton, 2000; Packard, 1991; Plog, 1990; Plog, 1976; Read, 1975, 1986; Redman, 1987; Robins, 1997; Shott, 1985; Smith, 1995a, 1995b;

Stein, 1986; Sundstrom, 1993; Van de Velde, 2001; Whalen, 1990). This body of literature, and the general prominence of sampling theory in particular, has led to sampling method and theory becoming firmly entrenched in U.S academic and contract archaeology (Orton, 2000). Conversely, Val Attenbrow has suggested that formal sampling schemes have been utilised by 'very few Australian researchers in their fieldwork' and that ' very few of the sample surveys carried out have produced representative samples, because either the samples have not been chosen probabilistically, and/or the survey has not been of sufficient intensity' (1988:82). Indeed, the selection of Victorian CRM reports (spanning 1977-2000) reviewed for this thesis revealed that not one of these reports had utilised a probability based sampling scheme (see Chapter 3). The use of a formal sampling strategy such as the sample design advocated below was seen as a means of addressing this perceived short coming in certain CRM projects, while providing the necessary quantitative archaeological data.

4.3. Designing the Sampling Strategy

The purpose of this section is to discuss the manner in which the various survey areas were to be stratified and sampled. The use of Geographic Information Systems (GIS) technology makes this stage of the planning process reasonably straightforward. The important decisions to be made were how large a sample was required, and how best to select sample areas from within the wider study area. Virtually all of the consultant's reports on the study area used a particularly small survey sample. In the consultant archaeologists case this is understandable as survey works are only performed according to the requirements of specified contract briefs. It was also apparent from the regional literature that virtually all of the survey samples so far have been stratified according to landform (Schell, 1994; Tunn, 1998). Overall, however, only a small percentage of the actual study area has been subjected to any form of archaeological survey.

The study area for this project, shown in Figure 2.1, covers an area of approximately 295,000 hectares (2,950 km^2). Several areas were chosen within the study area for intensive surveying. Survey areas were located at Brisbane Ranges National Park, Woodlands Historic Park, Organ Pipes National Park, and several private properties along the Deep Creek. Because of the sheer size of the study area, it was obviously not possible to survey the entirety. As such, a smaller sampling fraction was required. Originally, it was planned to spend some 54 days in the field, during which time it was hoped to intensively survey at least 25 hectares per day. This was considered an achievable program of survey, which would result in a total of some 1,350 hectares being surveyed (approximately 0.5% of the total study area).

Once the areal extent had been determined, a simple random stratification method was chosen to sample the study area. Each parcel of land available for survey was firstly located, and then mapped using *ArcView 3.2*. The process of randomly stratifying the survey area using GIS is not difficult. Once the areas to be surveyed were delineated using *ArcView 3.2*, a new map layer was created to show the location of the landforms to be included in the survey. This layer was based upon the 'Lsys250' digital map layer described in detail below.

The Land Systems (Lsys250) overlay is a digital data set (1:250,000 scale) showing different land formations in Victoria, based on Rowan's (1990) land classificatory system. Numerous environmental variables are contained in this data set, and are mainly derived from field observations, aerial photography, satellite imagery and meteorological data. Rowan's (1990) system assumes that attributes such as rainfall, geology, topography, soils, and indigenous vegetation are not random occurrences, but are mutually dependant. Patterning occurs governed by geomorphic processes, which in turn influences the observable distributions of attributes such as soils and vegetation (Rowan, 1990:7). A land system is one mapping unit containing a complex series of attributes within that unit, which are readily identifiable from any other unit. The digital data attaches a unique identification code to each of these distinguishable units. For example, an identifier code such as $7.1Pvf4_2$ identifies one unique 'string' of attributes occurring in a given area (the same unit can occur more than once).

The code $7.1Pvf4_2$ translates into the following series of attributes: -

7.1 = West Victorian Volcanic Plains

P= Undulating Plain

v= Volcanic rock

f= Finely textured unconsolidated deposits

4= 400-500mm annual rainfall

$_2$= Subscripts identify units with similar landforms, climate and lithology, but differing soils and vegetation. In this case, there are two other units similar to this one, differing only in soil type (Rowan, 1990:50).

While this type of complex mapping was once performed manually (McConnell, 1995), this information is now available for use with GIS in digital format. The data is available for the entire state of Victoria at 1:250,000. Using the 'Lsys250' data, and data files delineating the boundaries of the study area, it was a relatively simple process to calculate the amount of each land system within the study area, and the relative percentage of each land system required for surveying. Once the areal extent of the various land systems within the survey area are known, it is possible to proceed with the stratification of the sample.

Stratification

The survey design and proposed sample design for the Brisbane Ranges National Park will serve as an example of how the sampling process was designed to operate. One of the unforeseen complications in using the Brisbane Ranges National Park as part of the sample was the presence of an Aboriginal community boundary dividing the park in two. This contemporary administrative boundary follows a bitumen road (Durdiwarrah Road) splitting the park approximately in a 60:40 ratio. To the north of Durdiwarrah Road is the area under the control of the Ballarat and District Aboriginal Co-Operative, while to the south is the area under the control of the Wathaurong Aboriginal Co-Operative. This boundary does not follow any known traditional boundary, and is the result of *Aboriginal and Torres Strait Islander Cultural Heritage Protection Act (Cth) 1984*.

The aim for the Brisbane Ranges National Park was to attempt to survey 26 randomly located 25-hectare quadrats. This meant surveying two quadrats per day, with one day deliberately held over for any additional surveying. A field method similar to the 500x500 metre (i.e. 25 hectare) quadrats used by Ebert (1992) in his 'distributional' survey (*c.f.* Thomas 1975) was chosen. Therefore, 26 randomly located quadrats of 500x500 metres needed to be located within the Brisbane Ranges National Park. The complication here being that I not only had to stratify according to land system, but in the interests of local community politics and fairness, I had to locate an equal weighting of survey energy in each of the Aboriginal Co-Operative areas discussed above. Firstly, then, the park was stratified according to Co-Operative area (Table 4-1).

Community Area	Hectares	% of Total
Wathaurong Area	3,306.5	41.1
Ballarat Co-Operative Area	4,738.9	58.9
Total	8,045.5	100.

Table 4-1: Distribution of lands in the two community areas.

In order to utilize 26 survey quadrats of 500x500 metres each, distributed fairly between the Co-Operatives: -

Calculation = 26 Quadrats x % of area for each community area.

Therefore: -

(1) 26 quadrats x (0.4109) = 10.68 (11 quadrats = 275 ha)

(2) 26 quadrats x (0.5891) = 15.41 (15 quadrats = 375 ha)

A total of 650 hectares was selected for surveying in the Brisbane Ranges National Park. This represents approximately 8.0% of the park. This stratification technique was selected to maintain an even and fair distribution of survey quadrats, and hence community employment opportunities, based solely upon the total area under each co-operatives jurisdiction. Having established that 11 randomly located survey quadrats were required in the Wathaurong area and 15 in the Ballarat Co-Operative area, the next step was to stratify each area by 'landform'.

In the Brisbane Ranges National Park, including the Steiglitz Historic Park, there are three main landform types (Table 4-2).

Landform	Description
Plain	(Relief 9-30m)
Low Hill	(Relief 30-300m)
High Hill	(Relief 300m and above)

Table 4-2: Landform types present in the Brisbane Ranges National Park.

Within the Ballarat Co-Operative section of the park (4,738.963 ha), the various landforms account for the following proportions (Table 4-3).

Landform	Proportion
Plain	85.208 ha (1.79%)
Low Hill	1,218.991 ha (25.72%)
High Hill	3,434.764 ha (72.48%)

Table 4-3: Proportion of Landforms within the Ballarat Co-Operative section of Brisbane Ranges National Park

Therefore, of the 15 survey quadrats allocated to the Ballarat Co-Operative area (Table 4-4),

Landform	Number of Quadrats
Plain	0.0179 (15) = 0.268
Low Hill	0.2572 (15) = 3.858
High Hill	0.7248 (15) = 10.872

Table 4-4: Number of Survey Quadrats allocated to the Ballarat Co-Operative area of the Brisbane Ranges National Park.

Rounding to the nearest whole number, the Ballarat Co-Operative area was stratified so as the 'High Hill' unit received 11 survey quadrats, the 'Low Hill' unit received four survey quadrats and the 'Plain' unit was numerically allocated no quadrats (including some of the plains unit in an opportunistic sample during the fieldwork rectified this anomaly).

The Wathaurong Aboriginal Co-Operative area was stratified using the same method. Thus, within the Wathaurong Aboriginal Co-Operative area of the park (3,306.558 ha), the various landforms account for the following proportions (Table 4-5).

Landform	Proportion
Plain	1,025.282 ha (31.01%)
Low Hill	1,073.300 ha (32.46%)
High Hill	1,208.003 ha (36.53%)

Table 4-5: Proportion of Landforms within the Wathaurong Co-Operative area of the Brisbane Ranges National Park.

Therefore, of the 11 survey quadrats allocated to the Wathaurong Aboriginal Co-Operative area (Table 4-6),

Landform	Number of Quadrats
Plain	0.3101 (11) = 3.411
Low Hill	0.3246 (11) = 3.570
High Hill	0.3653 (11) = 4.018

Table 4-6: Number of Survey Quadrats allocated to the Wathaurong Co-Operative area of the Brisbane Ranges National Park

Again, rounding to the nearest whole number, the Wathaurong Aboriginal Co-Operative area was allocated four quadrats in the 'High Hill' landform, four quadrats in the 'Low Hill' landform and three quadrats in the 'Plain' landform.

The process of randomly locating each of the 26 quadrats within the Brisbane Ranges National Park was not particularly difficult using GIS software. In this instance, a public domain random point generation script (program) written for *ArcView 3.2* was used. There are several other assumptions that must be taken into account in the random stratification process. The random points, once generated, were considered the bottom left hand corner of a 500x500 metre quadrat (i.e. the southwest corner). The remaining three corners of the quadrat were all then placed relative to the first point. Random points were eliminated from the process if they fell within 500 metres of a National Park boundary. It was originally considered necessary to stay completely within the boundaries of the National Park, as the park is bounded by private property on all sides, and permission had not been sought to cross these boundaries.

The points of origin were also at least 500 metres away from any other random point. If a randomly selected point of origin (i.e. the southwest corner of a quadrat) was closer than 500 metres to another random point of origin, this simply meant there had been a calculation error, as the points would be overlapping. Once the series of random numbers were generated, some minor rounding up or down was performed for the sake of later convenience in the field. This was to allow for rapid acquisition of locations in the field. The GIS was used to generate the random number as a series of Cartesian co-ordinates (x, y) in UTM (Universal Transverse Mercator) format. The result looked similar to the following example: -

X= 251621 (easting)
Y= 5809411 (northing)

Again, for convenience in the field, the figures above were rounded up or down as follows: -

X= 251621 becomes 251500 (-121 metres)
Y=5809411 becomes 5809500 (+89 metres)

Twenty-six sets of co-ordinates like the above example were generated. Once rounded up or down, the co-ordinates were entered into Microsoft Excel and saved in text format. This allows the raw data to be uploaded into the memory of most contemporary Global Positioning Systems (GPS). The final field-ready results of this process can be seen superimposed on to a map of the Brisbane Ranges National Park (BRNP), in Figure 4-2.

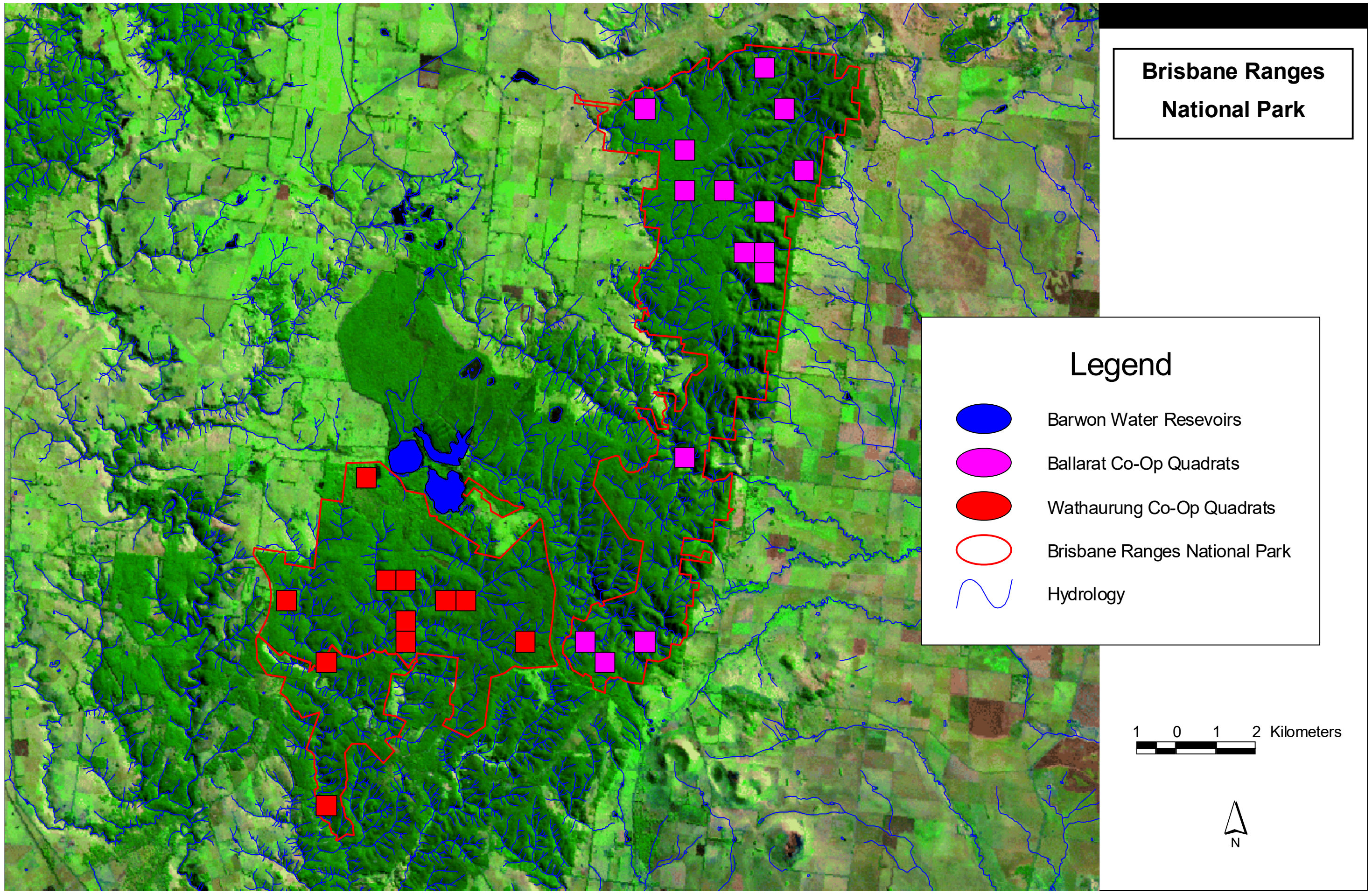


Figure 4-2: The 500mx500m survey quadrats laid out within the Brisbane Ranges National Park. The northern portion of the park is the area referred to in the text as the Ballarat Co-Operative area (Pink Quadrats), while the southern portion of the park is referred to as the Wathaurong Co-Operative area (Red Quadrats).

Once the sample areas were selected, the random points were loaded into the memory of the differential GPS (DGPS) unit, which was on loan from Omnistar Pty Ltd. This type of unit (Omnilite 132) provides real-world precision beyond the capabilities of most other GPS equipment. This type of DGPS delivers sub-metre accuracy in virtually all conditions. Locational readings accurate to plus or minus one metre are more than adequate for a distributional survey of this nature (Wandsnider and Camilli, 1992). Although such pinpoint accuracy may be considered as overkill when recording archaeological material in a survey of this nature, it is equally no burden to have this level of accuracy. Most common GPS receivers offer positional accuracy no better than ± 10-15 metres.

The major benefit of DGPS is precise recording in the field without the necessary skill required in traditional surveying methods, such as using Electronic Distance Machines (EDM) or theodolite. A DGPS point, line or polygon reading, once downloaded and mapped into a GIS program can be visually checked for accuracy relatively quickly. If there were disturbances in the signal while the DGPS was in the field post-processing data is available to correct for anomalies such as solar flares. The owners of satellite based differential signal networks can verify, at any given time, the accuracy of the signal that each field unit is receiving, thus verifying the positional accuracy of the unit. Any maps created in a GIS environment from the data collected using DGPS can be easily verified by checking mapped objects against known survey markers or other known points.

Field Operation

In the field, it is a relatively straightforward process to navigate to selected waypoints using a DGPS unit. Any GPS unit will allow the user to navigate to point on the landscape with a reasonable degree of precision. For the purposes of this survey, it was known at any given point in time where the field crew would be on the landscape to an accuracy of plus or minus one metre. Once the field crew had been directed to the selected quadrat, a standard prismatic compass could be used to orient the quadrat to magnetic north. The actual surveying was planned in a simple enough manner. From the selected waypoint, the crew would progress north for a distance of 500 metres. The crews of between 10 and 15 people would be spaced evenly at a distance of five metres apart. Once the first transect had been completed, the crew would turn 180^0 and walk another

transect 500 metres due south. This process would be continued until the entire 250,000 m^2 (25 hectares) had been surveyed.
The information relayed to the DGPS via satellite is updated every second, so precise locational data is known at any given point. While the DGPS was mainly used to orient and record precise point data, this type of equipment can be used to record virtually any geographic item. For instance, surface features can be mapped quickly and accurately. Similarly, spot heights can be recorded to produce a contour map at a later stage. By using DGPS, there was no need for marking out quadrats with tapes, stakes or string lines. Similarly, using aerial photos or maps to locate quadrats is superfluous (Ebert, 1992:161). Topographic maps were only needed to locate the nearest road access point to the selected waypoints. Similarly, aerial photos were only used to assess vegetational coverage. Although technology has advanced to the point where we can take to the field without the use of maps or aerial photographs, these items carried at all times in case of equipment failure. In the event of an equipment failure, the UTM co-ordinates could still be located manually, albeit without the same degree of precision.

The relative surveying or archaeological skill of each member of the field crews was unknown before actually arriving in the field. It was assumed that all volunteers required the same training for this project, regardless of any individual's prior learning or background. The first half-day of each survey session was spent discussing the project with the volunteers. During this discussion, the field methods to be employed for the survey were explained, including how the survey would proceed, basic artefact identification and recording, use of the DGPS, getting to and from the field locations, logistical matters, and general house-keeping. The various Aboriginal field workers who were employed throughout the survey and Parks Victoria (PV) staff assisting in the survey works were present at these briefings. Each field crewmember was to carry a number of fluorescent flags on wire bases with which to mark any artefacts located. The flagged artefacts were then to be recorded using a customised recording form.

One of the major objectives of the fieldwork was to collect baseline archaeological data for use in the predictive modelling component of the project. Collecting this data from various landforms and locations was an attempt to create a 'non-biased' data set for modelling purposes, rather than being reliant upon the existing data sets. With this in mind, it was decided to base the recording of material for this project at the artefact level, in a manner similar to Ebert's (1992) 'distributional' survey methodology. This 'off-site' approach assumes that the archaeological record consists of a continuous distribution of archaeological materials across the landscape, with areas of higher or lower artefact density. The higher density areas are traditionally called 'sites'. The 'off-site' approach allows the direct comparison of materials and their setting in the landscape from any region, without the added complications or intellectual baggage of defining what constitutes the 'site'. At the artefact level of recording there are none of these problems. Indeed, as Ebert (1992:69) comments 'sites are never discovered during survey, it is always artefacts, features and other individual, physical real materials that we find' rather than any abstracted notions of the 'site'. Archaeologists analysing their field data construct archaeological 'sites' after the conclusion of surveys.

Creating a dataset for this thesis at the artefact level was a comparatively straightforward exercise, albeit not without limitations. The nature of the surface archaeological record in the study area meant that an enormous quantity of data would be generated rapidly by recording every artefact. Given the time constraints of the project, and the sheer volume of data, it was decided to limit the number of attributes recorded for each artefact. This limiting of attributes was also seen as a way of maintaining consistency across the four survey teams by reducing the amount of possible 'interpretational' error or bias introduced by different field workers. Thus, the attributes recorded for each artefact were kept relatively straightforward. Bearing in mind that the data requirements for this project are primarily spatial, the survey recording form (and associated artefact attributes) were designed to reflect this objective. Table 4-7 details each of the artefact attributes recorded.

Field	Notes
Record No.	Unique alpha-numeric code given to each recorded item
Type	This field was an attempt to integrate the standard AAV site codes used in the Minark recording system, as well as some added by me
Type Sub-Class	This field is for a more precise description of the item being recorded, i.e. broken flake or geometric microlith.
Material	Raw Material type for each artefact recorded
Size	The maximum dimension of each item recorded (excepting scar trees) to be determined from a simple size chart (shown in Appendix 9-4)
Retouch	Has the item been retouched or reworked in any way? Yes or No?
Cortex Percentage	An estimate of the cortical percentage where applicable
Easting and Northing	UTM co-ordinates as given by the DGPS
MASL	Metres above sea level, as given by the DGPS
Vis %	An estimate of the surface visibility at the point where the item was being recorded
Photo	Photograph taken and number from digital camera (not every item)
Comment	Any relevant comments from the recorder.

Table 4-7: Details of the various attributes recorded for each artefact located during the BPAP survey.

These attributes were chosen because they can be assessed rapidly by visual inspection alone, and did not require the survey volunteers to have a particularly advanced level of archaeological field skills. They were also chosen to provide minimal additional information regarding the individual artefact. For example, the physical size and amount of cortex present on a core can indicate the level of reduction the core has undergone (i.e. a small, heavily reduced core with no cortex may have been exhausted as a raw material source). Similarly, the presence of retouch or use wear on certain artefacts can tell us something of the activities that may have been taking place in the locality where the artefacts were found. The scarcity of certain stone may also be inferred from the amount of reduction that artefacts made on that material have undergone. The attributes are essentially the same as those collected by consultant archaeologists, thus perhaps allowing some degree of comparability between those data sets gathered by consultants, and those gathered as part of this project.

The positional information (Easting, Northing, and Metres Above Sea Level) was collected directly from the DGPS for each item. In the interest of maintaining a backup system, the DGPS data was mostly recorded manually rather than using the data-loggers. Some data was recorded using the hand-held computer, which generally worked quite well. Data entry fields were provided on the recording form for the type of artefact, the artefact sub-class, material, size, retouch (yes or no), cortex percentage, easting, northing, metres above sea level, visibility percentage estimate, photograph number, and comments.

A small ‘target’ style artefact-measuring card was used to measure artefacts (See Appendix 9-4), and place them into one of seven classes:

- Size Class 1= 1-25mm,
- Size Class 2=26-50mm,
- Size Class 3=51-75mm,
- Size Class 4=76-100mm,
- Size Class 5=100-150mm,
- Size Class 6=151-200mm, and
- Size Class 7= >200mm).

Surface Visibility conditions were estimated for each artefact recorded. The purpose of this was to estimate the percentage of actual ground surface unobscured by vegetation or other non-archaeological material.

Overall, the system worked smoothly. For this survey, where the major goal was recording spatial information relatively quickly, the recording form was adequate. If more data were considered necessary, then this system of recording would need re-designing. The system was rapid, simple, and unambiguous. The functions available using the handheld computer attached to the DGPS unit, however, were tested and found somewhat lacking. The software installed in this type of unit is a ‘generalist’ package for data capture. Data can only be entered in a few fields as text. There is limited ability to customise the software for specific uses, such as an archaeological survey. Highly customisable third party software is available for use on this type of handheld computer, such as ‘*ArcPad*’ produced by Environmental Systems Research Institute (ESRI), the producers of *ArcView* and *ArcInfo* GIS packages. This software, or similar, could easily be used to design a data capture system specifically for field archaeologists, based on either personal specifications or perhaps a system designed to integrate fully with those being designed by Aboriginal Affairs Victoria (VAHIS – or Victorian Aboriginal Heritage Information System).

Some Definitions

As the major thrust of this thesis is predominantly spatial and attempts to look at the patterning of site(s) occurrence in space, stone artefact data collection and analysis was a secondary, but nonetheless important, objective. In order to maintain a relative consistent approach to artefact definition across different regions, with different field crews, the relatively simple artefact definitions proposed by Hiscock (1988), and discussed by Holdaway and Stern (In Prep.) were adopted.

- Core – An artefact displaying negative flake scars made in the production of other flakes. May also display cortex on one or more surfaces.
- Flake – Flakes must display a ventral surface. May also display a bulb of percussion, striking platform, and cortex on the dorsal surface only.
- Tools or Implements – Artefacts that display evidence of secondary retouch or use wear of some form, and
- Debris – All other material that is the product of stone tool manufacture, but does not obviously conform to the preceding three categories.

While this is by no means a definitive set of artefact classifications, and much has been written and debated regarding typological and functional classifications of Australian lithics (Fullagar, 1986; Hiscock, 1983; Hiscock, 1985, 1993; Hiscock and Mitchell, 1993; Kamminga, 1982; Morwood and L'Oste Brown, 1995; Wright, 1977) this scheme was adopted for its simplicity and replicability, rather than any analytical power.

Land Access

Access to land for conducting a large field survey on the fringe of the Melbourne urban area was always considered somewhat problematic, mainly because of the closely settled nature of the urban-rural fringe. Several strategies were employed early in the fieldwork planning process to alleviate the land access problem. These strategies were:

(a) A feature article on the project and the archaeology of the Maribyrnong Valley was published in the ‘Sunbury-Macedon Regional News requesting access to properties in the region,

(b) Members of the Upper Maribyrnong Catchment Landcare Group were approached at a regular monthly meeting after a lecture given on the archaeology of the region. Twelve landowners granted access to properties ranging from five to 2,500 hectares,

(c) Parks Victoria Ranger’s-in-Charge across the region were approached to be involved with the project.

It was explained to the landowners that the main interest of the project was in the larger properties where a variety of landforms could be surveyed without interruption by property boundaries. Out of courtesy however, all properties offered were visited. The larger properties contained an adequate representation of the geomorphic units needed for the survey. It was also considered more efficient in terms of time and energy to be based for longer periods at the larger properties. Commuting back and forth between smallholdings with a survey crew of 12-15 people would have been relatively cumbersome. Basing survey operations on the larger properties allowed the project crew to become much more familiar with the area in question than if only a short period was spent at each location. This familiarity allowed the intuitive identification of areas where archaeological deposits might occur, outside of the sampling frame established for each locale. Having inspected a variety of properties, three larger holdings were chosen as the sample areas around Deep Creek – Darraweit Guim. In total, these three properties provided some 3,460 hectares for survey.

While negotiations were in progress with the Upper Maribyrnong Catchment Landcare Group, negotiations were underway with staff from Parks Victoria in order to ascertain where it might be appropriate to access Parks Victoria managed lands for surveying. Within the study area however, there is a limited amount of land remaining in public ownership, the majority of lands being freehold.

Fieldwork Sessions

The survey was divided into four sessions. Each session was to be conducted in a different part of the study area. Each session was of between 10 and 14 days duration. The fieldwork sessions were to be conducted at:

(1) Brisbane Ranges National Park
(2) Deep Creek Farms
(3) Organ Pipes National Park, and
(4) Woodlands Historic Park.

4.4. Project Limitations

One over riding limitation of this project is the difficult task of integrating cultural resource management data with an academic or research oriented question or series of questions. The data collected for CRM purposes over the years was never designed for a problem oriented research project. As pointed out by Witter (1977), CRM data is not generally designed for in depth analyses or comparison, but is collected as an inventory of archaeological sites located. Alongside this major constraint, numerous other limitations encountered during the course of the research had varying impacts upon the project outcomes, and the writing of this thesis.

Visibility

Without doubt, the greatest single limitation in any pedestrian survey is ground surface visibility. For the majority of the fieldwork conducted for this thesis, the surveying activities took place in areas of extremely low surface visibility. This seriously limits the effectiveness of archaeological surveying. Indeed, for archaeological surveying to be effective, surface visibility should be 20% or greater (Hall, 1989; Simmons and Djekic, 1981). Having the luxury of being able to relocate to areas of better visibility allowed the survey to continue, and for a great deal of data to be collected. Also utilising slightly unorthodox methods at times, such as using a garden rake to expose the ground surface, yielded increased artefact data in certain areas.

Data Access

When archaeological sites are recorded in Victoria, AAV requires that each new recording have an individual site card lodged with the registry. From these site cards, the data for each new site is entered into the registry's computerised sites database. Until 2002, this database was the MINARK system. A new database system was introduced towards the end of this project, known as VAHIS (Victorian Aboriginal Heritage Information System). Data held in MINARK was transferred to the new VAHIS database during the upgrade process.

To analyse data using GIS, specific data structures are required. Namely, if we wish to analyse point data (such as site locations), then the table of data in question must contain only one row of data per unique point. The unique row of data can contain up to 255 fields of information per point. For example, if we use the AAV site number as the unique identifier of each site (this, in fact is the only unique identifier available), the unique identifier value (i.e. the site number) can only appear in the table once. However, an enormous quantity of data can be attached as columnar data to this unique identifier. Indeed, an *ArcView 3.2* table can hold up to four billion records.

There is a major problem when data from either MINARK or VAHIS is to be analysed using a GIS package such as *ArcView 3.2*. The original data structure of MINARK was such that multiple values could be entered into each field of the database for each of the variables recorded on the AAV site cards. In this way, one site card could contain all the information considered necessary about the site in question, which is then entered into MINARK. Therefore, for MINARK variable number 26 for instance, 'Site Contents', the

MINARK user could enter up to 32 values in the same field. There are 96 possible variables in MINARK, most of which allow multiple value entries per variable per field.

ArcView 3.2 utilises the DBase (*.dbf) file format, and as such can only use single value fields per variable. Consequently, data exported from MINARK has the multiple entries 'stripped out' as it is imported into the *ArcView 3.2* DBase format. This leaves one row of data per unique identifier (site number). Large quantities of the more useful data are lost in the file translation process. There may be ways in which this problem could be addressed when exporting data from MINARK, however I had no control over this stage of the process, and as such could not manipulate the MINARK data prior to export. VAHIS initially appeared to be the solution to these problems. This however, was not the case. While VAHIS utilises a more complex and scaleable relational database structure, the same problems arose when data was exported from VAHIS to tables for import into *ArcView 3.2*.

The net result of the various data supply and translation problems has been that the vast majority of the actual archaeological data in the older MINARK system, and the current VAHIS system could not be accessed for this project. Unlimited access to these systems was not allowed as the data is considered sensitive, and certain copyright issues were believed to exist. Aboriginal Affairs Victoria was also moved from the Department of Human Services to The Department of Natural Resources and Environment midway through the project, adding another layer of complexity to the data access and usage problems (AAV was moved once again from the Department of Natural Resources to the newly created Department of Victorian Communities within the Department of Sustainability and Environment immediately following the Victorian election victory of the Brack's Labour Government in December 2002). Thus, from the data supplied a reconstructed series of tables were created which could be utilised in *ArcView 3.2*. These useable tables took an extraordinary length of time to create; given the quantity of data supplied. The data supplied from MINARK and VAHIS consisted of tables containing hundreds of thousands of cells of information, which had to be formulated into a useable table for the 1,005 sites analysed for this thesis. One table provided by AAV in May 2002, for example, contained 49,236 rows, each row containing nine fields of data (443,124 cells). The final tables constructed from these raw tables contained approximately 22,000 cells of data. Unfortunately, some of the more valuable data in the MINARK database for spatial analysis was not useable. Quantitative data such as the artefact types, numbers and raw materials present for each site could not be extracted into *ArcView 3.2* compatible tables for this thesis. This integration may be possible at some stage in the future, perhaps utilising different software or stand-alone programming, however these possibilities were beyond the scope of the thesis, and beyond the control of the author.

Shovel Test Pitting

Several of the CRM reports (n=12 or 6.7%) discussed in Chapter 3, made use of various small-scale sub-surface testing regimes. These techniques include shovel test pitting (n=10), auguring (n=1), and one series of 500mmx500mm test pit excavations. The purpose of this section of the thesis is to discuss the efficacy of these techniques, analyse the results achieved, and determine the effectiveness and applicability of these techniques for the questions being addressed in this thesis. Small scale sub-surface sampling techniques, such as shovel test-pitting (STP) have been developed as a means of assisting in the location of sub-surface archaeological materials during archaeological survey. These methods have been applied both to the recovery of buried materials from known surface sites, and to the discovery of hitherto unknown sub-surface deposits, particularly where surface visibility is poor (Lightfoot, 1989). Although seldom mentioned in the Australian CRM or archaeological literature, these techniques have been utilised in numerous projects and contexts (du Cros, 1989, 1993, 1995; du Cros and Porch, 1996; Lane and Sciusco, 1996; Marshall, 1996a, 1996b; Nicholson, 1998; Rhodes and Murphy, 1994; Richards and Sutherland, 1995; Smith, 1995b).

Shovel test pitting (STP) developed very early in the history of formal archaeological sampling when it was recognised that if archaeologists could not see the ground surface, then the chances of finding archaeological phenomena diminishes accordingly. These ‘diminished returns’ were compounded and made more problematic when the data was to be used to make inferences about particular sampling universes (Nance and Ball, 1986). Thus, the STP methods were developed in the hope that this type of sampling would allow for the recovery of representative samples of material from otherwise ‘invisible’ (Nance and Ball, 1986) contexts, and allow for more accurate inferences to be made regarding distributions of archaeological material. Like any techniques however, STP sampling has its champions and its critics. The American and European archaeological and CRM literature contains many case studies arguing either for or against the application of these types of sampling methods (Canti and Meddens, 1998; Howell, 1993; Kintigh, 1988; Krakker, Shott and Welch, 1983; Lightfoot, 1986, 1989; Lynch, 1980; Nance and Ball, 1989; Shott, 1985, 1989; Stone, 1981).

A major perceived benefit of STP is that it can be used as a 'method of last resort' in archaeological surveying. When other techniques (such as field survey) prove impossible due to poor visibility, STP can be utilised. Once an STP sample is collected, statistical techniques can be applied to the data to estimate the overall density of archaeological material present in any given area, or indeed the probability of encountering further archaeological material. In any case, the use of a systematic sampling technique, such as STP, is often seen as preferable to the use of non-systematic sampling techniques (Shott, 1985).

Like all methods of archaeological data recovery, the use of STP is subject to the vagaries of the environment in which it is to be used, the limitations or requirements of the research questions being addressed, the expense of STP (Nance and Ball, 1986), and the archaeological 'return' for the time and money invested. Given these factors, the use of STP is not always either practical or appropriate. The examples available from the study area demonstrate that STP is somewhat limited in the quantity of data capable of being recovered using this method in CRM survey activities. From the CRM reports for the study area, three projects made use of STP as a data recovery technique, and seven projects made use of STP as a site discovery technique. While this sample is too small to draw definite conclusions, these projects illustrate that STP has proved to be a better data recovery technique than a data discovery method in the current study area (the projects utilising auguring and 500mm^2 excavations could not be easily quantified, so have been excluded from the following calculations).

Example	Pits Excavated	Artefacts Recovered	m^3 Excavated	Artefacts $/m^3$	Known Sites
1	18	7	0.144	48.6	No
2	51	3	0.408	7.3	No
3	45	3	0.360	8.3	No
4	66	33	0.528	62.5	No
5	88	0	0.704	0	No
6	119	2	0.952	2.1	No
7	150	23	1.200	16.1	No
8	76	39	0.608	64.1	Yes
9	165	522	1.320	395.4	Yes
10	150	65	1.200	54.1	Yes
Total	928	697	7.424	-	-
Average (all)	92.8	69.7	0.742	93.9	-
Average (excluding known sites)	76.7	10.1	0.613	16.4	-

Table 4-8: Data from Victorian CRM reports in the study area for this thesis that have utilised shovel test-pitting methods. These results indicate a recovery rate of 1 artefact per 1.33 shovel test pits. Volumetric measurements assume that each test pit conformed to 0.2mx0.2mx0.2m dimensions (0.008m^3). The 'm^3 excavated' figures assume that 0.2mx0.2mx0.2m test pits were utilised.

Table 4-8 presents data collected from 10 CRM reports in the study area that utilised STP as a data collection method. As Table 4-8 shows, 928 shovel test pits were excavated, recovering 697 artefacts. This is an average of 69.7 artefacts per STP exercise, from an average of 92.8 test pits, or 1 artefact per 1.33 shovel test pits. Three of the sites subjected to STP were previously known sites, and not sites newly located by the STP exercise. If these three sites are removed from the calculations the results of the other seven STP exercises appear very different. Removing these three sites from the totals, results in a revised total of 537 shovel test pits having been excavated, resulting in the discovery of 71 artefacts, or one artefact per 7.6 shovel test pits.

The actual amount of sediment excavated from these STP exercises could not be calculated from the CRM reports, as most report authors did not list this data. However, if we assume that all the STP were 0.2m x 0.2m x 0.2m (0.008m^3), then approximately 4.3m^3 of soil has been excavated and sieved to recover or discover these 71 artefacts. (0.06m^3 per artefact or 16.4 artefacts per m^3). As a method of site discovery, STP would appear to be somewhat limited. However, as a means of data recovery from known sites (including locating site boundaries), STP appears far more efficient and useful. From the three known sites in the examples, 391 shovel test pits recovered 626 artefacts or 0.62 shovel test pits per artefact (0.01m^3 per artefact or 93.9 artefacts per m^3). This represents a rate of data recovery approximately six times greater than when the STP method was used as a means of site discovery alone (i.e. 93.9 artefacts/m^3 ÷16.4 artefact/m^3 = 5.7).

While it is not possible to quantify the data from the Victorian CRM reports further, the American and European CRM and archaeological literature supports the notion that STP is not appropriate for all sampling circumstance. Indeed, many practitioners have come to believe that STP has some very severe limitations (Shott, 1985). Firstly, STP methods are not appropriate in some environmental contexts. For example, STP sampling would not be of great benefit on the side of steep hill slopes, where any material discarded in prehistory has most likely been moved down slope through time. Smith (1995b) experienced great difficulty in certain forested environments in Tasmania where the vegetation was so dense that STP could not be used to penetrate to the ground. These factors may be controlled at the survey design stage by choosing sample areas where STP can be applied without undue environmental hindrance, although this is not always possible. Similar limitations were envisaged in the current study area where the soils of the basalt plains and hill environments are predominantly shallow and stony.

The major problems with STP as a field technique however, are not related to where it may or may not be most conveniently applied, but simply the scale at which it is to be applied, and the nature of the archaeological record being sampled. The higher the latent density of artefactual material present, the more effective STP is at discovering new material. This efficiency is still quite low however. For example, in a computer simulation of the effectiveness of STP, Kintigh (1988) determined that test pits needed to be a minimum of 1m x 1m in order to have an 87 percent chance of finding at least one artefact where the average artefact density is two artefacts/$m^{2.}$ Similarly, Lynch (1980) concluded that unless extremely small transect intervals were used when laying out STP samples, only the densest of artefact scatters would be identified. In general, the literature supports the conclusion that the performance of STP as a discovery technique is 'much poorer than other methods' (Shott, 1985) and is not well suited for use in areas 'characterised by low site density, and low artefact density within sites' (Shott, 1985).

Shovel testing provides a 'proof of presence' test for cultural materials at very low resolution. The binary opposites 'present' or 'absent' do not provide a great deal more data than a surface survey, particularly when it is recognised that STP seldom penetrates the plough zone. The STP programs from the study area have not assisted in the recovery of chronological data, and as such do not contribute greatly to understandings of the prehistory of the region. Archaeological excavation (where appropriate) is the only method in which stratified material can be investigated, and placed into a chronological, geomorphological and regional cultural context.

As a method of data recovery from known sites, STP is a valuable and efficient tool. However, STP is not a particularly efficient means of site discovery in the current study area, particularly as the size of the area being investigated increases. Krakker *et al* (1983:469-480) conclude that 'executing anything approaching an adequate subsurface testing program for a substantial sized area generally seems out of practical reach'. More research needs to be devoted to testing the effectiveness and efficiency of STP under Australian field conditions, rather than uncritically adopting a method not entirely suited to the nature of the Australian hunter-gatherer archaeology. Given the arguments within the CRM and archaeological literature concerning STP, and the apparent inefficiency of STP in the CRM reports from the study area, a choice was made not to utilise STP as a component of the sampling design for this thesis.

Environmental Determinism

Much has been written on the subject of environmental determinism and archaeology. In the arena of predictive modelling from existing data, such as the case here, basing models partially on environmental data is an unavoidable condition. Because of the cost and time constraints of creating GIS data, modellers tend to make use of available data sets, and attempt to determine relationships between environmental variables and regional archaeological spatial distributions. From these relationships, if any exist, it is hoped to produce a 'model' of archaeological spatial distributions that may aid in the preservation of archaeological sites, rather than causal explanation of archaeological phenomena. It is constructive to recognise that GIS and GIS data sets were not designed with archaeology in mind, but can be used to assist in the construction of archaeological models nonetheless.

The type of model being developed here is primarily designed to predict and protect archaeological materials within a CRM framework; therefore, it has been argued that a different set of rules should apply 'essentially sanctioning the environmental determinist approach for practical reasons' (Gaffney and van Leusen, 1995). The aim of CRM-based models is to identify relationships and describe patterns in known data with a view to forecasting the likelihood of unknown resources occurring in specific areas.

It is therefore specifically acknowledged that these types of models do not take account of the cultural or cognitive aspects of human settlement systems, and instead rely on identifiable patterning across the landscape. It should be noted that the validity of this approach increases as the scale of observation increases (Gaffney and van Leusen, 1995). As we move further away from the local and specific (micro) to the regional and systemic (macro), repetitive spatial patterning becomes clearer, while the impact or influence of cultural or cognitive choices appear to become less apparent.

This chapter has introduced and discussed the methodology used to stratify the study area, and some of the specific limitations involved in conducting archaeological survey in this region. In the next chapter the fieldwork undertaken for this thesis will be discussed.

Chapter Five

5. In the Field

This chapter provides a detailed discussion of the fieldwork undertaken during the course of this project: the areas surveyed, the methods employed, and the conditions encountered. After discussing the fieldwork and the results obtained some of the practical and theoretical limitations that had varying impacts on this project are considered.

5.1. Introduction to the Fieldwork

Like every other practitioner who has attempted to conduct field survey, the survey results discussed here were subject to a range of biases and limitations. As with other projects discussed in Chapter 3, surface visibility proved to be the single most difficult obstacle. In some areas, it was simply impossible to complete any surface survey at all due to the very poor visibility. Consequently, the original research design, which called for a probabilistic sampling approach, had to be abandoned very early in the fieldwork program. In an ideal world, a probabilistic sampling method would be used in virtually all survey work. However, the conditions encountered during the fieldwork for this thesis were far from ideal. The project could not be moved to another area of the state with better visibility conditions, as the project was designed around the rural-urban fringe of Melbourne. Collecting data for developing predictive models or models of Aboriginal behaviour is (arguably) best undertaken in more arid areas where visibility is not such an issue (Holdaway and Wandsnider, 2001; Holdaway *et al.*, 1998; Johnson and Witter, 1996; Lewis, MacNeill and Rhoads, 1996; Pardoe and Martin, 2001; Robins, 1997). For example, much of the predictive modelling literature from the United States in particular is based on projects undertaken in the more arid southwest (Dean, 1990; Fuller, Rogge and Gregonis, 1976; Matson and Lipe, 1975), where conditions are most suited to surveying. However, this project was designed to answer questions specifically relating to the unique environmental conditions encountered in the Melbourne region.

Consequently, the results of the field survey discussed here are subject to much the same biases as many other data sets collected from field survey within the study area. Where the data collected here may differ though is in the ‘intensity’ of the survey utilised to collect it, the total area surveyed, and the level of detail recorded. While the probability-based methods were not tenable, this project was afforded the luxury of being able to choose virtually all areas displaying higher visibility for survey across the study area. Specific limitations and constraints are discussed at the end of this chapter.

5.2. Brisbane Ranges National Park.

Fieldwork in the Brisbane Ranges National Park (BRNP) commenced on Wednesday 6th December 2000, and ran for 14 consecutive days, until Wednesday 20th December 2000 (inclusive). Fourteen people took part. Comparatively little archaeological work has been undertaken within the BRNP. Only one other major archaeological survey has been completed within the park. Petra Schell's (1994) survey of the BRNP located and recorded 345 artefacts in a five-day survey program. Schell (1994) did not conduct any form of systematic surveying, choosing to survey walking paths and picnic areas only (1994:16). She explained that this was considered necessary as poor visibility; dense vegetation and difficult topography forced her to concentrate on cleared and accessible areas. She does not disclose the total area surveyed. Schell recorded 11 artefact scatters, two isolated artefacts and one scarred tree (1994:16). Of the 345 artefacts, quartz appears to dominate the assemblage in all of the 'land units' inspected. Silcrete and quartzite are also noted as being present. Schell's report does not provide the raw figures for most of the material recorded, so it was not possible to calculate the percentage composition of the assemblage, while the graphs of the assemblage composition are unclear. Notable results from Schell's survey were (a) the dominance of quartz in the assemblage, and (b) the paucity of material located in 'swampy' areas (1994:18). Schell noted the presence of quartz outcrops in the Brisbane Ranges, and an outcrop of silcrete near the historic township of Steiglitz. This silcrete outcrop showed evidence of quarrying activities by Aboriginal people. Before the commencement of survey for this thesis, there were 15 archaeological sites recorded in the BRNP. These sites are four isolated artefact occurrences, ten artefact scatters, and one scarred tree.

Two other archaeological projects have been undertaken in or near the BRNP. In 1998, Brendan Marshall and David Wines recorded a large artefact scatter in the grounds of St Thomas' church at Steiglitz Historic Park. This scatter was recorded in some detail as the area was to be asphalted for a car park (Marshall and Wines, 1998). Marshal and Wines (1998) recorded 776-flaked artefacts in this reasonably large scatter. The assemblage consisted almost entirely of silcrete, with only 2.0% of the total being made on any other raw material. The majority of the assemblage consisted of broken flakes, however there were a relatively large number of blades present (10.0%). This site is located along the banks of Sutherland's Creek, where several other sites were also discovered during Marshall and Wines (1998) project.

In 1997, a pipeline survey was conducted for the Moorabool Water Treatment Project (Brown and Lane, 1997). Brown and Lane conducted a two-day linear survey of approximately 10.4 kilometres of easement before the construction of a new pipeline. They recorded four artefacts during this survey. The only notable aspect of this survey becomes apparent when these results are compared to the results obtained from the fieldwork conducted for the thesis (In almost identical areas on the shores of the Stony Creek Reservoirs, Brown and Lane (1997) recorded no cultural material, while the survey for this thesis recorded artefacts by the thousand. Differing visibility conditions due to water levels or vegetation are possible reasons why Brown and Lane (1997) did not locate this material during their survey).

Brisbane Ranges National Park Fieldwork

The Brisbane Ranges extends from the town of Bacchus Marsh in the north, to Meredith in the south. At their highest point, the range reaches an altitude of 440 metres above sea level. Very steep gorges and valleys extensively dissect the eastern margin of the range, while the western margin of the ranges provides easier access with more undulating topography (Parks Victoria, 1997: 7). There is an extensive network of roads and tracks criss-crossing the park. These roads and tracks are the legacy of almost 166 years of pastoralism, timber harvesting, gold mining and park management activities throughout the 7,718 hectares of the park. While extensive, this network of roads and tracks does not provide complete access to large tracts of the park. Many areas of the park, particularly in the more rugged sections, can only be approached on foot

Geologically, the basal rock of the ranges consists of beds of tightly folded and uplifted Ordovician sandstone, siltstone, slates, and shales (Parks Victoria, 1997:7). This basal material has subsequently been overlaid by poorly consolidated silts and gravels, resulting in the formation of a generally infertile and eroded contemporary soil matrix (Parks Victoria, 1997:7). Surrounding the Brisbane Ranges on all sides is the extensive basalt plains of the ‘newer volcanics’ deposited over the last 2-4.5 million years.

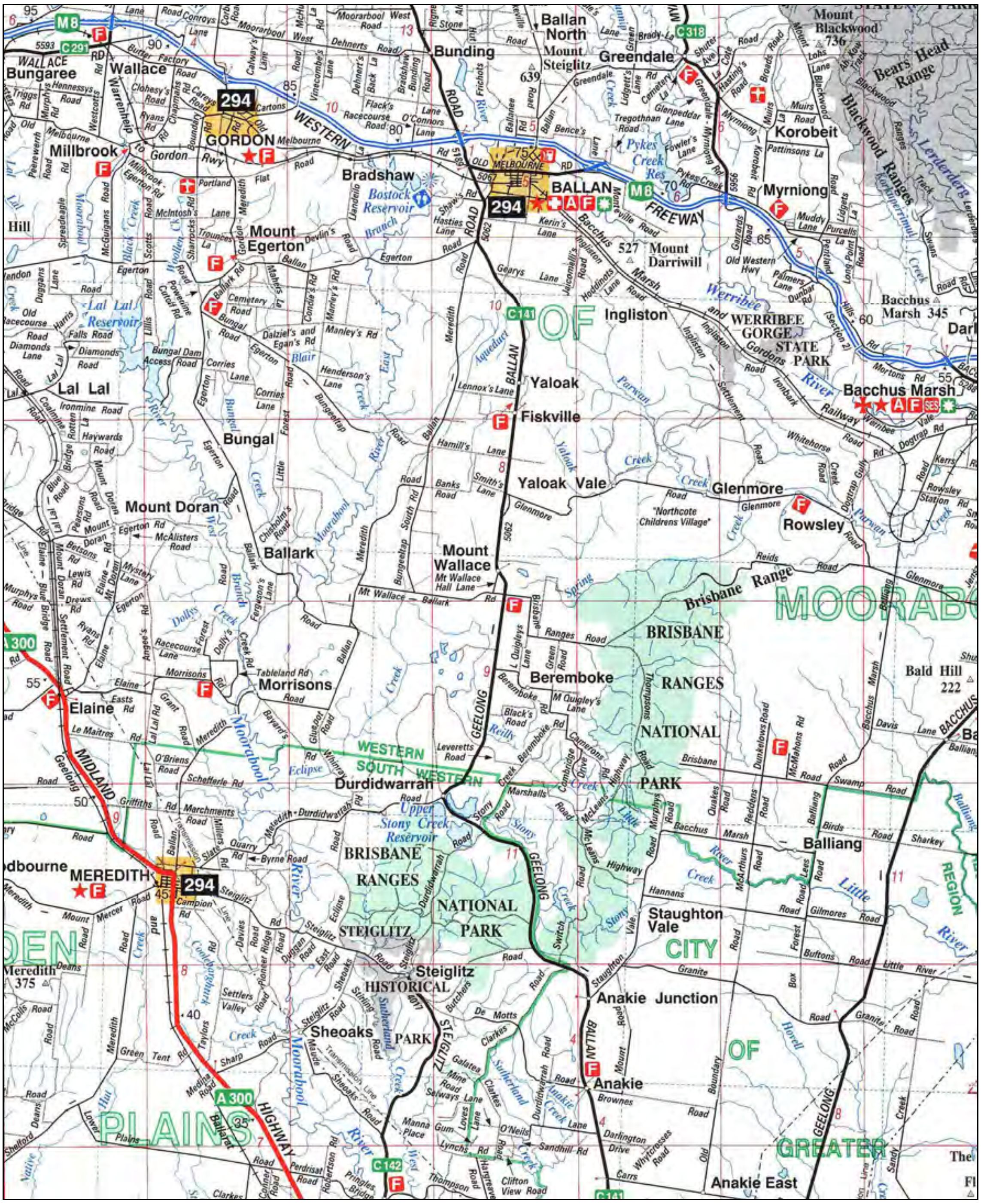


Figure 5-1: Locality map of the Brisbane Ranges National Park. Source: Vicroads Country Street Directory of Victoria (2000).

The BRNP has undergone radical environmental change since the arrival of European settlers after 1835. The most extensive environmental changes were caused by gold mining activities of the 1850s. Indeed, 'most of the trees seen today are either coppice regrowth or regeneration since harvesting operations' (Parks Victoria, 1997:7). Although the park today has an extensive and rich flora, including Messmate Stringy bark, Red Stringy bark, Broad-leafed Peppermint, Red Ironbark, and woodland areas of Manna

Gum, White Sallee, and Swamp Gum, (Land Conservation Council, 1985) there is virtually no old growth timber anywhere in the park.

This has obvious implications for the survival of culturally modified trees, resulting in a locally biased view of this archaeological site type. Despite the widespread disturbances of European pastoral and gold mining activities, the Victorian Wildlife Atlas (Natural Resources and Environment, 1997) lists 170 bird species, 25 mammals, 24 reptiles, and 15 frog species as being present within the park. This rich diversity of fauna, combined with some 475 floral species (Natural Resources and Environment, 1996), sources of stone raw material, and permanent fresh water supplies led Schell to conclude that the BRNP was a 'resource rich environment for Aboriginal people to exploit' (1994: 9).

Throughout the BRNP, ground surface visibility could only be described as extremely poor. The general ground surface visibility was significantly influenced by past activities in the park, such as gold mining. In certain areas, the land surface is entirely obscured by a mantle of crushed rock produced by the gold batteries that once operated in the park (Figure 5-2). In the more rugged areas of the park, ground surface visibility was more or less zero (See Figure 5-3). This lack of visibility, combined with thick and scrubby regrowth, dense *Xanthorrhea australis* thickets, and the generally 'broken' nature of the terrain rendered field survey extremely difficult.

While attempting to complete as many quadrats as possible using the methods discussed in Chapter 4, it became necessary to alter the initial survey methods. Five quadrats were completed in the planned method (125 hectares), from which 42 artefacts were recorded. The relative scarcity of artefacts encountered cannot be regarded as indicative of Aboriginal land use patterns in this specific area before European settlement. The highly disturbed nature of the landscape, an extremely high level of background quartz 'noise' and very low surface visibility limits the interpretative value of these recorded items. Nonetheless, under extremely difficult survey conditions, evidence of Aboriginal occupation of this area was still located.

Figure 5-2: Gold battery in the Brisbane Ranges National Park. Crushed rock by-products of the batteries coated the land surface with a mantle of introduced rock material, rendering the detection of stone artefacts impossible.

Figure 5-3: Scene typical of the 'scrubby' nature of regrowth vegetation in the Brisbane Ranges National Park. The ground surface visibility in areas like this is virtually zero. Archaeological surface survey under these conditions is quite ineffectual.

At this point, the survey design was altered to include certain areas adjoining the National Park boundaries, as well as other areas within the park. ‘Barwon Water’ manages areas adjoining the northwestern park boundaries. Permission was sought to enter the Barwon Water managed lands (subsequently granted by Barwon Water senior management). Incorporating areas managed by Barwon Water in the survey proved to be an extremely fruitful decision. Although the logic behind the original survey design had been to gather a statistically ‘useable’ data set through stratified random sampling, being forced to alter the design was not seen as detrimental to the overall aims of the project.

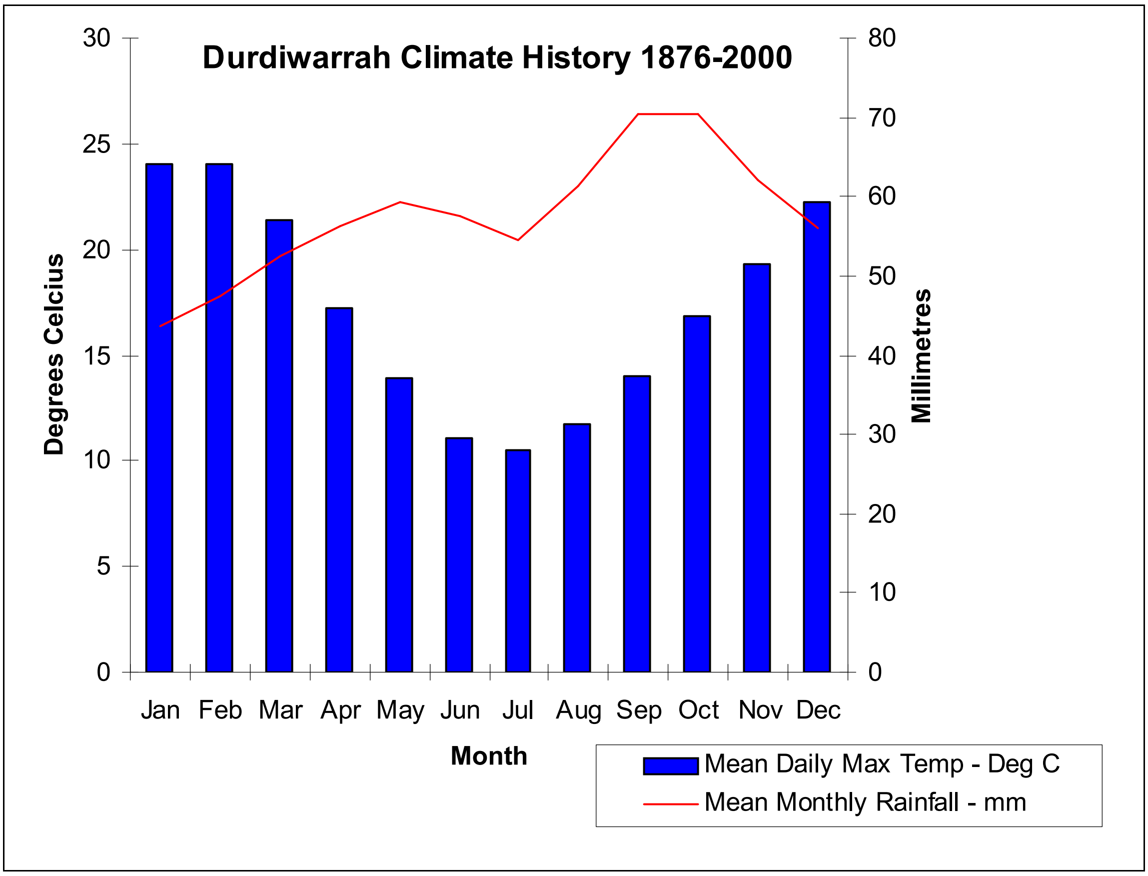


Figure 5-4: Climate history from the Durdiwarrah weather station for the period 1876-2000.

Having been forced to abandon the initial field methods, the survey proceeded to the area managed by Barwon Water. The area consists of three water storage reservoirs, several thousand hectares of swamps, and a large *Pinus Radiata* plantation. The water storage facilities are bounded on three sides by national park, and by freehold land on the remaining boundary. The reservoirs are situated adjacent to Durdiwarrah Road, approximately 10 kilometres from Anakie. There are two reservoirs on the western side of the road, and one on the eastern side of Durdiwarrah Road. The distinction becomes important as the Aboriginal community boundary between the Wathaurong Aboriginal Co-Operative and the Ballarat and District Aboriginal Co-Operative, established under the *Aboriginal and Torres Strait Islander Cultural Heritage Protection Act (Cth) 1984* follows Durdiwarrah Road. With this in mind, negotiations with representatives of the two Aboriginal organizations led to a modified plan of works that divided the remaining field time as fairly as possible.

Upper Stony Creek Reservoirs

In the years shortly after Geelong was first settled (1836), the fledgling town suffered from severe shortages of potable water (Brownhill and Wynd, 1990).The limited rainfall of the area made the construction of storage facilities imperative (Figure 5-4). Various methods and schemes were attempted until H.O. Christopherson delivered a report to the Geelong town council on the suitability of storing collected water from Stony Creek in the Brisbane Ranges (Brownhill and Wynd, 1990). Christopherson's original survey describes the catchment of the Stony Creek as being '4,072 acres, embracing 3,714 ¼ acres of land, chiefly undulating slopes, intersected by gullies draining their waters into the Stony Creek, with the addition of 357 ½ acres of swamp or lagoons covered with permanent water' (Brownhill and Wynd, 1990:18). From his surveys, Christopherson concluded that two relatively small reservoirs could be built, storing 899,984,000 gallons of water when full. A third reservoir was added to the designs before construction was completed (Brownhill and Wynd, 1990). It is Christopherson's 4,072 acres (1,648 hectares) where the survey for this stage of the project took place. Most of the original '357 ½ acres of swamps or lagoons' is where the reservoirs were eventually constructed, and became operational by 1873 (Brownhill and Wynd, 1990:23). Large areas of swamp and lagoon have subsequently been added to the holdings now managed by Barwon Water since the original land purchases of the 1870s. The reservoirs are located at the north-western boundary of the park, north of Steiglitz, at Durdiwarrah (Figure 5-1 and 5-6). Figure 5-5 shows the layout of the three main storage reservoirs.

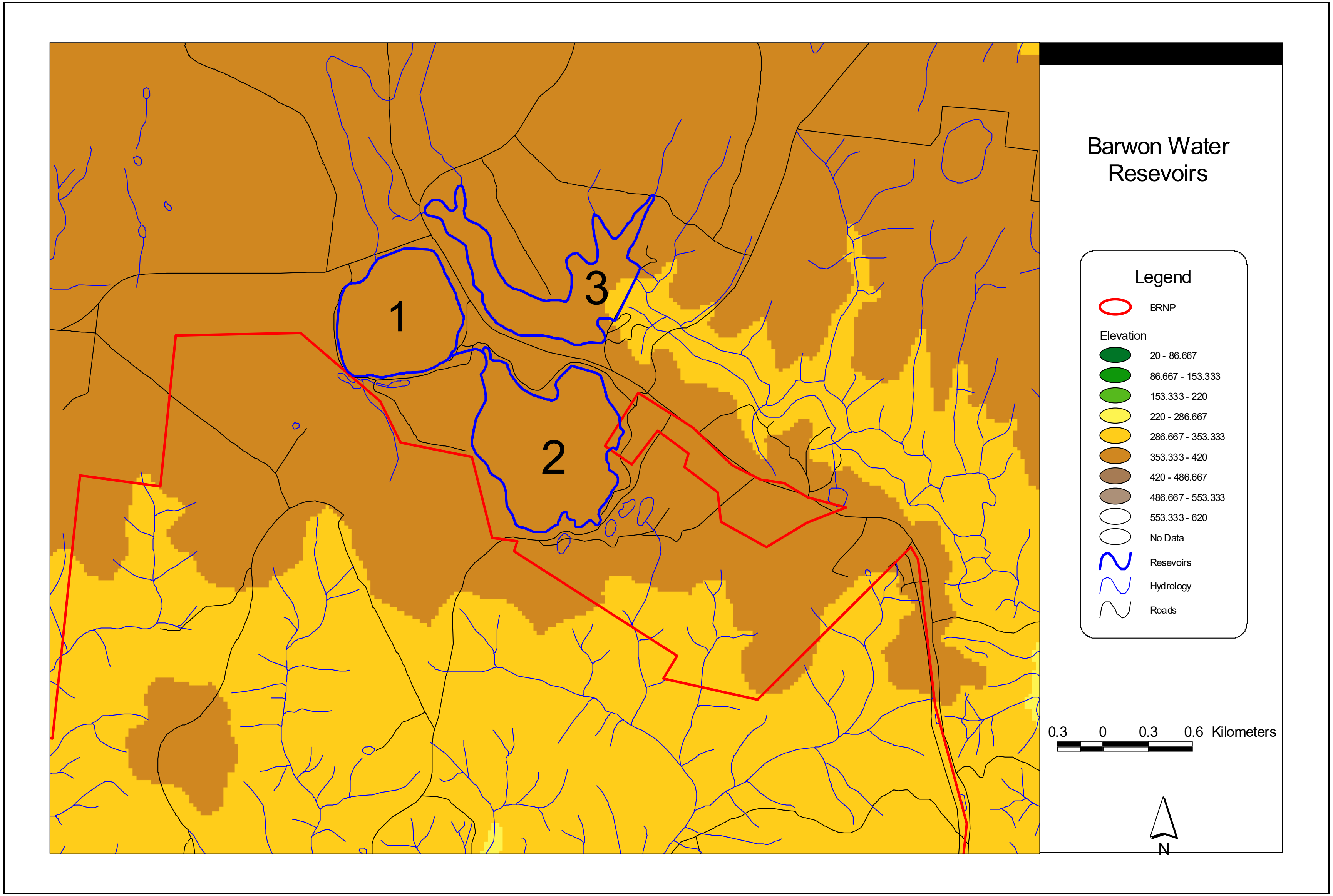


Figure 5-5: Map showing the three reservoirs managed by Barwon Water as discussed in the text.

The reservoirs are comparatively small by modern standards, and are closely bounded on all sides by either national park or freehold land. The two western reservoirs were close to capacity during the fieldwork season, while the third (eastern) reservoir had been completely drained for maintenance works. This lack of water in the third reservoir proved to be fortuitous, and allowed the floor of the reservoir to be intensively inspected for archaeological materials.

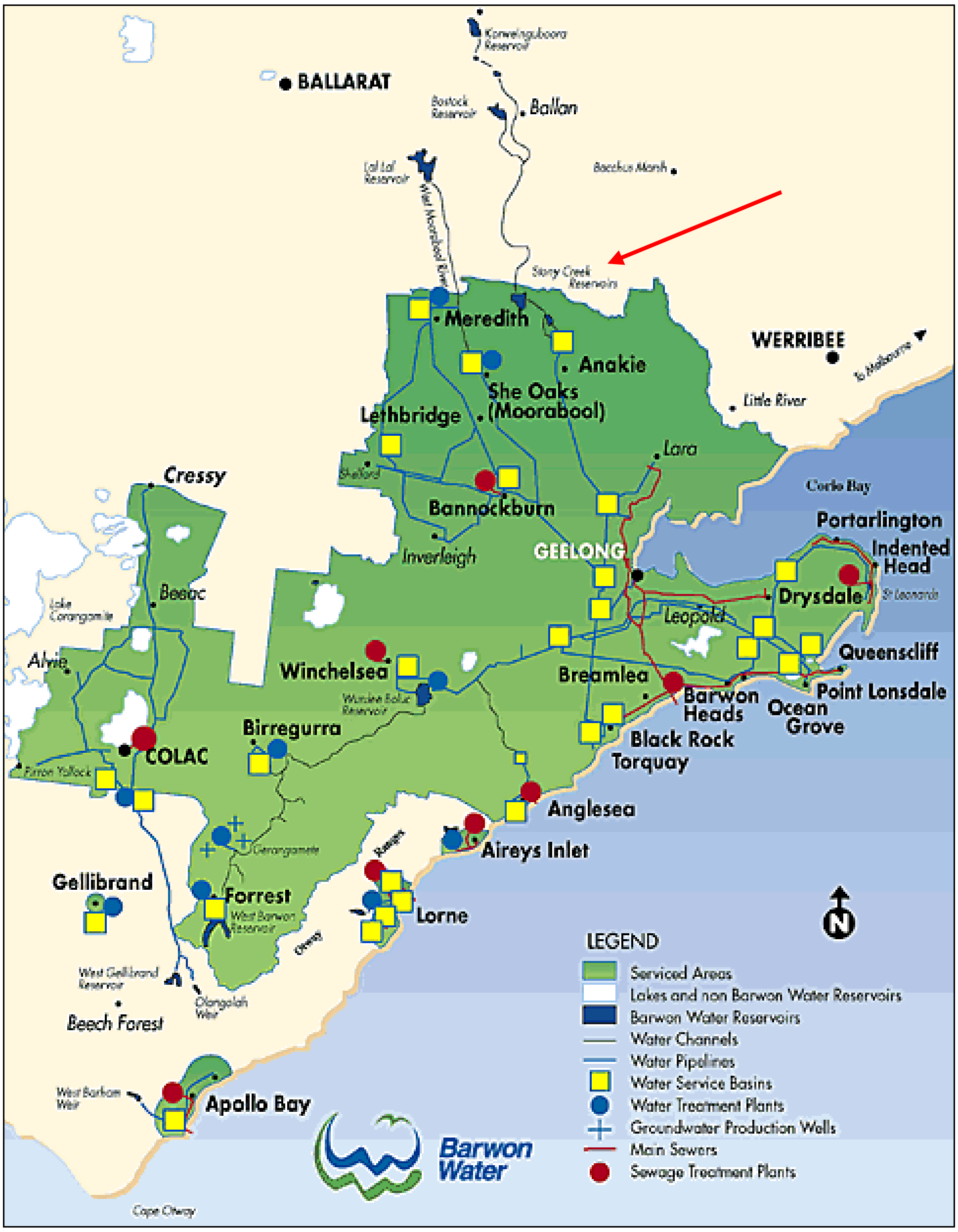


Figure 5-6: Map of the area managed by Barwon Water, showing the upper Stony Creek Reservoirs on the upper margin of the 'serviced areas', arrowed in red. Map courtesy Barwon Water.

The shorelines of the western reservoirs (Numbers 1 and 2 in Figure 5-5.) were intensively surveyed by the entire field crew over the course of several days. The eastern reservoir (Number 3 in Figure 5-5) was also intensively surveyed. During this component of the fieldwork, extensive scatters of stone artefacts were found concentrated around the shorelines of the reservoirs, as well as along the course of the original Stony Creek. Before the reservoirs were flooded in the 1870s, the creek was active. As such, it offers something of a 'time-capsule'. There has been limited human-induced disturbance to these usually submerged materials since the 1870s. This will have limited the impact of disturbances usually associated with European settlement, such as agriculture, and limited the impact of artefact collectors. The extent of erosion and deposition caused by the waters of the reservoir is unknown. Despite being submerged for 130 years, numerous artefacts were recorded along the former banks of the Stony Creek (n = 753). The original creek that drained the swamps upstream (Numbers 1 and 2 in Figure 5-5) would have once provided a permanent supply of fresh water. The swamps upstream of the original creek line would have provided a resource-rich environment for the Aboriginal inhabitants of the area. The material along the creek line was distributed in a three-fold pattern. There were discrete activity areas located right on the original creek; other activity areas situated 30-50 metres away from the creek (also 20-30 metres vertically above the creek), as well as a background scatter of material between the denser 'patches' (Isaac and Harris, 1975).

In most of the areas bounding the reservoirs, artefactual material was found on a deflated clay hardpan surface. Most of the sandier topsoil had been removed through either wave-action or aeolian erosion. In the empty eastern-most reservoir, the exposed ground surface was similarly deflated, but densely covered with gravel-like materials (Figure 5-7). The archaeological material had been more or less deposited directly onto this lag surface, where the sandier soils had been eroded away. Thus, although the material could not be considered *in situ*, it has been demonstrated in other submerged sites that artefactual material does not actually move far through moderate wave action. A study of submerged artefact assemblages in Western Australia, for example, rejected the notion that artefact spatial distribution in the sites analysed was primarily the result of wave action (Dortch, 1996). Dortch (1996) identified conjoinable materials in three submerged sites at Lake Jasper in Western Australia, and noted the presence of dense clusters of 'tiny' (1996:121) microlithic pieces in a small area (one square metre). This would suggest that if wave action were a factor, conjoinable material would not be found, and very small microlithic pieces would be scattered more widely than Dortch's site demonstrated (Essling, 1999).

Figure 5-7: The ground surface of the dry Stony Creek reservoir. This image shows a sample of the gravel beds mentioned in the text.

With this in mind, the assemblages recorded during the fieldwork for this project may be regarded as a relatively accurate spatial document of past Aboriginal land use of the creek margins and swampier uplands, although conjoin analyses were not undertaken. Although the spatial resolution of this material is useable as an indication of past land use practices, there is no chronological inference possible. The assemblage is a palimpsest of materials discarded over an indeterminate period.

Aboriginal utilisation of swamps for subsistence activities is well documented in the archaeological and ethnographic literature (Dortch, 1996; du Cros, 1989, 1991; Head, 1984, 1987; Lourandos, 1997). Indeed, this particular aspect of Aboriginal subsistence activity is commonly incorporated into archaeological predictive models of site location in southeastern Victoria (du Cros, 1991). One of the difficulties in locating archaeological material in swamp areas is the nature of those environments. Swampier areas normally support a far greater diversity of plant and animal life than surrounding areas. This added diversity of resources normally results in the margins of swamps being heavily vegetated, obscuring significant amounts of pre-contact archaeological material from archaeological survey efforts.

As an example, a fourth area was inspected during this stage of the fieldwork. This fourth area is located just to the north of the empty eastern Stony Creek reservoir and consisted of a large remnant swamp (Figures 5-9 and 5-10). From what could be determined, this swamp has remained relatively undisturbed since the arrival of Europeans in the area. The fourth area inspected forms part of an extensive system of remnant swamps, which eventually drain into the Stony Creek reservoirs. The remnant swamp areas are heavily vegetated on all sides, with the eastern-most margin, having a crescent-shaped dune structure reminiscent of the lunette features appearing at lakes and swamps further to the north and west (McNiven, 1998). This sandy dune is between 50 and 100 metres in width, and is approximately six metres above the water line of the swamp. The dune is orientated on a north-south axis along the eastern margin of the swamp, and is approximately one kilometre in length.

Figure 5-8: Members of the field crew attempt to locate material along the top of the sand dune mentioned in the text. Ben North is standing on the management track, surrounded by dense bracken fern. A number of artefacts (n = 39) were located along this track despite the very thick vegetation. The main area of swamp is located directly behind the photographer.

A management track has been semi-cleared along the crest of the dune (Figure 5-8). This was the only part of the dune that afforded any ground surface visibility. Along this track, the survey located and recorded a number of artefacts (Table 5-1). These artefacts were distributed in a linear pattern along the track, most likely through movement and/or re-deposition caused by earth-moving equipment. The material recorded along this area of track was similar to the material from the other reservoirs, however there was more quartz debris apparent in this area than the others. This is problematic, as the debris may also be the result of the earth moving activities that had taken place at this site. Nonetheless, seven quartz artefacts located showed a variety of diagnostic features, and were considered Aboriginal in origin

Figure 5-9: The fourth area of remnant swamp as discussed in the text. The dune discussed is located just behind the tree line in the background.

While the margins of this remnant swamp provided some evidence of Aboriginal occupation, the small amount of material recovered, and the possibility of extensive post-depositional disturbances does not permit any real inferences to be drawn from this data.

Artefact	Silcrete	Quartz	Quartzite	Total
Broken Flake	8	3	-	11
Complete Flake	1	1	-	2
Scraper	2	2	1	5
Core	1	1	-	2
Debris	1	17	1	19
Total	13	24	2	39

Table 5-1: Details of the assemblage located along the management track at the fourth area of remnant swamp discussed in the text. The large amount of quartz debris recorded is most likely the result of earth moving activities.

Figure 5-10: Alternate view of the remnant swamp area. The dune discussed in the text is located at the very ‘back’ of the image amongst the trees.

The data recovered from the survey in the Barwon Water managed lands cannot address specific questions regarding the chronology of Aboriginal occupation, and nor was it intended to, given the questions being addressed. The data collected through a surface survey can however, be used to identify spatial patterning across landscapes. The spatial integrity of the material should be viewed from the ‘macro’ scale rather than from the ‘micro’ scale. Each artefact has been subject to innumerable post-depositional processes since initial discard. However, when this data is viewed as a macro-scale ‘set’ the spatial impacts of these disturbances should be ‘averaged’ amongst the entire assemblage. This leaves us with a valuable and ‘readable’ archaeological document (Ebert, 1988).

Summary of the BRNP Fieldwork

The BRNP fieldwork session resulted in the recording of 3,503 artefacts and 1-scarred tree, predominantly located on the shorelines of the Stony Creek water storage reservoirs. In total, 516 hectares were surveyed during this phase of the fieldwork, at an average of approximately 36.5 hectares per day. This total is somewhat less than the original goal of 650 hectares, however achieving almost 80% of the initial goal was considered a very positive outcome, considering the difficulties encountered during this first survey phase. Despite the poor visibility throughout the park, and the extreme heat encountered during the survey, the methods employed still resulted in the recovery of significant quantities of archaeological data.

Deep Creek Farms

From the Brisbane Ranges National Park, the survey activities relocated to two properties on the Deep Creek at Bolinda, approximately 20 kilometres north of Sunbury (VicRoads, 2000). The two properties chosen to survey, 'Leigh' and 'Innisfail', were introduced briefly in Chapter 4 (a third 'contingency' property was also included, but not fully surveyed). The survey of these properties was also conducted over a 14-day period, with volunteers being accommodated at the Riddell's Creek Leisure Centre.

The two main properties surveyed for this stage of the project are located on Deep Creek, a major tributary of the Maribyrnong River. The upper reaches of the Deep Creek are characterised by landscapes with deeply incised creek valleys eroded down to Silurian and Ordovician bedrock through the softer basalt of the 'Newer Volcanics'. As this creek and others meander south toward the sea, the incised valleys become wider, deeper and steeper, such as those that can be seen at Organ Pipes National Park, and Brimbank Park, in the Sydenham and Keilor areas respectively. The majority of the landscape around the Deep Creek farms is made up of the almost ubiquitous 'basalt plains' of southwestern Victoria. These plains would have been predominantly grassland before the arrival of Europeans. Almost all remnant grasslands in Victoria have been destroyed since the arrival of the first settlers to the region in the 1830s (Jones, 1999). The Deep Creek area is no exception, having been extensively cleared, cropped and grazed for over 150 years.

Previous Archaeological Work

No previous archaeological works had been conducted on any of the lands earmarked for survey at, or near, the Deep Creek farms. There were no registered AAV sites within 3 kilometres of the Deep Creek Study area. This is due to a lack of survey activity in the area, rather than a lack of archaeological sites.

'Leigh'

The survey for this stage of the project commenced at 'Leigh' on Monday 8th January 2001, and continued until Sunday 21st January (inclusive). Once again, surveying was planned to occupy the entire 14-day period. One day was abandoned however, due to extreme heat (44ºC.). Following on from the experiences at Brisbane Ranges National Park, a quick appraisal of the prevailing conditions at the Deep Creek farms was enough to force the abandonment of the more rigorous survey designs. Although the farmlands had been extensively cleared of native flora, introduced pastures and weeds once again reduced ground surface visibility to almost zero throughout the entire survey area. In those areas where visibility was higher, a high-intensity survey was utilised. The number of volunteers in the field made the adoption of this type of survey strategy possible.

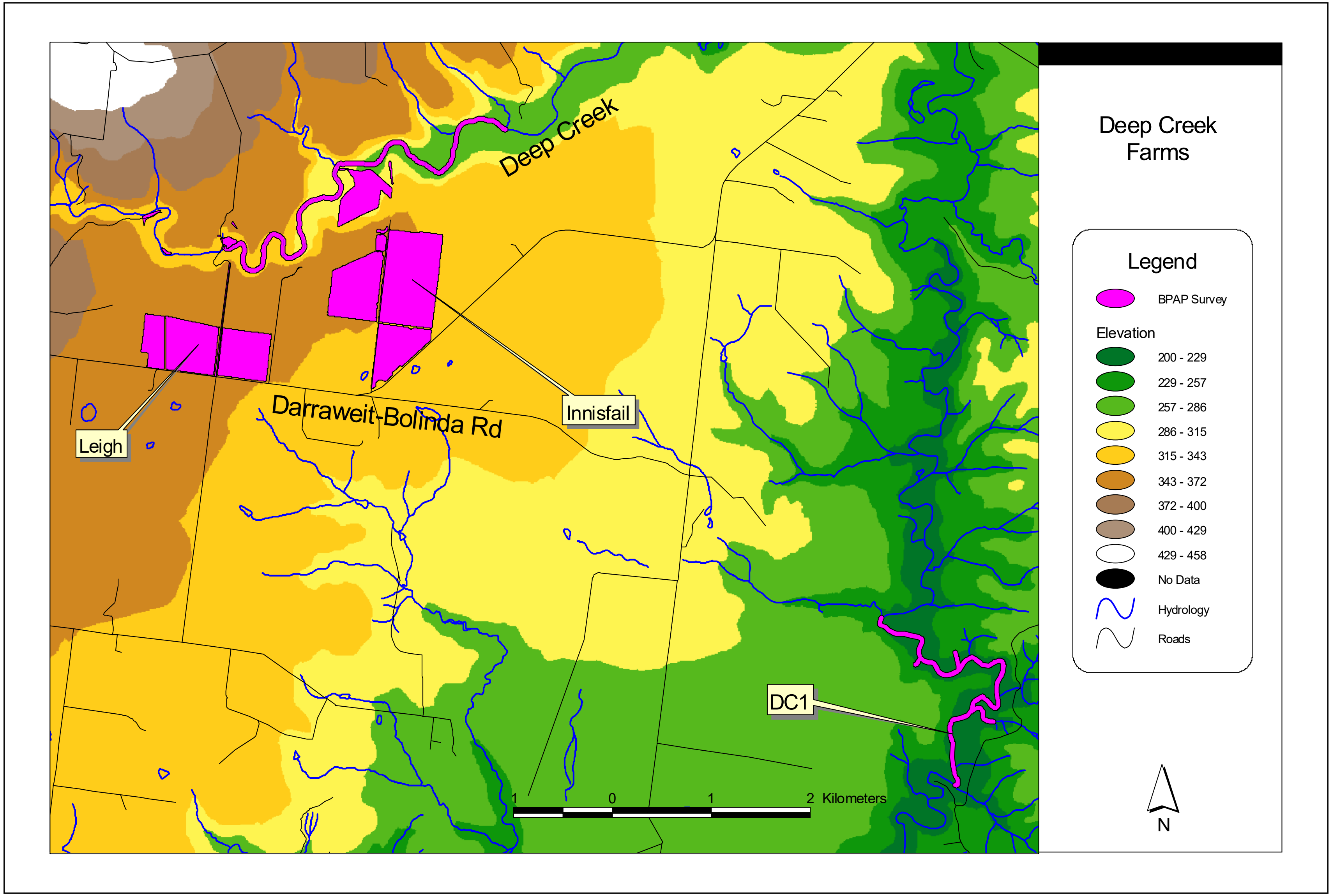


Figure 5-11: Location of the Deep Creek Farms Survey Areas. The area referred to as 'DC1' is shown in the bottom right hand corner of this map.

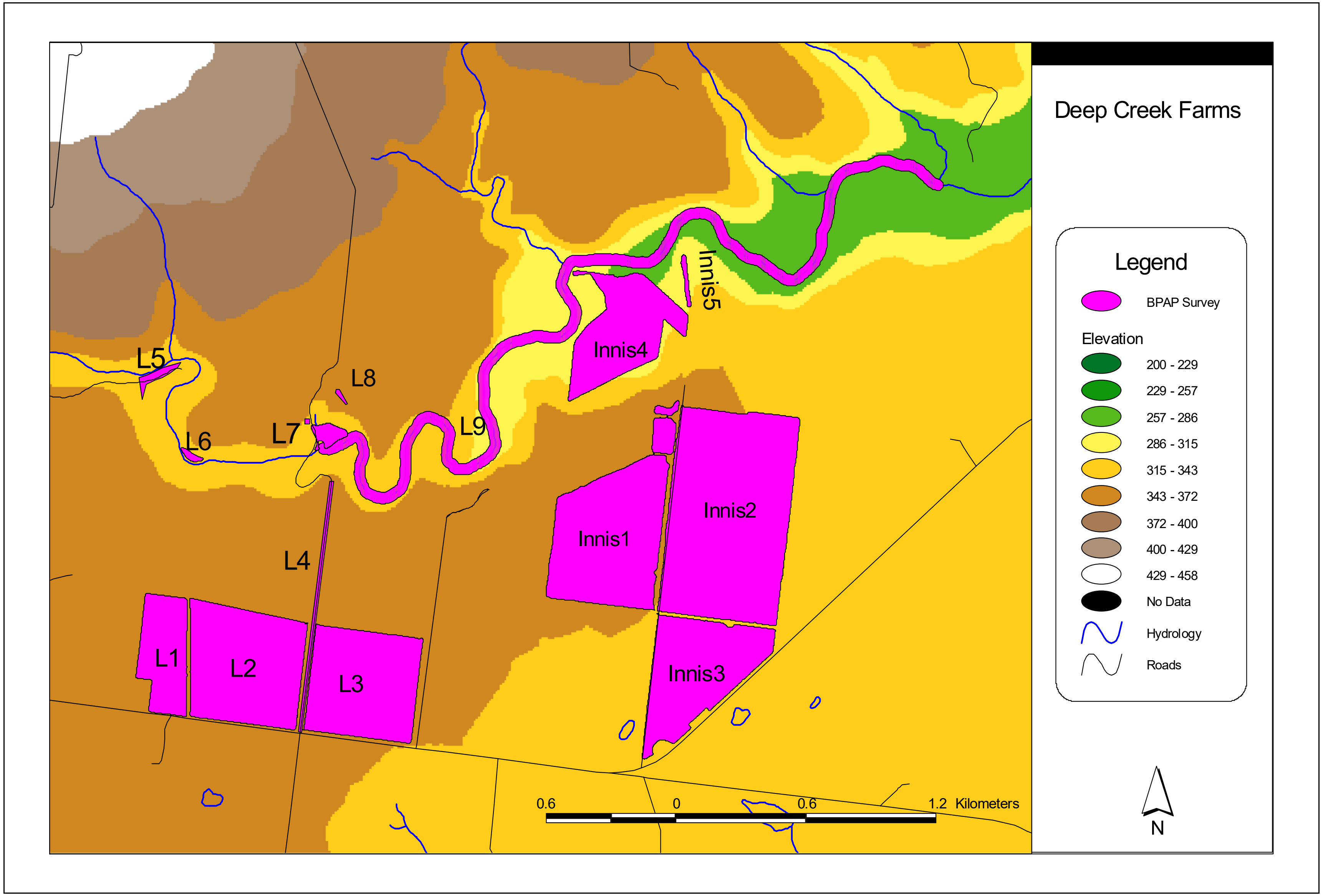


Figure 5-12: Location of the survey units within the Deep Creek Farms. 'DC1' is not shown on this map.

The surveying activities at Deep Creek commenced on the western-most property, known as ‘Leigh’ (see Figures 5-11 and 5-12, above). After spending several hours scouting for locations to survey, it was decided to begin the fieldwork in a series of recently ploughed fields on the basalt plains landform. These fields were approximately one kilometre from the Deep Creek, which is the nearest source of naturally occurring water (Figure 5-13). Three fields (L1, L2, and L3) and an access track (L4) were intensively surveyed by the entire field crew, resulting in the discovery and recording of two small silcrete cores. These two cores were found in L1 and L2 respectively; approximately 500 metres apart and thus bore no direct relationship to each other. A total of 61.1 hectares of ploughed Basalt Plain was surveyed using intensive transects. Members of the survey team were no more than five metres apart at any stage of the inspection of these fields. Ground surface visibility was as close to 100% as theoretically possible in these ploughed fields, with no vegetation cover present.

Figure 5-13: View of the heavily eroded banks of ‘Deep Creek’ on ‘Leigh’. This is typical of the incised creek valley of Deep Creek. The pink flags used to mark artefacts can be seen along the very top of the bank. There was an extensive scatter along the edge of this very steep eroded section of creek bank.

Although only two artefacts were recorded on the Basalt Plain this was in a highly disturbed sampling environment. The effects of agricultural activities, such as ploughing, on archaeological sites have received only scant attention in the Australian archaeological literature. However, experiments and observations conducted overseas have shown that ploughing does have significant impacts upon the surface archaeological record. Indeed, there is a tendency for ploughing to expose only small sub-sets of the archaeological record at any one time, sorted by size. This size sorting produces a skewed picture of the archaeology of an area, favouring the recovery or identification of larger items over smaller ones (Ammerman, 1985; Dunnell and Simek, 1995). Ploughing also causes considerable lateral movement of materials (Shott, 1995). This type of ‘ploughzone’ research has also shown that only a very small proportion of cultural material appears on the surface of a ploughed field during and after any particular ploughing iteration (Ammerman, 1985).

Without conducting similar experiments in ploughed fields on parts of the Victorian basalt plains, it is impossible to know the effects on the archaeological record. The basalt plains archaeological record may exhibit similar characteristics to those assemblages analysed overseas. Experiments overseas have shown that up to 95% of the archaeological record in ploughed fields may actually be beneath the surface at any one time, and that this material is in a constant state of movement within the disturbed (and active) soil matrix (Ammerman, 1985). If this were the case under Australian conditions for fields such as those discussed above, and if 95% of all cultural material present were in ‘suspension’ below the modern ploughed surface, then a crude projection would suggest that there should be approximately 40 artefacts distributed across these fields (0.65 artefacts/ha, or 65 artefacts/ km^2).

Figure 5-14: View from the junction of the plain and the Deep Creek valley. Similar areas of plain can be seen on the opposite side of the creek from the photographer's position. The descent is steep from the plain to the valley floor, although the actual vertical descent is seldom more than 30 or 40 metres.

Figure 5-15: Survey crew walking a close transect at L5. This was an area of better visibility on 'Leigh'. The large scatter located at L5 begins in the immediate foreground of this photograph, almost at the photographers feet.

Once the ploughed fields had been completed, the challenge at 'Leigh' was to locate other areas where ground surface visibility would allow any form of survey activity. In general, visibility conditions at 'Leigh' were amongst the worst encountered during the entire summer of fieldwork (figure 5-14). A number of small areas were subsequently located, and intensively inspected. The first of these areas was a small patch of exposed ground (L5) on the banks of the Deep Creek (Figure 5-15). In this three-hectare area, ground surface visibility was comparatively high. Close inspection of this small area revealed a large artefact scatter and one hearth. The scatter consisted of 343 artefacts distributed along the eroded bank of Deep Creek. The proximity of cultural material to the vertical edge of the creek bank, and the highly active erosion apparent at the site, indicates that this scatter may have been much larger. Figure 5-16, shows the part of the creek bank where this scatter was recorded. Although this area appears heavily eroded, the height of the scatter above the water line is considerable. This area has been a significant distance above the water line for a minimum of several thousand years, providing a safe camping area above an otherwise flood-prone creek. The Deep Creek is the major tributary of the Maribyrnong River and drains almost half of the Maribyrnong catchment, and is renowned for its flash flooding (Llewelyn-Davies Kinhill Pty Ltd., 1975). Another small survey area (L6) did not reveal any cultural material.

Figure 5-16: Part of the scatter of stone tools recorded at L5. As the image clearly shows, this material is being eroded away as the creek bank slowly disappears.

Once the scatter mentioned above was recorded, the survey moved approximately one kilometre east, to another small exposed area (L7). Again, a scatter of stone artefacts was located and recorded close to the Deep Creek (n = 70). This scatter was located almost at water level, and was much smaller than the other scatter recorded on the creek. The remains of a long abandoned stone hut (L8) were also inspected, resulting in the discovery of several flaked glass artefacts and some small pieces of ochre. These artefacts were found around the periphery of the ruined hut. It was impossible to determine whether the Aboriginal cultural material pre-dated or was contemporaneous with this ruin. This phase of the fieldwork also included the inspection of several kilometres of the Deep Creek frontage (L9). Ground surface visibility was extremely poor along both banks of the Deep Creek. No additional stone artefacts were located along the creek, however four scarred trees were recorded (one on 'Leigh', and three on 'Innisfail').

The survey moved from 'Leigh' to 'Innisfail' once all exposed areas had been inspected. The activities on 'Leigh' had located and recorded 424 stone artefacts of various types and materials, one hearth and one scarred tree. Approximately 66 hectares in total was intensively inspected on 'Leigh'. Unfortunately, the remainder of 'Leigh' was virtually impossible to survey in any meaningful way due to the extremely poor ground surface visibility prevalent throughout most of the property.

'Innisfail'

Conditions at 'Innisfail' were considerably better for surveying than at 'Leigh'. 'Innisfail' had been subjected to heavy sheep grazing, resulting in significantly reduced amounts of surface vegetation. A total of 144 hectares was intensively inspected at 'Innisfail'. The results obtained are broadly similar to those obtained at 'Leigh'. The survey of 'Innisfail' covered 102.4 hectares of heavily grazed Basalt Plain (Innis1, Innis2, and Innis3) without locating a single artefact. The visibility in this 102.4 hectares sample of 'Innisfail' was consistently high. These grazed areas were all located at more than 600 metres from the Deep Creek. Once these areas of Basalt Plain had been thoroughly inspected, the survey activities once again moved back to the Deep Creek. A newly ploughed field close to Deep Creek (Innis 4) revealed a small scatter of some 35 stone artefacts, while another very small ploughed area (Innis 5) next to the first revealed another 31 stone artefacts. These two areas (Innis 4 and Innis 5) are approximately 400 metres apart. Both however, are within 150 metres of the creek. Approximately 500 metres east of Innis 4 and Innis 5, a cache of 18 pieces of ochre was located directly on the creek (Figure 5-17). No stone artefacts or other material were found with the ochre. The cache of ochre appears to have been deliberately deposited in a rock-crevice near the creek. No rock art was found in the vicinity. Three scarred trees were recorded along the banks of Deep Creek on 'Innisfail'.

Before this session concluded, a third area of farmland became available for inspection (DC1) and it was decided to attempt to survey some of the Deep Creek frontage of this property.

Figure 5-17: View from the top of the escarpment looking over Deep Creek onto surveyed area at 'Innis4'. This is the ploughed area in the background of the image.

A section of the creek at DC1 was surveyed, rather unsuccessfully. The extremely thick vegetation rendered visibility almost zero. An area of approximately 26 hectares was inspected at DC1, and although visibility was virtually zero, one scarred tree was recorded. It is not known whether other cultural material was present on the ground in the DC1 section of the survey. The visibility was simply too poor to locate any cultural material, if indeed there was any material present. On one meandering bank of the creek, erosion has cut down through some thick alluvial deposits. These alluvial deposits were of a similar structure to those that occur lower in the Maribyrnong catchment, such as at Brimbank Park and the Keilor burial site (Anderson, 1972; Barlow, 1999; Bowler, 1969, 1970; Tunn, 1998). This alluvium revealed the presence a series of gravel beds stranded some distance above the contemporary creek, as can be seen in Figures 5-18 and 5-19, below.

One small silcrete microlith was found sitting on the eroded face of the sediments, approximately 800 mm below the contemporary ground surface. This was the only cultural material found at this location. The blue arrow in Figure 5-19 (below) shows the location of this find. This silcrete microlith was not *in situ*. It is likely that the artefact came to rest on older sediments after having moved downwards through a deep crack common in soils of this region.

Figure 5-18: Section of exposed alluvial terrace at the DC1 survey area. Four thinly bedded gravel beds can be seen (arrowed) in this image, indicating past stream activity. This is important in identifying the presence of deeply stratified deposits, which may contain traces of ancient Aboriginal cultural material.

Summary of Deep Creek Farms Fieldwork

In total 210.24 hectares of land was intensively surveyed at 'Leigh' and 'Innisfail'. The survey activities located and recorded 4-scarred trees, 1 hearth, a cache of ochre, and 491 stone and glass artefacts. Large areas of both creek flats and basalt plain were inspected during this phase of the fieldwork. The additional 26 hectares surveyed at DC1 resulted in the recording of one scarred tree, and one small silcrete microlith. The alluvial sediments at DC1 are of considerable archaeological potential, given that similar sedimentary sequences lower in the Maribyrnong catchment have revealed evidence of Pleistocene Aboriginal occupation of the region. Although the identified silcrete microlith was most likely intrusive to this site, the geomorphological sequence identified at DC1 is nonetheless likely to contain in situ archaeological deposits of considerable antiquity.

Figure 5-19: Another view of the alluvial deposits at DC1. To give some sense of scale, the person arrowed in green is 201 centimetres tall. The blue arrow indicates where the one small silcrete microlith was found at DC1.The red lines delineate the top and bottom of the extant gravel beds.

Organ Pipes National Park.

The penultimate fieldwork session of two-weeks duration was conducted at Organ Pipes National Park between January 24th and February 7th, 2001. Organ Pipes National Park (OPNP) is located approximately 20 kilometres northwest of the Melbourne CBD, just off the Calder Freeway at Sydenham (Figure 5-20 and 5-23). The park is divided in two by Jacksons Creek, a major tributary of the Maribyrnong River. The confluence of Jackson's Creek and Deep Creek is approximately 2 kilometres south (downstream) of OPNP. The irregular boundary of the park encloses an area of some 140 hectares of basalt plain and deeply dissected creek valley landscapes. OPNP is registered on the United Nations list of National Parks and Protected Areas as a Category III (Natural Monuments) area, primarily to reflect the geological significance of the basalt columnar jointing formations that give the park its name (Hills, 1975; Parks Victoria, 1998a).

The park is situated on the 'Keilor Plains', which forms a small part of the greater Western Victorian volcanic plains stretching from Melbourne to Millicent in South Australia (Hills, 1975), a distance of some 450 kilometres. Although a comparatively small park, the OPNP protects a sample of the basalt plains land system located in close proximity to Melbourne. This land system is under considerable development pressure northwest along the Calder Freeway corridor. The OPNP also protects a small part of the least modified area of Volcanic Plain grassland and grassy woodland west of Melbourne (Parks Victoria, 1998a). Less than 1% of the original grasslands of Western Victoria survive intact today (Jones, 1999; Society for Growing Australian Plants, 1995). Of this surviving grassland, an extremely small proportion is located on public lands (Parks Victoria, 1998a). Of significance to the greater project, as well as having implications for the archaeological record of the OPNP area, the Maribyrnong Valley (including the Jackson's Creek area) is the only natural 'corridor' following significant waterways from the forested mountains of Mount Macedon to the north, to the confluence of the Maribyrnong and the Yarra Rivers near Port Phillip Bay.

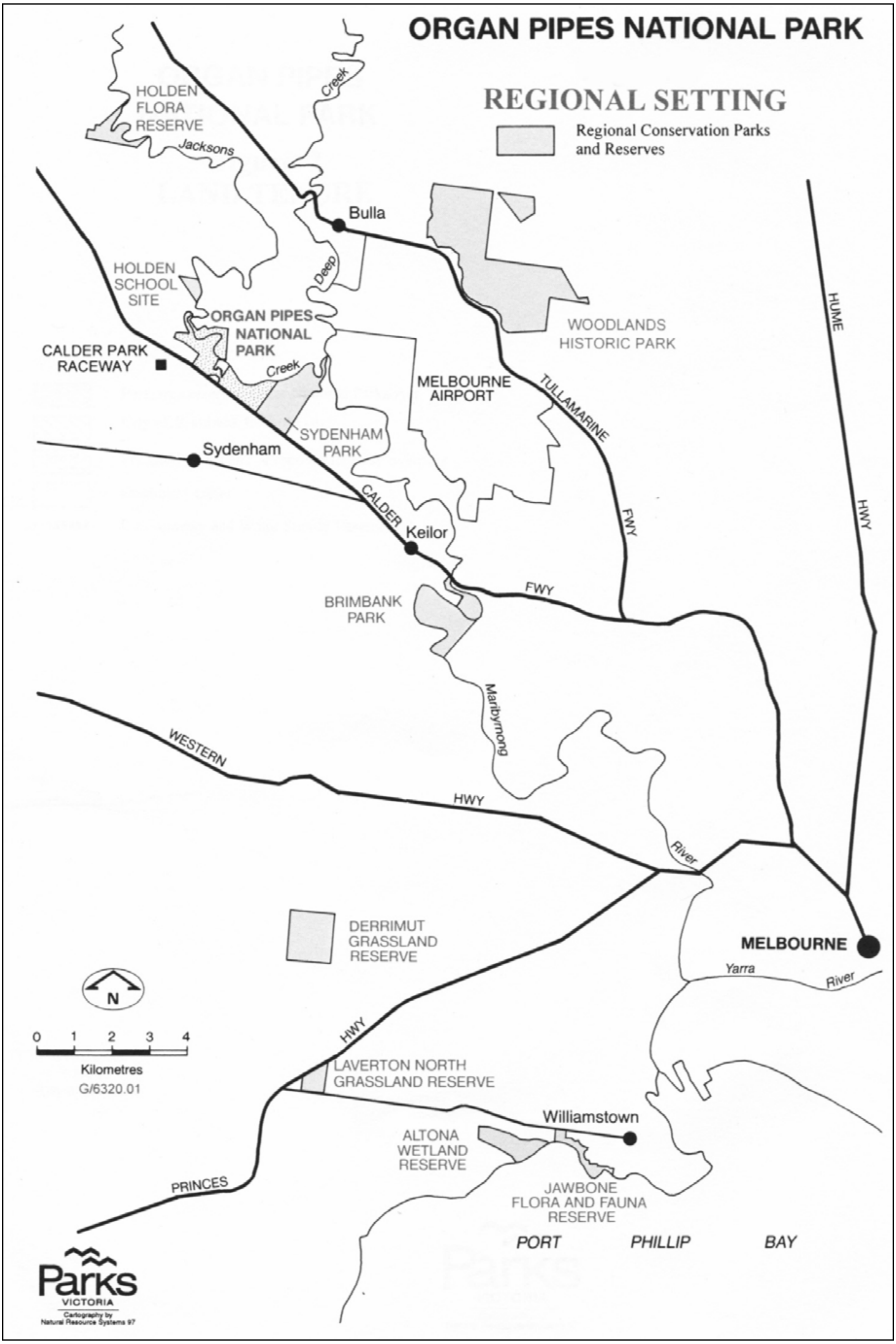


Figure 5-20: Map showing the location of Organ Pipes National Park in relation to the Melbourne CBD and Woodlands Historic Park. Source: Organ Pipes Management Plan, Parks Victoria, 1998.

Topographically, the OPNP area is similar to the Deep Creek farms area. However, the incised valley at OPNP is deeper, wider and steeper than that evident higher up in the Maribyrnong catchment. The terrain surrounding the deeply incised valley of OPNP is composed almost entirely of basalt plain of very low relief. The terrain further north in the catchment (such as at the Deep Creek farm sites) tends towards a mixture of low hills and basalt plain. The huge expanses of relatively flat basalt plain, characteristic of the area to the west of Melbourne, are relatively treeless grasslands. Trees occur mainly on creek or river margins, or around swampier areas (Aboriginal Affairs Victoria, 1996). This lack of trees is characteristic of the majority of the remnant basalt plain grasslands.

Figure 5-21: A section of the large artefact scatter that extends for virtually the entire length of the OPNP. This image was taken approximately 75 metres back from the edge of the escarpment, which can be seen by the row of small trees in the immediate background. The red line marks the approximate location of the edge of the western side of the escarpment.

Although the volcanic soils of the basalt plains are highly fertile, they are ‘shallow, heavy and prone to waterlogging. They swell in winter and crack deeply in summer. The plains also have low rainfall, hot summers, winter frosts, and ever-present wind’ (Society for Growing Australian Plants, 1995:12). Indigenous tree species have generally not adapted to these conditions, although the occasional Sheoak, Buloke, Wattle or Banksia survives on the otherwise inhospitable plains. The dominant vegetation regime of the basalt plains before settlement was grassland composed mainly of Kangaroo Grass

(*Themeda triandra*), Common Tussock Grass (*Poa labillardieri*), and Wallaby Grass (*Danthonia setacea*). Many other forms of indigenous vegetation were also common on the fertile basalt plains, such as daisies, lilies, orchids, a variety of other grasses, and native peas. Wetland areas were relatively common on the Basalt Plain in the later Holocene, and these were predominantly fringed with River Red Gum (*E. camuldulensis*) and had a grassy under story dominated by Wallaby Grass and Tussock Grass. These wetter areas also supported rich crops of various types of daisies. (Society for Growing Australian Plants, 1995).

An area of grassland and grassy woodland such as the OPNP was home to a wide variety of vegetation before the arrival of Europeans. The vegetation of the OPNP area was broadly similar to that described above, while the escarpment area was home to a dense woody scrubland, with a variety of species including correas, bottlebrushes, acacias and sweet bursaria (Melbourne and Metropolitan Board of Works, 1984; Society for Growing Australian Plants, 1995). This greater diversity was mainly a result of the shelter and drainage provided by the valley walls, and the more diverse soils of the escarpments.

It has been shown that of the 550 species of plants endemic to the basalt plains, 25% of these are recorded as having been used by Aboriginal people, with at least 20% being for food (Gott, 1999). Gott (1999) also suggests that at least 50% of the diet of Aboriginal people living on the basalt plains consisted of plant foods, and that the abundance of plant types also influenced the availability of animal food for human consumption. These incredibly rich and diverse patches of grassy woodlands bordering the basalt plains were also home to an enormous variety of fauna. The Atlas of Victorian Wildlife lists 15 mammal, 148 avian, nine amphibian, 16 reptilian and three fish species as being indigenous to the region (Ecology Australia Pty Ltd, 1996).

The generally low relief and heavy soils of the basalt plains causes severe waterlogging during the winter months (June-August). During the winter months, the plains are also subject to strong, bitterly cold, westerly winds. Conversely, drought-like conditions are common in the extremely dry summer months, while the plains are blasted by hot winds (Aboriginal Affairs Victoria, 1996). The colder and wetter winter months, combined with a lack of shelter and fuel for fires would have made the majority of the open plains unsuitable for more permanent occupation by Aboriginal people in all but times of absolute necessity. These same factors, however, increase the attractiveness of localities such as the OPNP (Jackson's Creek) area. The deeply incised valleys provide shelter from the elements year round (particularly the wind), and the heavily wooded areas within these valley areas would have provided adequate supplies of timber for fuel, shelter and tool manufacture for Aboriginal people. Similarly, in summer the valley edges would have provided shelter from the relentless hot winds, while providing campsites in close proximity to permanent fresh water. These valley environments are not without detractions however. Large parts of the region surrounding OPNP are in a rain shadow caused by Mount Macedon to the northwest. This rain shadow reduces the amount of rainfall received at OPNP to around 580mm per annum, and as low as 400mm per annum in other nearby areas (Figure 5-22). The majority of this rain falls in winter and early spring (June-September), and can cause localised flooding and erosion in the Maribyrnong catchment, particularly downstream of OPNP (Parks Victoria, 1998a). Flooding in recent years (1993) destroyed vegetation and heavily eroded the banks of Jackson's Creek at OPNP (Parks Victoria, 1998a).

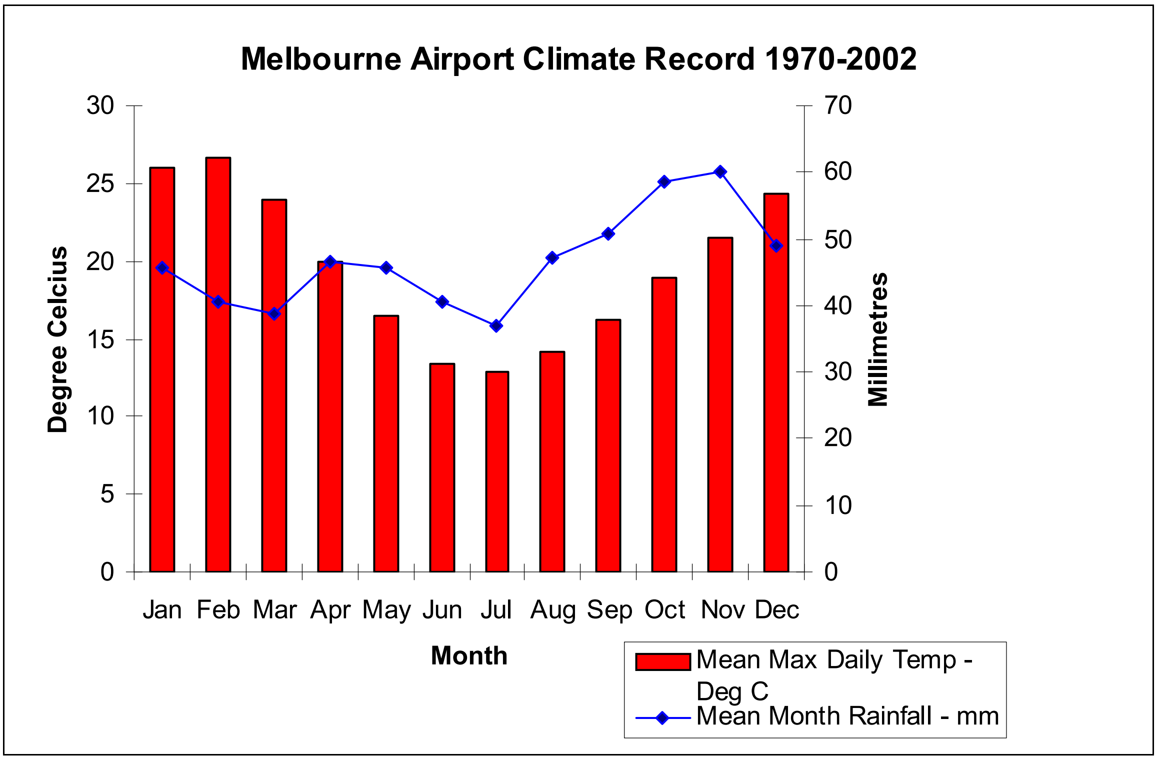


Figure 5-22: Melbourne Airport climate record for the period 1970-2002. This is the closest contemporary weather station to both OPNP and WHP

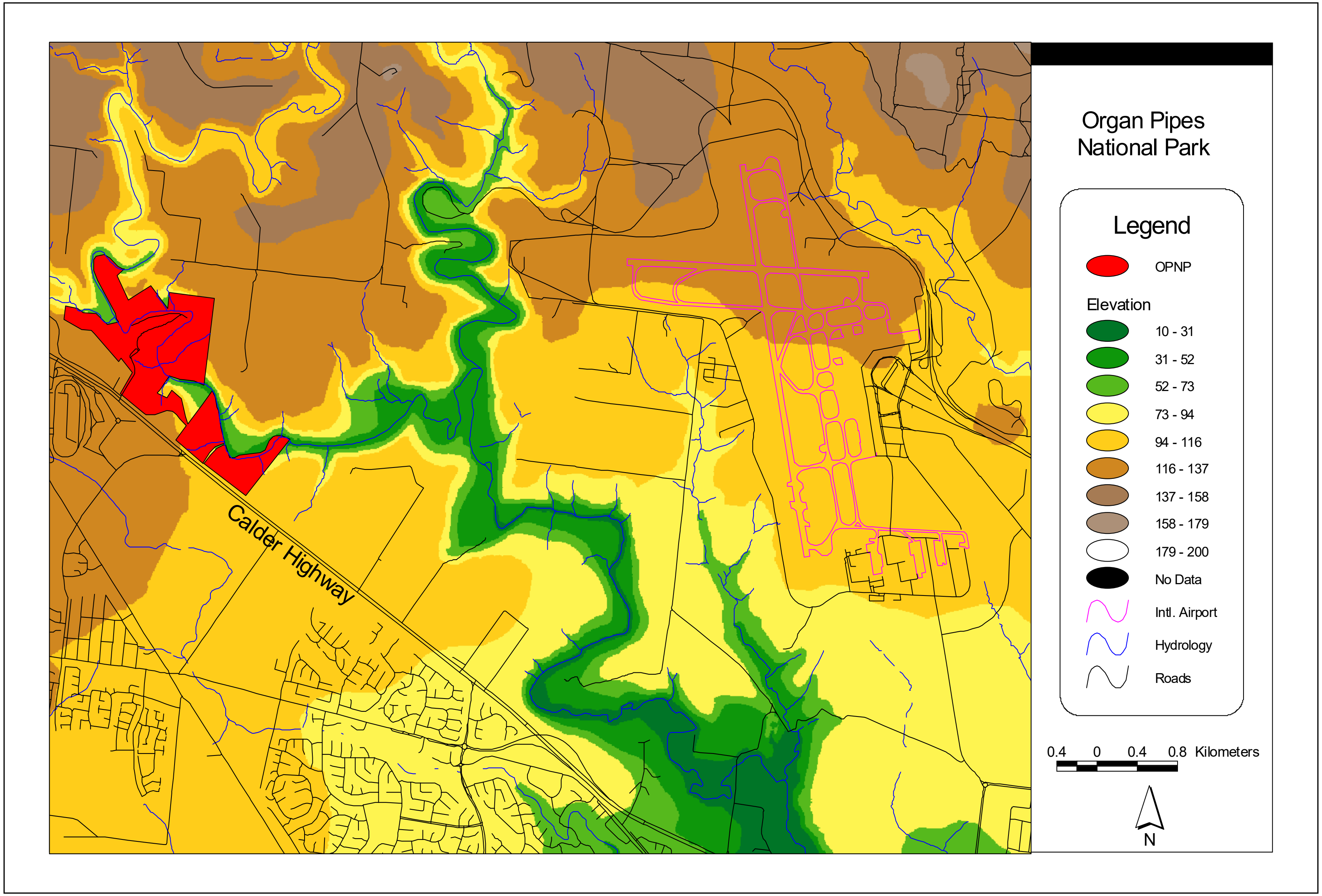


Figure 5-23: Organ Pipes National Park and environs.

Figure 5-24: Part of the extensive stone artefact scatter along the western edge of the escarpment at OPNP.

Previous Archaeological Work

Only one previous archaeological survey has been undertaken in OPNP. Annette Xiberras completed this survey as part of an indigenous training program in 1991 (Xiberras, 1991). Seven previously unrecorded sites were identified. Sixteen registered sites are located at OPNP. These sites consist of 12 artefact scatters, two isolated artefacts, one quarry, and one exposure in a bank.

OPNP Fieldwork

The vegetation and topography (Figure 5-23) of OPNP presented similar surveying challenges to those encountered in all of the previously surveyed areas. Both indigenous grasses and non-indigenous weeds (particularly Chilean Needle-Grass, Serrated Tussock, and Phalaris) are present throughout the park. Thus, ground surface visibility in the majority of OPNP could only be described as very poor. Despite the poor visibility, it was decided to attempt to survey as much of the park as possible in the two weeks of allocated fieldwork. The method of survey utilised was the same close-interval transect method as used in all the other areas surveyed for this project. Although the field crews physically walked transects through the majority of the park, only 25.4 ha

(17.7%) was intensively inspected. The remainder of the park was covered in dense vegetation affording no ground surface visibility whatsoever. Visibility in the 25.4 ha intensively inspected ranged between 10% and 100%.

Summary of OPNP Fieldwork

Approximately 25.4 ha of OPNP were intensively surveyed during the course of the two-weeks of fieldwork at OPNP. This resulted in the location and recording of approximately 5,060 stone and glass artefacts (196.85 artefact/ha). This was archaeologically by far the richest and most diverse area encountered during the entire survey program (Figure 5-25). The majority of material was located in a continuous scatter along the interface of the basalt plain and the escarpment edge, on the western side of the valley. This stone artefact scatter extends along the escarpment uninterrupted for approximately 1,000 metres. Where roads or buildings break the scatter, it continues on the other side of the disturbance. This is an example of the 'continuous' nature of the archaeological record in this region (Figures 5-21 and 5-24).

Figure 5-25: Artefacts recorded in the OPNP survey. The larger piece is a clearly used hammer stone, also with anvil pitting on two margins

Smaller amounts of archaeological material were also located along the banks of Jackson's Creek. The area where the majority of the material was located (see Figure 5-26, below) would have been the more attractive occupation area for a number of reasons. The western side of the escarpment (just below the 'lip' of the basalt plain) is located in the lee of the prevailing winds; therefore, it is cooler and less humid than the valley floor in summer. It is safer in time of flood or fire; would have allowed observation along the length of the valley; but was close enough to Jackson's Creek to exploit the resident flora and fauna.

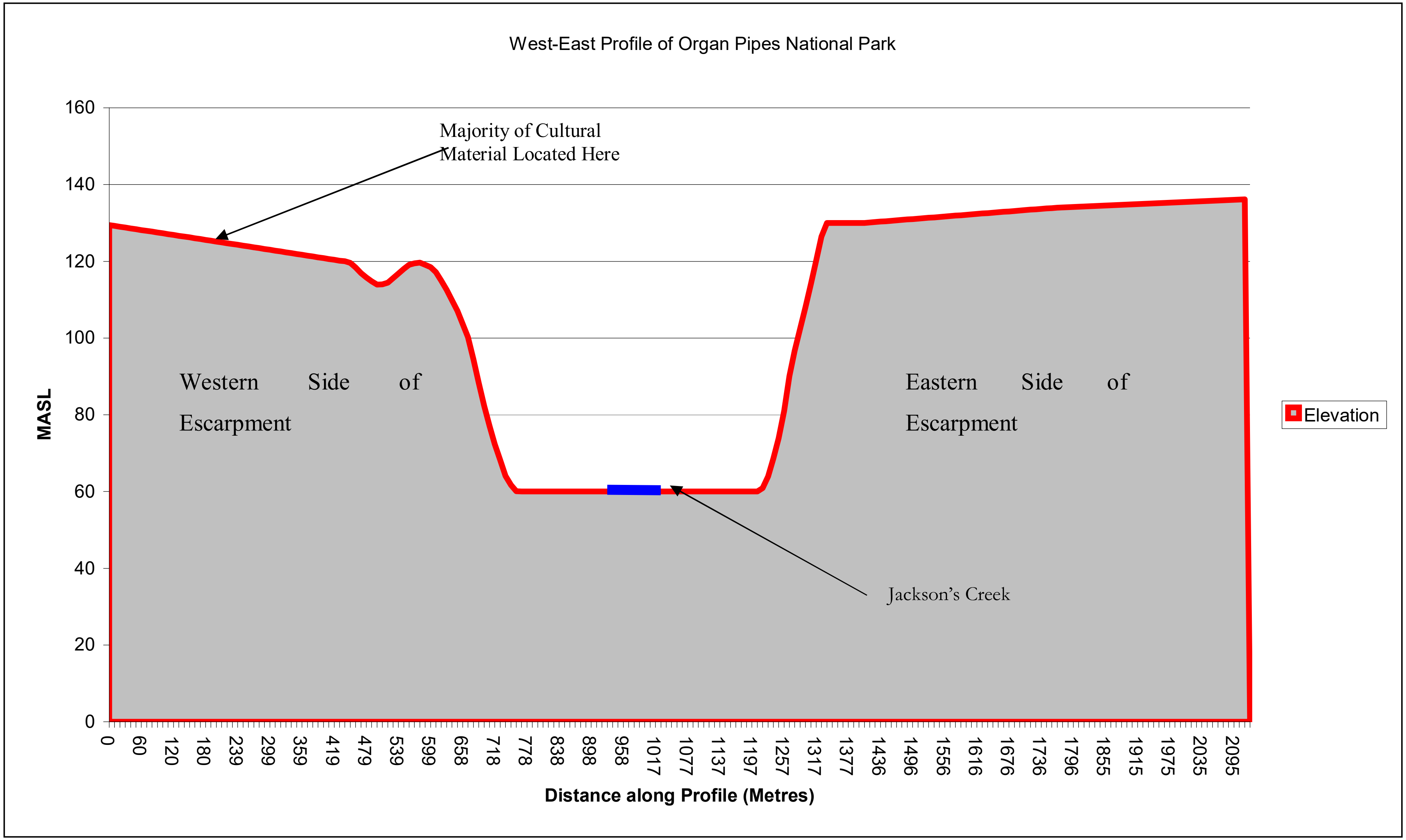


Figure 5-26: Profile of Organ Pipes National Park. The majority of cultural material was located on the western side of the escarpment, in the lee of the plain. This figure was generated using a landscape profiling routine in *ArcView 3.2*.The distribution of materials along the western margins of the escarpment can be seen in Figures 5-40 and 5-41 (below) .

Woodlands Historic Park

The final fieldwork session of two weeks duration was conducted at Woodlands Historic Park (WHP), between the 10th and 25th of February, 2001. Woodlands Historic Park is located approximately 20 kilometres northwest of the Melbourne central business district, and is immediately north of Tullamarine International Airport. Woodlands Historic Park is approximately 6 kilometres northeast of Organ Pipes National Park. Formerly known as Gellibrand Hill Park, WHP encompasses an area of just over 700 hectares of significant remnant native woodlands and grasslands (Parks Victoria, 1998b). WHP is also a significant cultural asset for numerous reasons. The park is culturally significant as a surviving example of the 1840s agricultural landscape, complete with rare examples of early pioneer buildings (Figure 5-28, below). There are sixteen Aboriginal archaeological sites recorded within the boundaries of WHP, particularly along the banks of the Moonee Ponds Creek. The close proximity to transport and greater Melbourne resulted in this final fieldwork session being conducted along similar lines to the Organ Pipes National Park session.

Although located relatively close to Organ Pipes National Park, the physical environment of WHP is very different. The majority of WHP is situated on Devonian Granodiorite, locally referred to as the 'Bulla Formation'. Marginally south of the 'Bulla Formation' is a narrow corridor of partially metamorphosed Silurian sedimentary rock. Moonee Ponds Creek forms the western boundary of the contemporary park. West of Moonee Ponds Creek there is a belt of Tertiary older volcanics composed of Olivine basalts (Carr *et al.*, 1996). As the name suggests, Moonee Ponds Creek once consisted of a series of 'ponds', which formed a flowing creek when rainfall conditions permitted. At other times, the creek would gradually contract, leaving a series of ephemeral 'ponds' (Parks Victoria, 1998b). A dramatic change in the natural structure of the Moonee Ponds Creek has led to the severe degradation of the contemporary watercourse. The main channel of Moonee Ponds Creek has now been eroded to bedrock, and reportedly bears little resemblance to how it appeared before European settlement (Parks Victoria, 1998b).

Carr *et al* (1996) determined that the indigenous vascular flora of WHP before the arrival of European settlers consisted of 343 species. There are currently 173 vascular plant species extant in the park (Parks Victoria, 1998b). This great diversity of vegetation is a product of the intersection of the western basalt plains and the Granodiorite hills in conjunction with the presence of Moonee Ponds Creek (Parks Victoria, 1998b). The park displays two distinctive vegetation regimes. The Granodiorite hills feature a remnant open forest of Yellow Box (*E. melliodora*), Manna Gum (*E. viminalis*), Grey Box (*E. microcarpa*) and Red Gums (*E. camuldulensis*) (Parks Victoria, 1998b). To the west of the Granodiorite hills, the basalt plains display an open woodlands structure, dominated by Grey Box (*E. microcarpa*) and Red Gums (*E. camuldulensis*) (Figure 5-27), interwoven with a mixture of native and exotic grasses (Parks Victoria, 1998b). Carr *et al* (1996) recorded 15 mammal, 150 bird, 9 amphibian, 16 reptile and 3 fish species as being endemic to the park. Many are either severely endangered or have become locally extinct since European settlement.

Figure 5-27: Bob Mullins, Wurrundjeri representative for this stage of the fieldwork, sitting opposite a cultural scar on a *E. camuldulensis*, near the northern car park at Woodlands Historic Park.

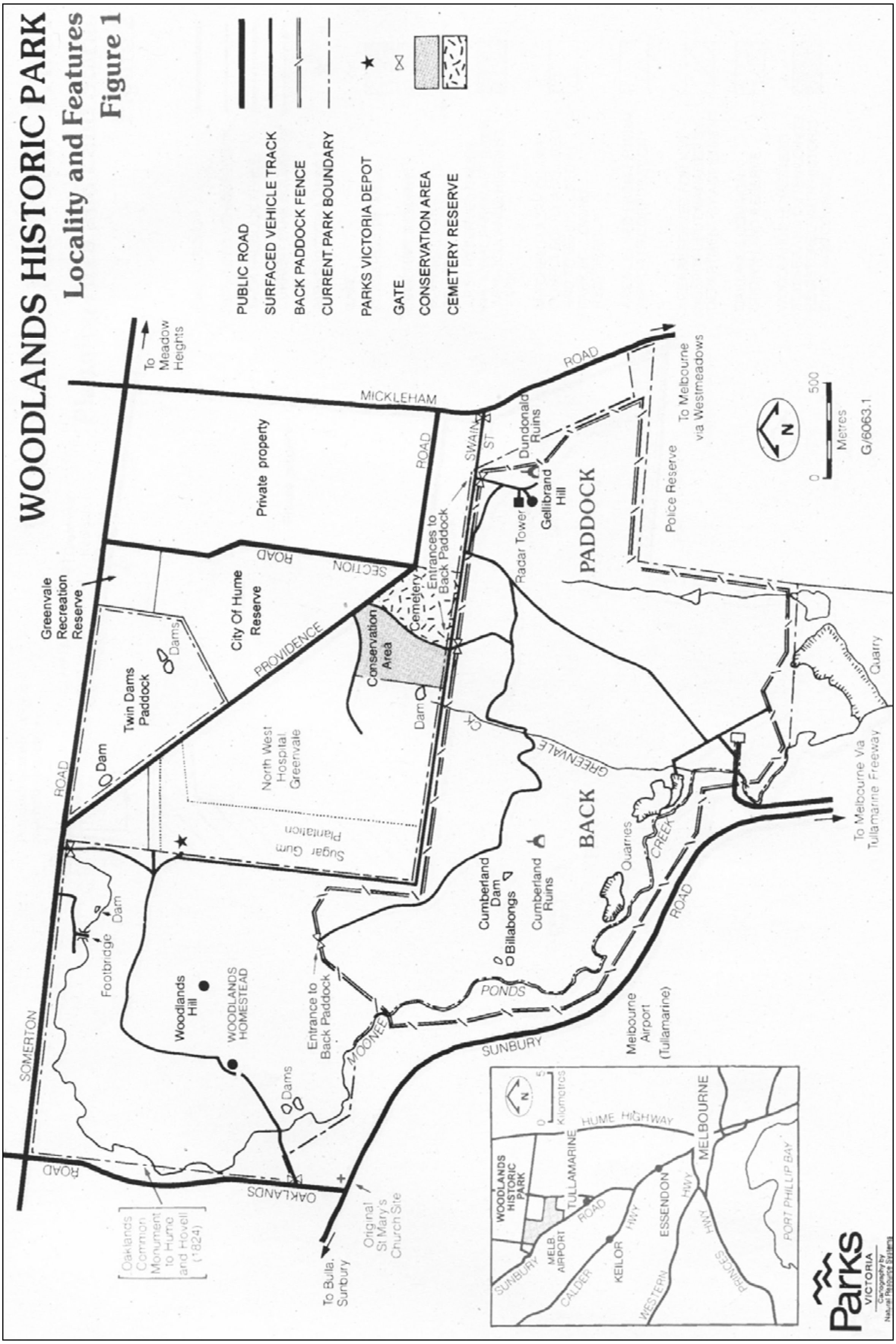


Figure 5-28: Map showing the layout of Woodlands Historic Park.

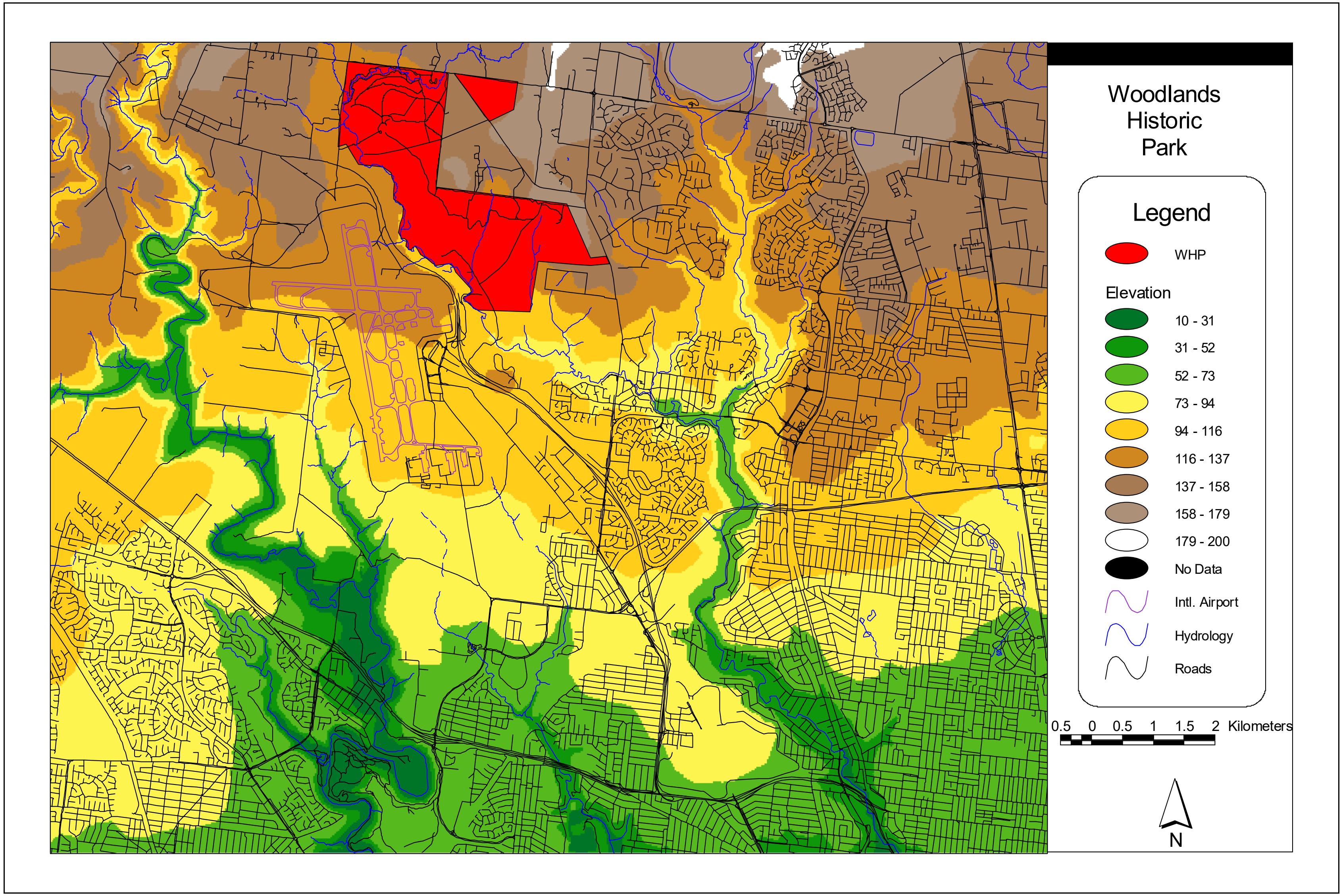


Figure 5-29: Woodlands Historic Park and environs. Note the proximity to Tullamarine International Airport. Figure 5-20 (above) shows the location of Woodlands Historic Park in relation to the Melbourne CBD, approximately 25 kilometres to the southeast.

Previous Archaeological Work

Before the commencement of the fieldwork component of this project, there had been no systematic archaeological investigation of the Woodlands Historic Park. Numerous opportunistic site recordings have been made before the BPAP project, (hence the 16 registered sites) but no other survey activity had taken place. Although there had been numerous archaeological survey projects in the general area, none actually included any part of the WHP. The most notable project to have taken place near WHP was the survey conducted by Weaver (1991) of the Moonee Ponds Creek. Weaver's (1991) survey commenced at the southern boundary of WHP, and continued downstream along the Moonee Ponds creek away from WHP. Weaver (1991) located 31 Aboriginal sites during five days of survey – 16 artefact scatters, 12 isolated artefacts, two stone raw material outcrops, and one scarred tree. Weaver (1991) noted that the majority of the sites recorded during this survey were located on eroded sections of the creek bank, or on the floodplain close to the creek margins. Three sites were found on higher promontories overlooking the creek. Notably, one recorded site included the remains of a hearth in the creek bank, approximately 60cm below the floodplains ground surface. The dominant raw material recorded by Weaver (1991) was silcrete, with occasional occurrences of quartz and basalt. The existing 16 registered sites at WHP consisted of one isolated artefact occurrence, eight artefact scatters and seven scarred trees.

Fieldwork

The survey for the final session of fieldwork was conducted over 10 days, between the 10^{th} and 25^{th} of February, 2001. Conditions in the field at WHP were not conducive to archaeological survey. During the WHP field survey a thick ground covering of native grasses and weeds once again made survey conditions difficult. Chilean Needle Grass in particular proved to be problematic (See Figure 5-31, below). This thick ground cover reduced visibility throughout the park to almost zero. Once again, high temperatures and the constant threat of bushfires were problematic. Indeed, there were two bushfires in the park during the survey, burning out approximately 30 hectares. This allowed for a thorough inspection of the resulting bare ground. The burnt out areas were located at opposite ends of the park. The larger burnt out area was located adjacent to Moonee Ponds creek, in the northwestern corner of the park. This area is located on the floodplain of the creek, largely dominated by open grassy woodland. The smaller burnt out area was located in the eastern section of the park, on the Granodiorite hills, dominated by open forested vegetation. Although ground surface visibility approached 100% in these two fire-affected areas, very small amounts of cultural material were recorded in either. On the Granodiorite hills (figure 5-30) 15 artefacts and two scarred trees were recorded, while at the larger burnt out area on the creek floodplain, 17 artefacts were recorded.

Figure 5-30: The view south from Gellibrand Hill in Woodlands Historic Park. The Melbourne CBD can be seen in the distance. Tullamarine airport is to the immediate right of this view.

It is difficult to say whether these latter 17 artefacts were made more 'visible' by the fire, as most of the material in the park was located in similar contexts (i.e. very close to Moonee Ponds Creek). In the smaller burnt out area on the 'back' of Gellibrand hill however, the fire definitely assisted in the site location process. The fire removed large quantities of grasses, leaves and bark, allowing for better visibility than for any other similar area in the park. The conditions encountered post-fire sit accord with Van Waarden's (1986) observations of improved visibility after similar fires in the You Yangs State Forest.

Figure 5-31: Photograph illustrating the level of vegetation cover in the Woodlands Historic Park. The majority of the vegetation in this illustration is Chilean Needle grass, an introduced weed species. Either weed or native grasses covered over 90% of the park

WHP Summary

In total, 274.4 hectares of WHP was surveyed during this final session. Nine hundred and twenty one artefacts, 13 possible quarried stone sources, four scarred trees and a possible hearth, were recorded. The overwhelming majority of the material recorded was located within a 100-metre corridor either side of the Moonee Ponds Creek. The material recorded was again dominated by silcrete (64.74%), quartz (27.9%), and quartzite (5.96%). While in many respects the survey of WHP was limited by very poor visibility, the results were still encouraging. To record almost 1,000 artefacts and other cultural material at this level of visibility indicates that there may be a far higher concentration of material at WHP than was otherwise detected.

5.3. Quantifying the Survey and Regional Comparisons

By the conclusion of the fourth fieldwork session, a significant amount of data had been collected. A total of 135,616 entries had been made into a Microsoft Access database during and after the fieldwork. Once the field sessions were completed, the database was scrutinised, and any incomplete or erroneous entries were removed. At the conclusion of this process, the database housed the records of exactly 10,000 artefacts. Although the number of artefacts recorded in each location differs significantly, as did the individual limitations and field restrictions in each area, it is still possible to offer a comparison of the various assemblages across the region. This section presents a summary of the regional data collected for this thesis. (The raw artefact data for each survey area is presented in Appendix 9-1).

Although being forced to discontinue the stratified random sampling methods was initially seen as detrimental, the results obtained more than justify the decision. The importance of this sampling problem must be seen in light of the total project. The problems encountered here are common to field archaeology throughout southeastern Australia, and plague academic and contract projects alike. Contracted projects rarely have the luxury of being able to change direction as radically as this project was able too, and thus are even more restricted by the vagaries of visibility and the survey environment. Shovel testing was entertained as a possible solution to the poor visibility, however, this method was not utilised for a number of reasons. The single greatest limitation with any attempt to apply shovel testing in the BRNP, for example, was that the majority of the park is 'broken' rocky ground, with very little soil coverage, rendering the shovel almost useless. Those areas with a deeper soil profile are limited to the areas of alluvium, dune or swamp foreshore as discussed in the text. There were also management concerns in the Brisbane Ranges National Park regarding the spread of *Phytophthora cinnamoni* (Cinnamon Fungus) by sub-surface testing techniques.

Tables 5-2 to 5-5 show the field survey data from the four fieldwork sessions. These data include landform type, gross area surveyed, ground surface visibility, actual area surveyed, artefacts located, and artefact density per hectare.

Brisbane Ranges National Park Survey Data

Landform Type	Area Surveyed (ha)	Visibility Range (%)	Actual Area Surveyed (M^2)	Artefacts Located	Density/ha
Basalt Plains					
	0	0-10	0	0	
	0	10-20	0	0	
	0	20-30	0	0	
	0	30-40	0	0	
	0	40-50	0	0	
	0	50-60	0	0	
	0.529	60-70	3,430	33	
	0	70-80	0	0	
	123.33	80-90	1,048,300	430	
	188.846	90-100	1,794,000	2995	
Sub-Total	312.7		2,845,730	3458	12.1
Gentle Hills					
	0	0-10	0	0	
	0	10-20	0	0	
	0	20-30	0	0	
	0	30-40	0	0	
	0	40-50	0	0	
	95.916	50-60	527,500	42	
	0	60-70	0	0	
	0	70-80	0	0	
	0	80-90	0	0	
	0	90-100	0	0	
Sub-Total	95.916		527,500	42	0.796
Steep Hills					
	0	0-10	0	0	
	158.012	10-20	237,000	3	
	0	20-30	0	0	
	0	30-40	0	0	
	0	40-50	0	0	
	0	50-60	0	0	
	0	60-70	0	0	
	0	70-80	0	0	
	0	80-90	0	0	
	0	90-100	0	0	
Sub-Total	158.012		237,000	3	0.126
Total	567.0		3,610,230		

Table 5-2: Tabulated survey data from the Brisbane Ranges National Park

Deep Creek Farms Survey Data

Landform Type	Area Surveyed (ha)	Visibility Range (%)	Actual Area Surveyed (M^2)	Artefacts Located	Density/ha
Basalt Plains					
	0	0-10	0	0	
	0	10-20	0	0	
	0.002	20-30	5	6	
	0.006	30-40	21	2	
	0.02	40-50	90	6	
	0.039	50-60	215	4	
	0.069	60-70	449	4	
	0.363	70-80	2,722	8	
	0.67	80-90	5,695	29	
	204.45	90-100	1,942,200	435	
Sub-Total	205.619		1,951,397	494	2.53
Steep Hills					
	20.194	0-10	10,097	1	
	0	10-20	0	0	
	0	20-30	0	0	
	0	30-40	0	0	
	0	40-50	0	0	
	0	50-60	0	0	
	0	60-70	0	0	
	0	70-80	0	0	
	0	80-90	0	0	
	0	90-100	0	0	
Sub-Total	20.194		10,097	1	0.99
Total	226.0		1,961,494		

Table 5-3: Tabulated survey results from the Deep Creek Farms

Organ Pipes National Park Survey Data

Landform Type	Area Surveyed (ha)	Visibility Range (%)	Actual Area Surveyed (M^2)	Artefacts Located	Density/ha
Basalt Plains					
	0	0-10	0	0	
	0.04	10-20	100	4	
	0.7	20-30	1,800	27	
	1.018	30-40	3,600	12	
	1.8	40-50	8,100	235	
	3.58	50-60	19,700	1,849	
	3.658	60-70	23,800	1,108	
	10.343	70-80	77,600	666	
	1.907	80-90	16,200	181	
	8.457	90-100	80,300	387	
Sub-Total	31.503		231,200	4,469	193.29
Incised Valleys					
	0	0-10	0	0	
	0	10-20	0	0	
	0	20-30	0	0	
	0	30-40	0	0	
	0	40-50	0	0	
	0.133	50-60	700	13	
	0.448	60-70	2,900	24	
	0.37	70-80	2,800	473	
	0.163	80-90	1,400	15	
	0.521	90-100	4,900	67	
Sub-Total	1.635		12,700	592	466.14
Total	33.0		243,900		

Table 5-4: Tabulated survey results from Organ Pipes National Park

Woodlands Historic Park Survey Data

Landform Type	Area Surveyed (ha)	Visibility Range (%)	Actual Area Surveyed (M^2)	Artefacts Located	Density/ha
Basalt Plains					
	0	0-10	0	0	
	96.57	10-20	144,900	343	
	0	20-30	0	0	
	0	30-40	0	0	
	0	40-50	0	0	
	0	50-60	0	0	
	0	60-70	0	0	
	0	70-80	0	0	
	0	80-90	0	0	
	0	90-100	0	0	
Sub-Total	96.57		144,900	343	23.67
Gentle Hills					
	0	0-10	0	0	
	164.55	10-20	246,800	534	
	0	20-30	0	0	
	0.4	30-40	100	2	
	0.5	40-50	200	0	
	0.814	50-60	4,500	34	
	2.617	60-70	17,000	7	
	8.026	70-80	160,200	5	
	13.424	80-90	114,100	13	
	0	90-100	0	0	
Sub-Total	190.331		542,900	595	10.96
Total	287.0		687,800		

Table 5-5: Tabulated survey results from Woodlands Historic Park.

Summary of Survey Data

Tables 5-2 to 5-5 are summarised in Table 5-6 as follows,

Landform	BRNP	%	Deep Creek	%	OPNP	%	WHP	%	Total	%
Basalt Plain	3458	98.7	494	99.8	4469	88.3	343	36.6	8,767	87.7
Incised Valley	0	0.0	0	0.0	592	11.7	0	0.0	592	5.9
Gentle Hills	42	1.2	0	0.0	0	0.0	595	63.4	637	6.4
Steep Hills	3	0.1	1	0.2	0	0.0	0	0.0	4	0.04
Total	3,503	100.	495	100	5,061	100	938	100.	10,000	100

Table 5-6: Artefacts recorded per landform in each of the survey areas.

The mean artefact density per landform surveyed is presented in Table 5-7 and Figure 5-32.

Landform	BRNP	Deep Creek	OPNP	WHP	Mean
Basalt Plain	12.1	2.52	193.29	23.67	57.895
Incised Valley	-	-	466.14	-	466.14
Gentle Hills	0.796	-	-	10.96	5.878
Steep Hills	0.126	0.99	-	-	0.558
Mean	4.341	1.755	329.72	17.32	-

Table 5-7: Mean artefact densities per landform across the study area.

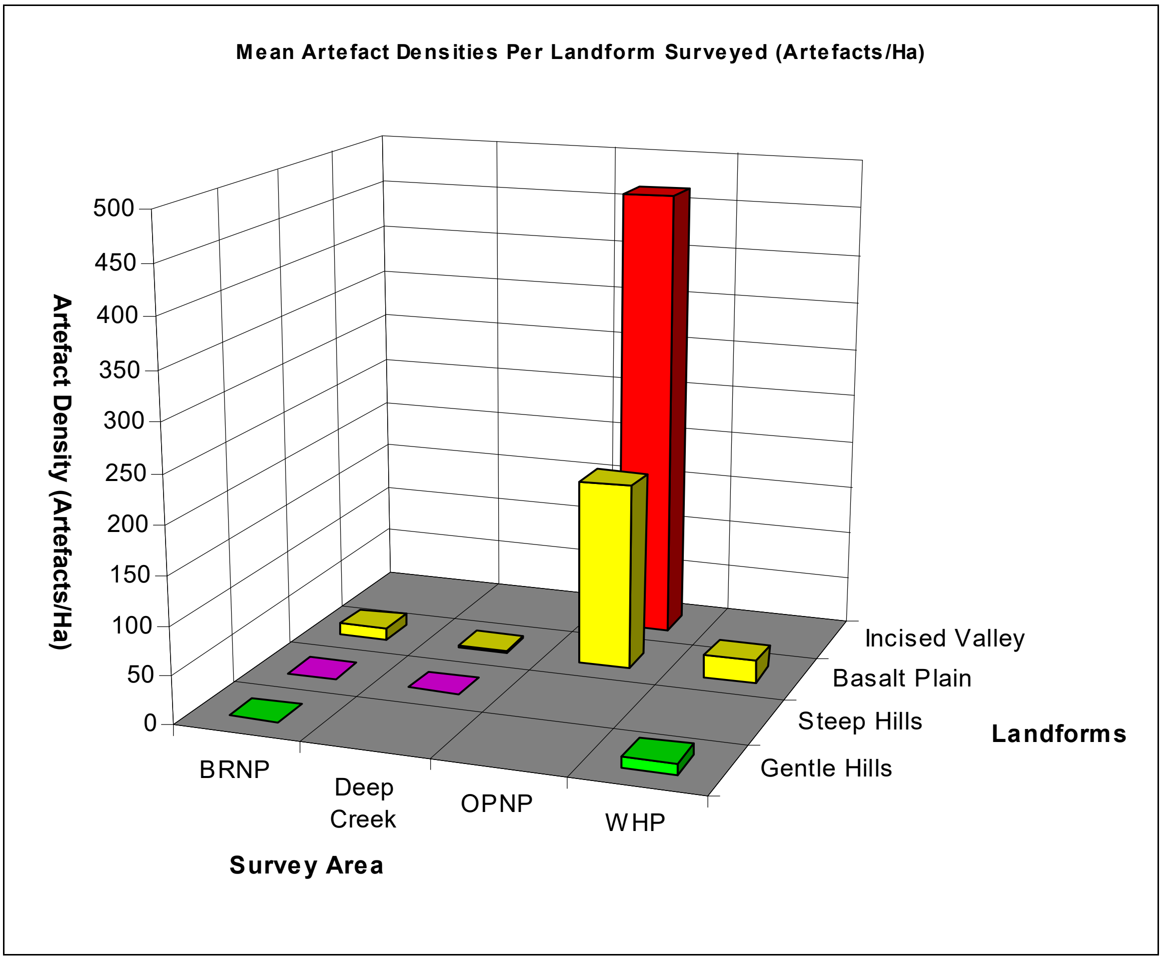


Figure 5-32: Mean Artefact density per landform from each of the four survey areas.

The incised valley and escarpment edge at OPNP had the greatest artefact density of any area surveyed (Figure 5-32).

Landform	BRNP (ha)	%	Deep Creek (ha)	%	OPNP (ha)	%	WHP (ha)	%	Total (ha)	%
Basalt Plain	312.7	55.2	205.6	91.1	31.5	95.1	96.6	33.7	648.8	58.2
Incised Valley	0.0	0.0	0.0	0.0	1.6	4.9	0.0	0.0	1.7	0.2
Gentle Hills	95.9	16.9	0.0	0.0	0.0	0.0	190.3	66.3	286.4	25.7
Steep Hills	158.0	27.9	20.2	8.9	0.0	0.0	0.0	0.0	178.6	16.0
Total	566.6	100	225.8	100	33.1	100	286.9	100	1,115.5	100

Table 5-8: Gross hectares surveyed before taking visibility into account.

Landform	BRNP (m^2)	%	Deep Creek (m^2)	%	OPNP (m^2)	%	WHP (m^2)	%	Total	%
Basalt Plain	2,845,730	78.8	1,951,397	99.5	231,200	94.8	144,900	0.21	5,173,230	79.5
Incised Valley	0	0.0	0	0.0	12,700	5.2	0	0.00	12,700	0.2
Gentle Hills	527,500	14.6	0	0.0	0	0.0	542,900	0.79	1,070,400	16.5
Steep Hills	237,000	6.6	10,097	0.5	0	0.0	0	0.00	247,097	3.8
Total	3,610,230	100	1,961,494	100	243,900	100	687,800	1.00	6,503,427	100.0

Table 5-9: Total ground surface survey coverage after accounting for visibility.

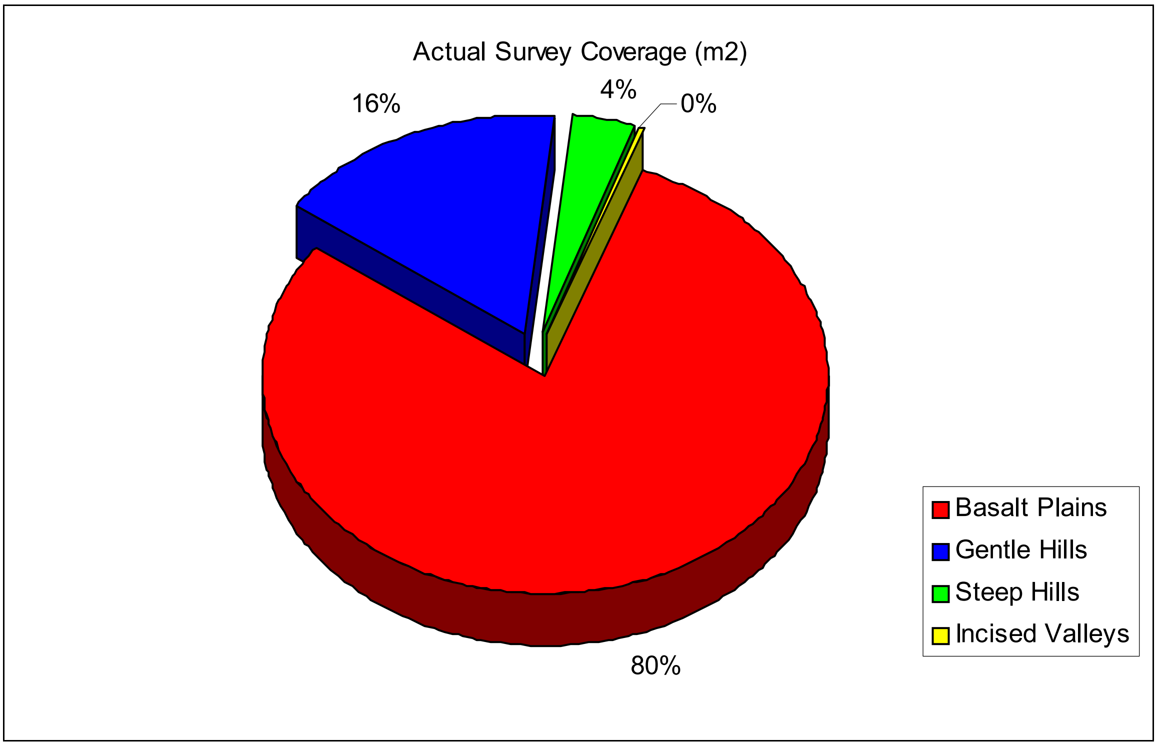
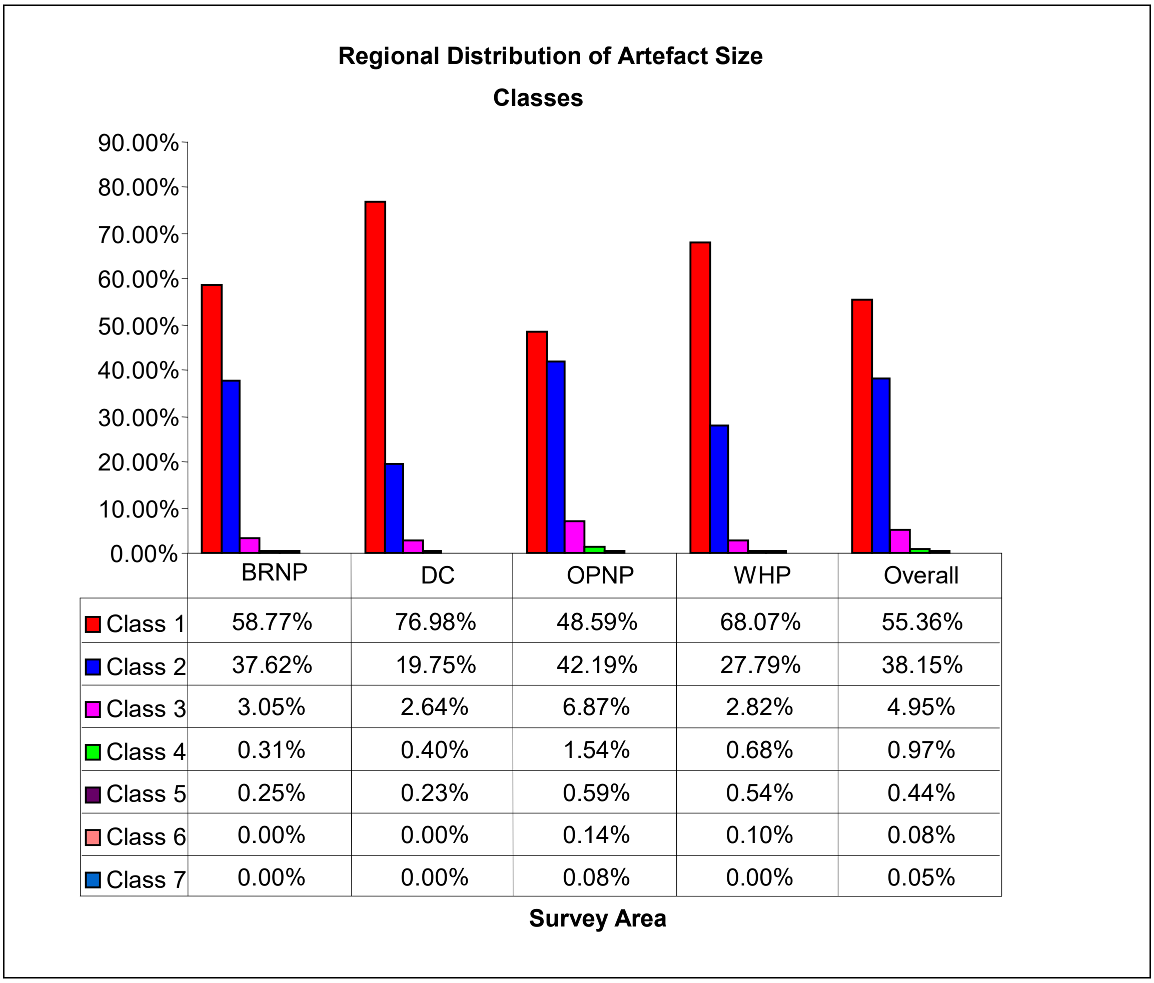


Figure 5-33: Chart showing the percentage of each landform surveyed.

After accounting for visibility (Tables 5-8 and 5-9), Figure 5-33 presents the percentage of each landform surveyed.



	BRNP	DC	OPNP	WHP	Overall
Class 1	58.77%	76.98%	48.59%	68.07%	55.36%
Class 2	37.62%	19.75%	42.19%	27.79%	38.15%
Class 3	3.05%	2.64%	6.87%	2.82%	4.95%
Class 4	0.31%	0.40%	1.54%	0.68%	0.97%
Class 5	0.25%	0.23%	0.59%	0.54%	0.44%
Class 6	0.00%	0.00%	0.14%	0.10%	0.08%
Class 7	0.00%	0.00%	0.08%	0.00%	0.05%

Figure 5-34: Regional distribution of artefact size classes across the four survey areas.

The majority of artefacts recorded across the region were either Size Class 1 or Size Class 2 (Figure 5-34 and 5-35). The data from Organ Pipes National Park indicates that this is where the largest, least reduced artefacts are located. This is to be expected given the numerous known silcrete quarries in the Maribyrnong valley. Size Class 1 artefacts however, are generally the most common in all of the surveyed locations.

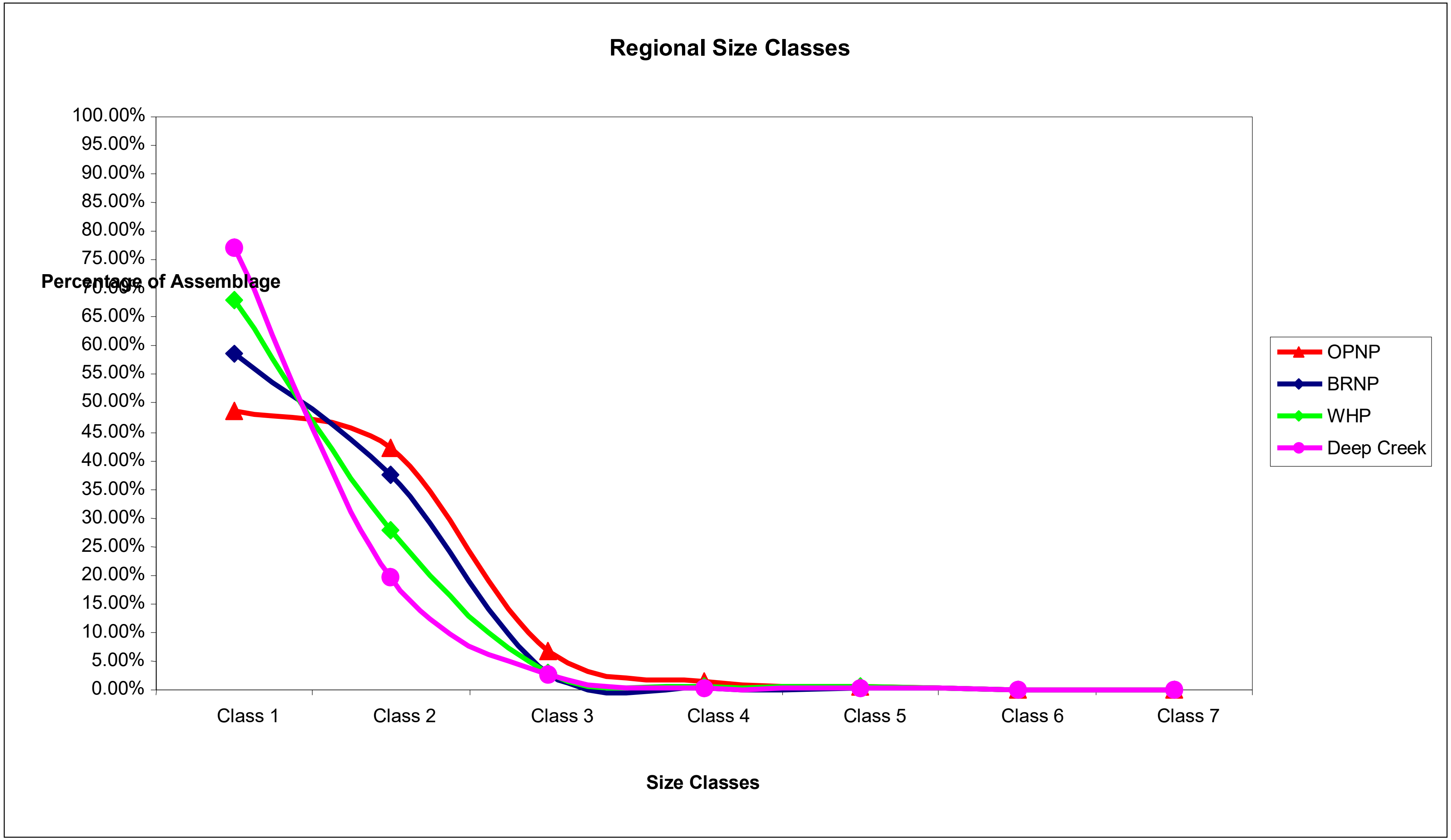


Figure 5-35: Line graph showing the ‘spread’ of size classes.

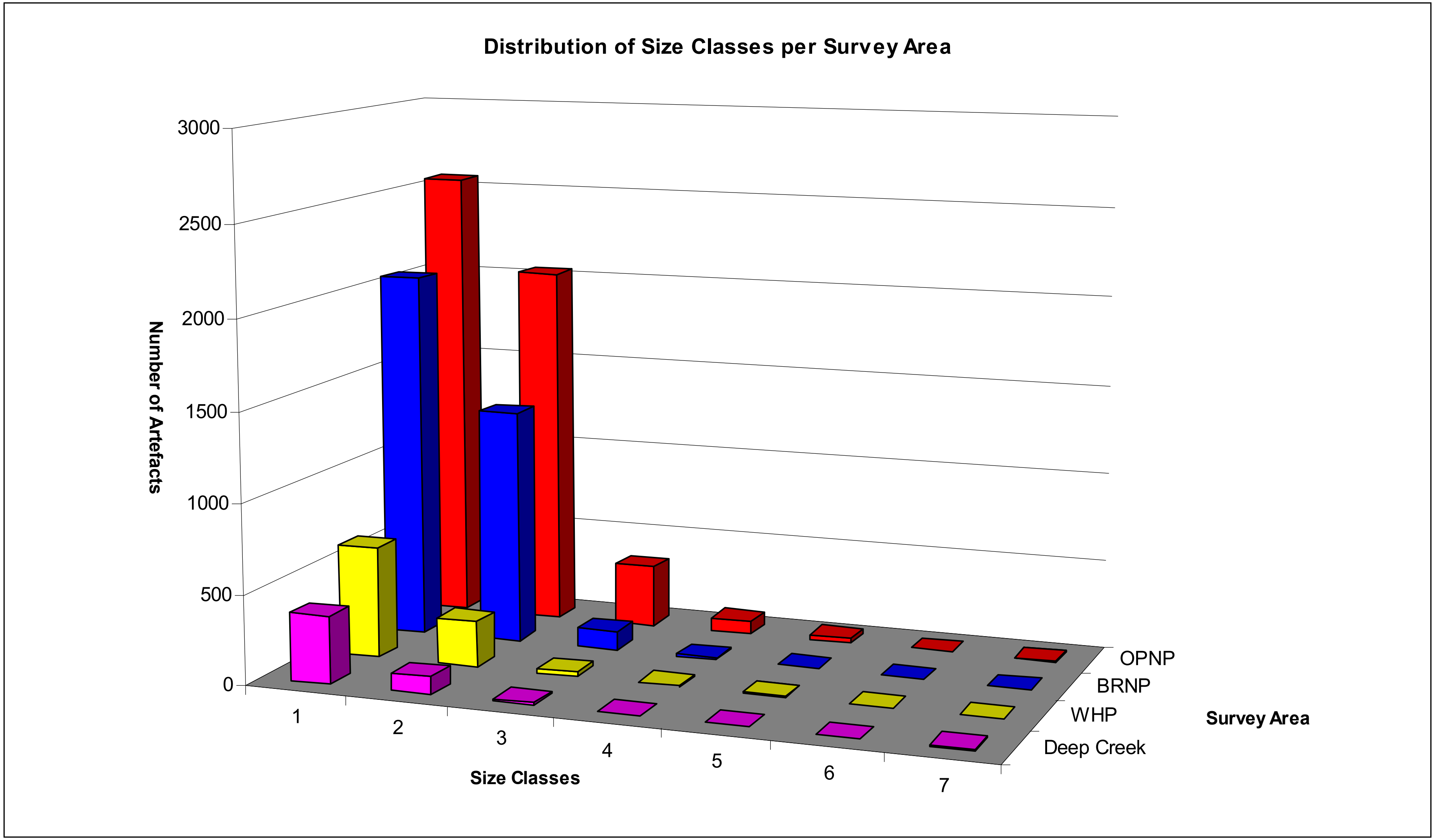
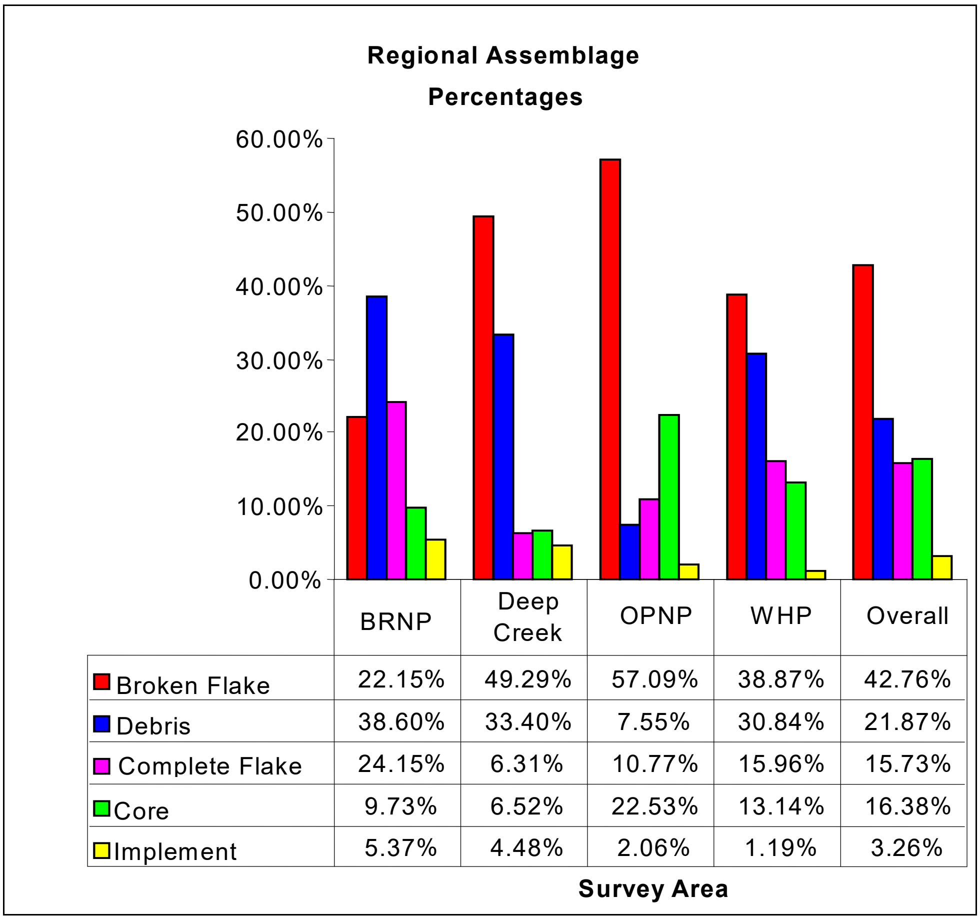


Figure 5-36: Distribution of size classes per survey area.



	BRNP	Deep Creek	OPNP	WHP	Overall
Broken Flake	22.15%	49.29%	57.09%	38.87%	42.76%
Debris	38.60%	33.40%	7.55%	30.84%	21.87%
Complete Flake	24.15%	6.31%	10.77%	15.96%	15.73%
Core	9.73%	6.52%	22.53%	13.14%	16.38%
Implement	5.37%	4.48%	2.06%	1.19%	3.26%

Figure 5-37: Percentage of each artefact type in each assemblage across the four survey areas, and the overall breakdown of artefact types.

OPNP has the widest dispersal of material across the size classes, indicating more artefacts in the larger classes, and perhaps a less reduced assemblage. This may indicate proximity to source material, or a large primary manufacturing site, and is indicative of significant Aboriginal occupation occurring along Jackson's Creek (Figures 5-34, 5-35, 5-36, and 5-37). This largely conforms to the general model of Aboriginal behaviour developed in the previous consulting work and academic research in the region. There are very low numbers of complete flakes or formal tools present in the OPNP assemblage, but very high number of broken flakes and cores. The large number of cores in particular indicates stone tool manufacturing activities taking place. The material recorded at OPNP and WHP is also subject to an un-quantifiable amount of recently introduced bias. The OPNP and WHP assemblages may have been 'picked over' by collectors for many years. It is not possible to determine to what extent this has influenced the composition of the extant assemblages, however the extremely low number of complete flakes and formal tools in an area where lithics were manufactured would suggest possible disturbance by collectors. The mean percentage of formal tools across all assemblages is a modest 3.26%, while OPNP (2.06%) and WHP (1.19%) are considerably lower than this figure.

Artefact Type	Mean	Mean %	SD
Core	408.5	16.38	504.66
Broken Flake	1066.25	42.76	1236.62
Complete Flake	392.25	15.73	374.11
Debris or débitage	545.5	21.87	545.01
Implement	81.25	3.26	82.38

Table 5-10: Mean, Mean Percentage of Assemblage and Standard Deviation of each artefact type for the four survey areas.

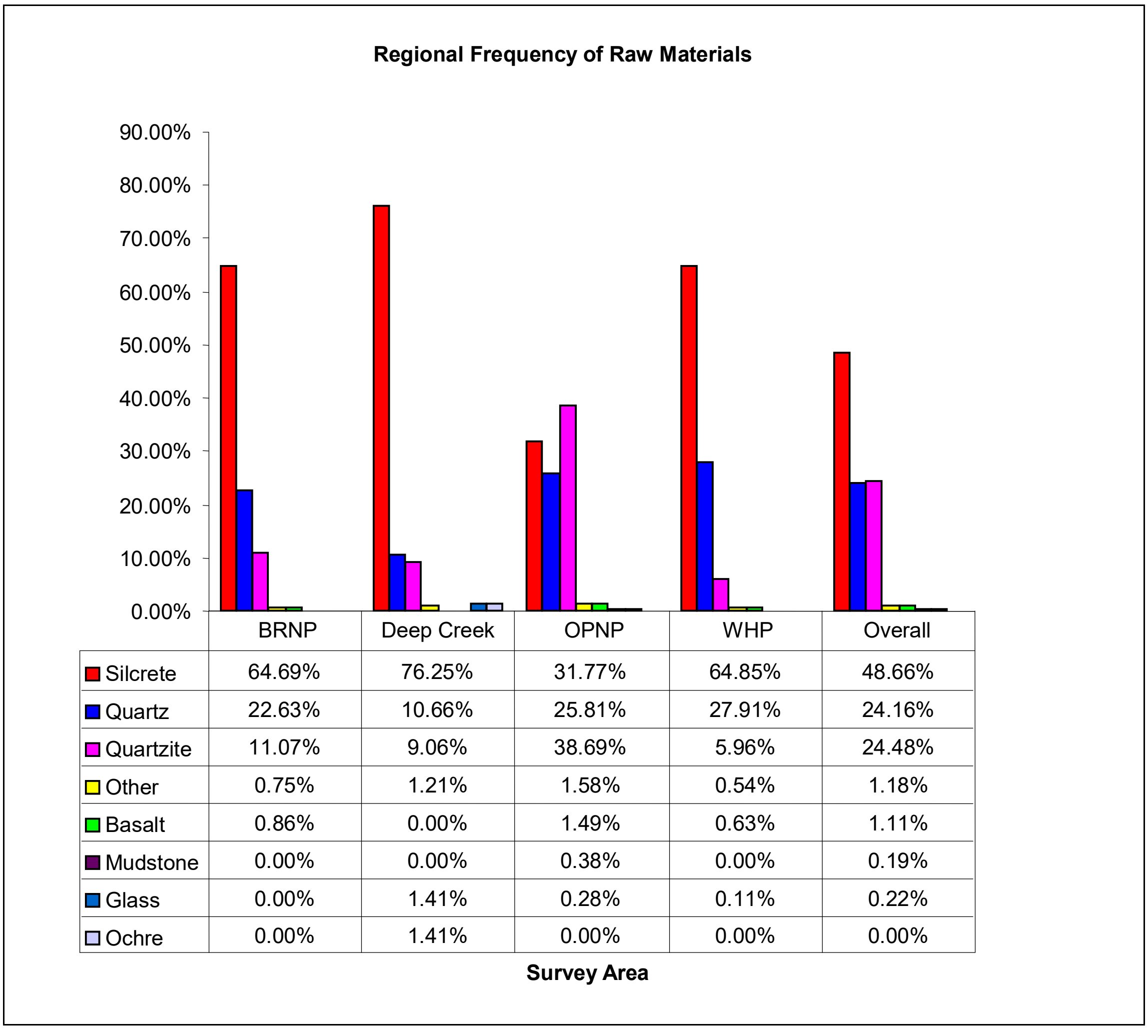


Figure 5-38: Frequency of raw materials in each of the four survey areas

Silcrete is the dominant raw material across the region, however the assemblage's at all four survey areas are diverse, demonstrating the range of raw materials utilised in prehistory (Figure 5-38). Broken Flaked pieces account for the highest mean percentage (42.7%) of all assemblages (Table 5-10). The study area is comparatively rich in lithic materials suitable for the manufacture of stone tools. OPNP is the most diverse assemblage (Figure 5-39) in terms of the number of different raw materials utilised (n=7).

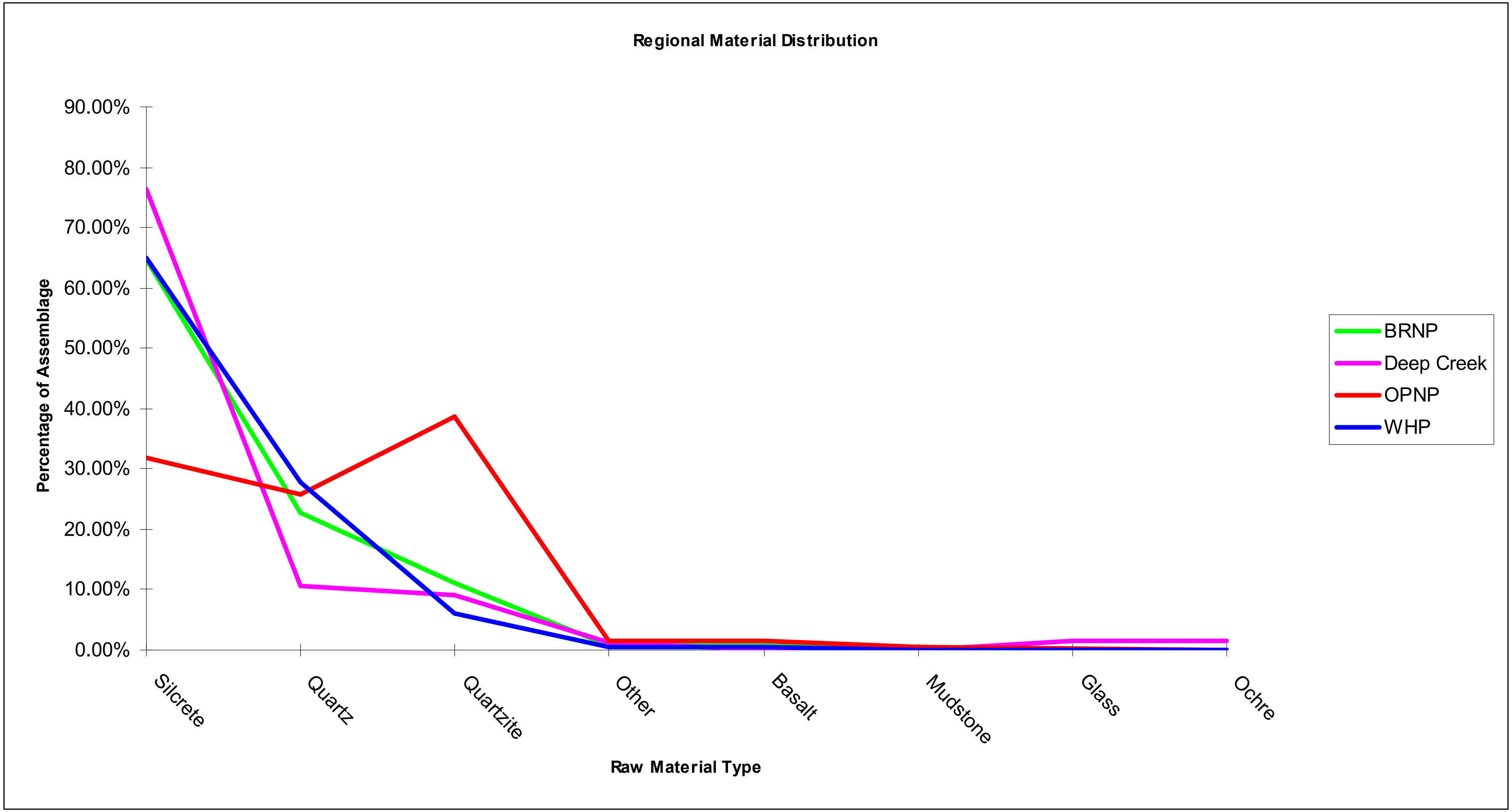


Figure 5-39: Graph of raw material types, showing that more diversity is present in the OPNP assemblage than any other. The steeper the curve the less raw material diversity.

To summarise, OPNP was the largest and most diverse assemblage recorded, in terms of both the number of artefacts present, the types of raw materials, and the size of the artefacts recorded. The availability of lithic raw materials in the Maribyrnong Valley is well known, so it is not surprising that the OPNP area displays the level of diversity identified. This appears to have been an important stone tool-manufacturing locale, which should be viewed as a part of a more or less continuous Maribyrnong Valley industrial 'complex' located along the margins and the floors of the deeply incised valleys of the Maribyrnong River, Deep Creek and Jackson's Creek.

The distribution of scarred trees today is largely a function of where old growth trees are left standing rather than a true picture of their original extent when Aboriginal people created them. It is not possible to estimate the number of scarred trees that may or may not have been present in the area before European settlement. However, these items would have been a far more common part of the landscape than they are today. Nonetheless, there are still 117 registered scarred trees across the study area, and this survey identified a further nine examples.

Two isolated hearths were located (at Deep Creek and WHP respectively). These hearths were also problematic to categorically identify as Aboriginal in origin. Both were relatively shallow un-stratified deposits of charcoal and clay (i.e. < 15 cm deep) located close to the contemporary land surface. No artefacts or burnt clay was present in the deposits. There was evidence of burnt tree roots in both hearths. In both cases, representatives of the Aboriginal communities present wanted these items recorded as hearth sites. These sorts of pressures may result in the production of spurious data if inappropriate or inaccurate identifications are made or demanded in the field. These features were therefore not recorded as hearths.

Known Site Data

The data recorded during the fieldwork component of this project generally conforms to the data extracted from the consulting reports reviewed in earlier chapters. While there are minor differences between every assemblage recorded, the differences are largely superficial. Across the entire region, silcrete dominates all of the assemblages. The artefacts are generally small, with very low numbers of identifiable formal tools. Other materials include quartz and quartzite. The density of lithic material varies directly with the proximity to permanent fresh water and areas of higher biomass. The higher the biomass and the more reliable the water source, the higher the density of archaeological materials present, such as at OPNP.

Contrasting the New Data

Although the data collected during the fieldwork component of this thesis generally conforms to the results of the data collected by the various consultant archaeologists, major differences in the distribution, spatial scale and accuracy of the site data are apparent. Until recently, all AAV sites were hand-plotted on 1:100,000 topographic maps (in fact, this is still undertaken as a 'back-up' should the AAV GIS data be destroyed or fail). A 'dot' and the site number are plotted on the maps in the approximate location of the site (according to the original site card). Much of this paper-based system has been subsequently digitised, with any corresponding errors in translation being transferred to the new GIS system. AAV has attempted to validate the new digitised data by checking the GIS co-ordinates against the original co-ordinates from the site cards, and adjusting the GIS data where necessary. This process does not guarantee the accuracy of the GIS data however, as it simply replicates whatever data (accurate or not) was originally recorded on the site cards. Older sites cards (i.e. pre-GPS) are more likely to contain locational errors as the locations were predominantly established in the field using topographic maps (du Cros and Rhodes, 1998). While this was one of the only ways in which to locate sites, the level of accuracy cannot be greater than ± 100 metres. Although AAV have attempted to crosscheck the accuracy of the new computerised database(s), the only way to achieve this is to check the location of existing sites in the field. By choosing a sample of the entire database from each region and 'ground-truthing' each site, AAV would be able to establish the accuracy of the database in each of the regions. This would also provide an indication of whether sites are being destroyed or not (having the sites registered and plotted on a map does not guarantee that a site will still exist 10 years after it was recorded). The method employed by AAV of checking site(s) accuracy between maps, site cards and the GIS records will result in the correction of certain classes of errors (mainly typographic), however errors in the original recording will be replicated in the updated GIS records.

The major difference between the known site data and the materials identified for this project however, are the ways in which the notion of 'archaeological site' has constrained the view of the archaeological record of the region. The traditional 'bounded' site concept does not adequately represent the actuality of the archaeology. The material identified during this project highlights the differential but spatially continuous use of landscapes indicated by differing artefact densities across the various survey areas. The archaeological material displays a more or less continuous background scatter across the region on the more recent geomorphic surfaces. Similar patterns have been identified in older geomorphic surfaces in the study area (Tunn, 1998). Areas of higher artefact density occur throughout the landscape, and represent areas of more intensive landscape utilisation. Between the 'patches' however, 'scatters' are nearly always evident. The traditional 'site-bound' notion of Aboriginal archaeological materials does not represent the archaeological record of this region. The materials located during the fieldwork for this thesis display a distinctive 'distributional' style (Ebert, 1992) patterning as Figures 5-40 and 5-41 clearly demonstrate.

This chapter has presented the extensive new archaeological data collected specifically for this thesis and contrasted it with the existing AAV data. The following chapter presents models of Aboriginal land use and archaeological sensitivity.

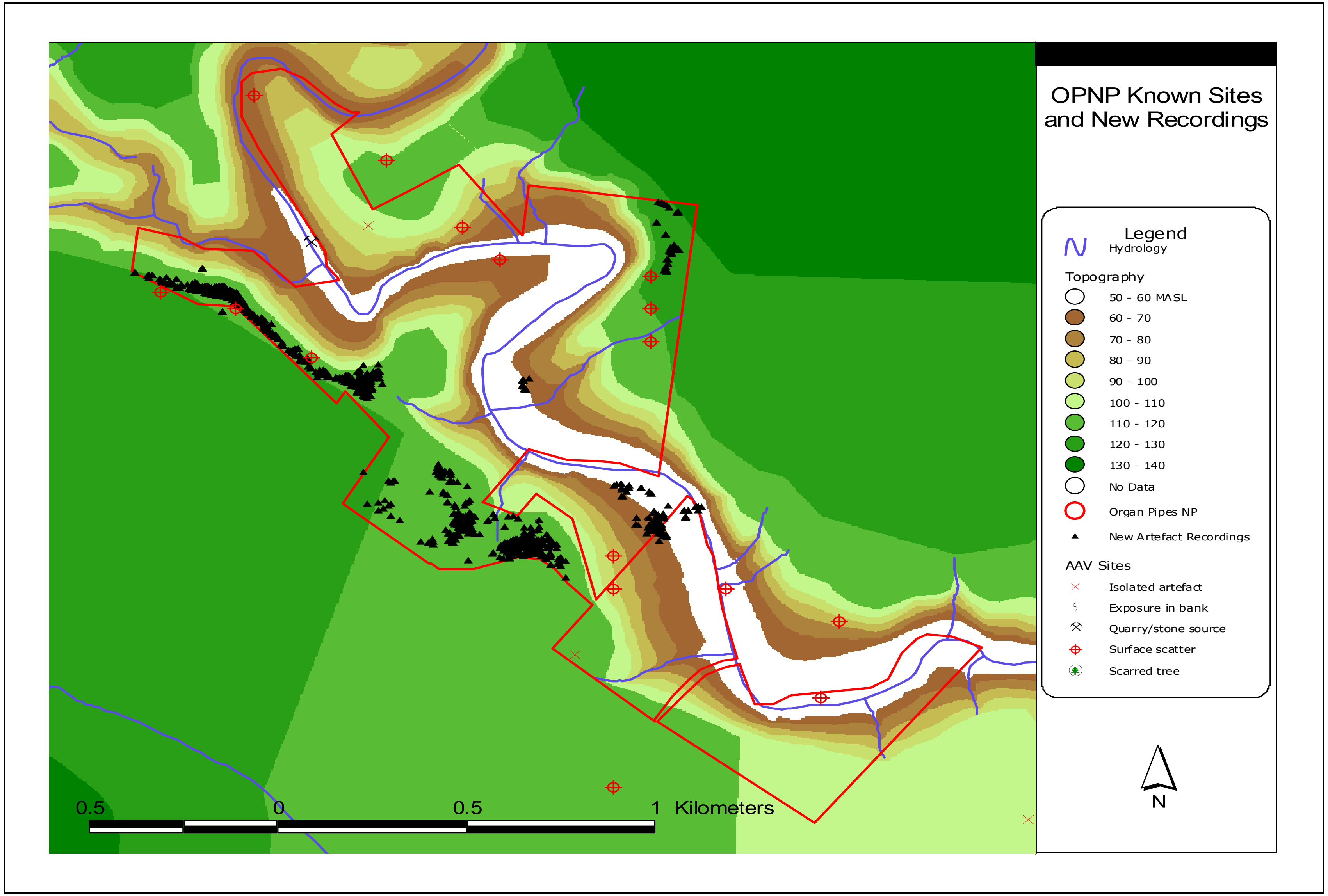


Figure 5-40: Known AAV sites and newly recorded data.

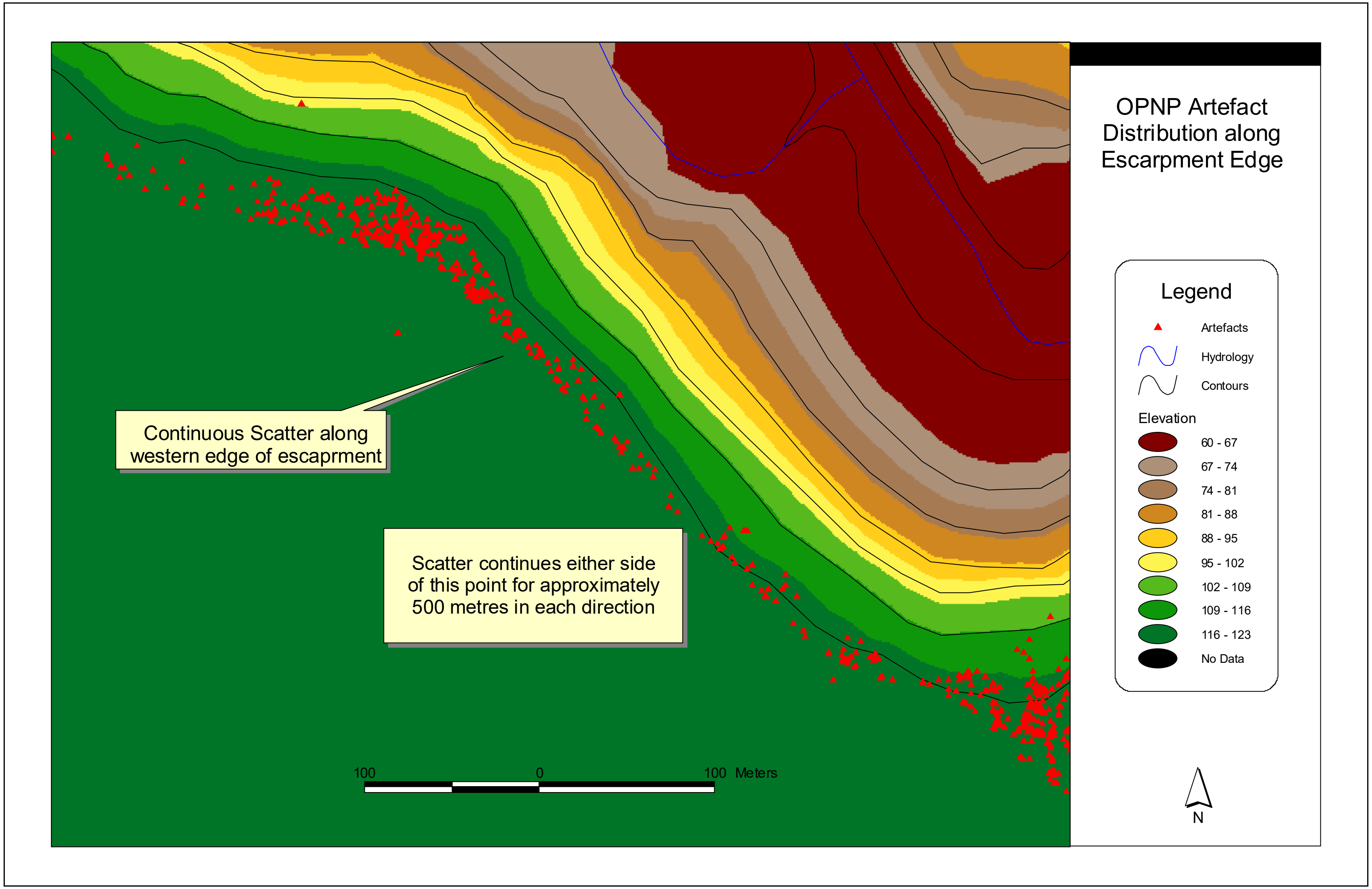


Figure 5-41: Map showing the large scatter located along the break of slope (escarpment) between the basalt plains (brown) and the incised valley below (green).

Chapter Six

6. Models of Land Use and Archaeological Sensitivity

This chapter presents various generalised Aboriginal land use models that integrate the available archaeological and palaeoenvironmental data for the study area. Numerous other land use models have been constructed for areas adjoining the thesis study area (Coutts, 1976, 1981a, 1981b, 1984; Ellender, 1991a, 1991b, 1994; Gaughwin, 1981; Richards, 1998; Richards and Jordan, 1996; Smith, 1991; Sullivan, 1981, 1984; Van Waarden, 1986). The land-use models constructed here represent broad, generalised models of four environmentally distinctive phases over the last 30,000 years. The models are presented in order of decreasing antiquity, and the commensurate increase in the quantity and quality (i.e. resolution) of archaeological and palaeoenvironmental data for each period, culminating in a late-Holocene model of Aboriginal land use, and a model of archaeological sensitivity for the study area.

The four broad periods and associated land use models presented are: -

- 30,000 BP.
- Height of the Last Glacial Maximum (c. 18,000BP)
- The Holocene-Pleistocene Transition (c. 10,000 BP)
- The Late Holocene (c. 2,500 BP)

Each of these periods is characterised by specific environmental conditions that would have significantly influenced human behaviour and land-use decisions. While nothing can be known of the social or political world of prehistoric Aboriginal populations in deep antiquity, the archaeological and palaeoenvironmental data allow for the reconstruction of generalised models of land-use in each of the periods in question. These periods are representative of narrow slices of time, and are deliberately narrow to provide a snapshot of prevailing conditions at each temporal marker, and to accommodate a view of the wide range of changes taking place through time and space. For example, the climatic deterioration leading up to the last glacial maxima took place over several millennia, and the commensurate impacts would have been both spatially and temporally diverse, however here only the height of the LGM is presented. Similarly, the amelioration of climatic conditions post-LGM took place over several millennia. The effects of the climatic changes of the LGM on human populations of the region should be seen as taking place over a period of perhaps six or seven millennia, and not just as a snapshot at 18,000 BP (Chappell, 2001).

6.1. Building Models.

Models are essentially abstract representations of an observed or hypothesized phenomenon (Winterhalder, 2000). The models developed here focus on very specific elements of Aboriginal behaviour in prehistory, and how these elements may have been affected by different climatic and ecological constraints and opportunities. These are therefore 'self-consciously reductionist' models' (Winterhalder, 2001:14).

Predictive Modelling

Predictive modelling in archaeology has its origins in the settlement pattern analyses first utilised by Julian Steward (1938) and Gordon Willey (Willey, 1953). These pioneering studies focused primarily upon the relationship between regional environments and settlement patterns (Dalla Bona, 1994; Kohler and Parker, 1986). Out of the development of settlement pattern studies, and the increasing emphasis on scientific research methods, catchment analysis methods were developed to investigate regional processes (Higgs and Vita-Finzi, 1972; Vita-Finzi and Higgs, 1970) that emphasise the relationships between people and their environment (Roper, 1979). The 'new archaeology' of the 1960s, and the heightened interest in archaeological sampling techniques and data analysis methods (Binford, 1964), led to a shift by some archaeologists away from 'single-site' archaeology, to broader regional questions. The introduction of new technological tools (i.e. computers) gave practitioners the ability to interrogate greater quantities of data than had previously been possible (Dalla Bona, 1994). Against this backdrop, contemporary predictive modelling has emerged.

Amongst the first studies to explicitly state that a research goal was to predict actual archaeological site location was that of the Southwestern Anthropological Research Group (SARG) in the United States (Plog and Hill, 1971). The SARG members reasoned that if the structure of a particular settlement system under consideration was known, then it should be possible, *a priori*, to predict the location of unknown archaeological sites (Plog and Hill, 1971). Similar prediction-based research questions began to appear in the archaeological literature during the early 1970s (Green, 1973; Thomas, 1975). Although it has been claimed that the use of predictive modelling in pure research based activities has gradually declined (Dalla Bona, 1994), the perceived benefits of predictive modelling in CRM applications has fuelled the continued development of predictive modelling method and theory (Kohler, 1988; Kohler and Parker, 1986; McManamon, 1984; Warren, 1990a).

Cultural resource management agencies are generally mandated with the responsibility of managing and protecting a finite archaeological resource base for a relevant region, state or nation. This is attempted using various combinations of techniques, including excavation, site discovery and recording programmes, and more recently the application of predictive modelling. The responsibility to manage and protect the archaeological record means many agencies are constantly seeking improved methods to locate and record archaeological sites, particularly in the face of rapid development and urban expansion (MacNeill, 1998). In this environment, the benefits of archaeological predictive modelling to cultural resource and land managers appear obvious, even though no one is entirely certain as to how predictive modelling should be approached (Kohler, 1988), and the approach eventually chosen is dependant on a great many variables. Paramount among these is determining the purpose for the model. Is the model to be a purely academic exercise, or is the model designed to 'red flag' (Altschul, 1990) areas of archaeological sensitivity for planning and management agencies?

Types of Predictive Models

There are many types of predictive models in CRM and archaeology (Kohler, 1988), which may be briefly summarised, together with their various theoretical perspectives, and the range of decisions involved (Gibbon, 1998). In an Australian context, the most comprehensive review of the various approaches to theoretical model building, and indeed the wide variety of possible theoretical positions, is that of Bernard Hutchet's (1990; 1991; 1993). Two major approaches are used in the construction of archaeological predictive models (inductive and deductive), particularly those developed within a CRM framework where their primary purpose is not explanation, but usually prediction. Explanation is perhaps the more desirable outcome of research activity, as theoretically grounded explanation is a more powerful tool than prediction alone.

Deductive Modelling involves deductive logic where the researcher moves from the abstract (theory) to the non-abstract (archaeological reality). Deductive predictive models commence from a certain theoretical perspective and proceed towards an understanding of extant archaeological data or phenomena primarily via explanation. Indeed, Kohler defines a deductive modelling approach as one that begins 'with a theory as to how people use a landscape and to deduce from that theory where archaeological materials should be located' (1988:37). For example, a model of archaeological site location may be constructed using the theoretical perspectives of behavioural or human ecology

(Butzer, 1982). Once the model has been constructed, and middle-range theoretical issues such as discard rates, depositional and post-depositional processes have been incorporated, the modelling process can then turn to data gathering and the interpretation (explanation) of the data (Ebert, 1988).

Kohler and Parker state that a deductive models must…
(1) 'Consider how humans make choices concerning location. This requires considering a mechanism for decision-making, and an end for decision making; what is the goal?
(2) Specify the variables affecting location decisions for each significant chronological or functional subset of sites; and
(3) Be capable of operationalisation' (Kohler and Parker, 1986: 432)

In the realm of CRM predictive modelling, deductively based models are comparatively rare. The majority of models are inductively based.

Inductive Modelling involves the researcher moving from detailed data to more generalised theory. In archaeological predictive modelling, the researcher begins with site data and then makes estimates or inferences regarding the overall spatial distribution of archaeological material in that sampling universe (Kohler, 1988; Neuman, 1997). This type of modelling exercise makes use of existing data, such as site records held by management agencies, and is the most common approach to predictive modelling (Ebert, 2000; Kohler, 1988) particularly in CRM applications. This approach is also known as correlative or inferential modelling (Kohler, 1988).

It has been argued that inductive predictive models are simply 'formal devices of pattern recognition' (Warren and Asch, 2000: 8). Inductive predictive modelling in CRM and archaeology primarily consists of attempting to find correlations between site location and any number of relevant environmental attributes collected from contemporary geographic data. Once (or if) any correlations are established, the process then moves on to 'modelling' the probable locations of further unknown site locations (Ebert, 2000). There are severe theoretical failings in the inductive modelling approach. Arguably, the most problematic issue with inductive or 'correlative' (Church, Brandon and Burgett, 2000: 135-7) modelling is the almost implicit assumption that settlement decisions made by people in the remote past are somehow directly linked to geospatial attributes that can be derived or deduced from modern maps (Ebert, 2000). While certain environmental attributes undoubtedly influenced prehistoric human settlement choices, these attributes are not static through time. Change in the environmental structure of a place through time is seldom taken into account in inductive models.

As an approach to predictive modelling, the inductively based model also has major appeal. The principal reason for the popularity of this approach is that the majority of the data required already exists in the form of site databases and geospatial map data. This significantly reduces the costs of any modelling project – another area of considerable appeal to agencies funding predictive modelling exercises (Church, Brandon and Burgett, 2000).

Mathematical – vs.- Graphical

> '…their potential weakness lies in their tendency to make us believe we have an insight into the data when we merely have created a mathematical epiphenomena' (Rindos, 1989: 13).

Dalla Bona (1994) discusses the second significant decision that is required when building a predictive model – the choice between a mathematical (numerical) or graphical modelling methodology. Although the two may be combined, it has been the usual practice for modellers to choose one over the other.

Mathematical predictive models make extensive use of any one of the numerous multivariate statistical methods in order to determine if correlations between archaeological site locations and the variables under analysis exist (Dalla Bona, 1994).

Graphical techniques make use of modern computer hardware and software (particularly GIS) to develop a model as a series of map overlays of the relevant variables under consideration.

A third category of predictive model often seen in CRM literature and reports is known as the intuitive method. Intuitive models are based upon a practitioners experience in the field, and their 'feel' for the archaeology of a particular area. Intuitive models are seldom tested, or are indeed testable, in an empirical sense. The 'predictions' will mostly be a series of statements such as 'sites will occur on terraces above waterways'. These are intuitive statements, and are not a 'predictive model' in the true sense of the term (Kohler, 1988). This type of 'model' is common in Victorian CRM, and many reports (eg. du Cros, 1989a; 1990, 1991) contain 'predictions' such as the preceding example.

The findings of the majority of the CRM reports reviewed for this thesis are based upon the archaeologist's notion of where sites will be located (intuition), rather than any formalised research or sampling design (Altschul, 1988; Moon, 1993). While there is nothing essentially wrong with using intuition, or expert knowledge, the results must be viewed with some caution. The use of intuition as a means of selecting areas to survey will also result in a biased view of the total archaeological record. If, for instance, 90% of all surveys were conducted within 100 metres of fresh water, then the site database would misleadingly indicate that the overwhelming majority of material is located within 100 metres of water.

Attributes of Predictive Models.

While predictive models may make use of a variety of methods and techniques, they can generally be divided between deductively or inductively based, and are either mathematical or graphical in design (this delineation is not absolute). All models however, regardless of method, should share a number of common attributes. Models should be testable, be simple enough to be useful, and must be able to be operationalised (Kohler, 1988; Kohler and Parker, 1986; Kvamme, 1988a, 1988b; Moon, 1993). Finally, because models are simple representations of reality, they are always fallible (Kohler, 1988; Moon, 1993). The choice between different approaches and styles of modelling depends as much upon the required outcomes, and the available data, as it does on the methods utilised. Either way, 'there is nothing inherently unscientific about either approach' (Warren, 1990: 90) and each method has its champions and its critics (Ebert, 2000; Westcott and Kuiper, 2000).

Predictive models, regardless of type, can be constructed to almost any scale. Contemporary predictive models of prehistoric archaeological site location have been constructed utilising a study area of as small as a few hectares, up to very large undertakings such as the Minnesota Department of Transport's 'Mn/Model' (Brooks *et al.*, 2000) which models prehistoric archaeological site location for the entire state of Minnesota (22,000,000 hectares). Projects of this scale and budget are rare. The Minnesota Department of Transport (MN/Dot) spent $US4.5 Million on the project between 1995 and 2000, employing 49 people in various capacities. Although a rare level of commitment to one project, the Mn/Dot model has been shown to have saved the Minnesota Department of Transport $US 12 Million since 1998 (Anon, 2000). The majority of predictive modelling projects however , are nowhere near this scale or scope.

The scope of predictive modelling projects is also broad. Models may be constructed to predict the location of archaeological sites from any temporal period or archaeological class. For example, predictive models have been developed in recent years to model the process of frontier settlement in the eastern United States (Zubrow, 1990), to model the development of trade in the Great Lakes area of the United States (Allen, 1990) or the modelling of Palaeolithic and Mesolithic archaeological site location in the Southern Netherlands (Kamermans and Rensink, 1999). The major limitations on predictive modelling are the availability of the appropriate data upon which to base the models (in the case of inductive models) or the appropriate theoretical perspectives (in the case of deductive models). The scope of a model is also dependant upon the required outcomes of the modelling process. If the model is to predict contemporary site location for management agencies to aid in the preservation of the archaeological record, then the model is constructed primarily for convenience, and not to answer specific research questions regarding human behaviour in the past.

Modelling Sensitivity

It is generally considered impossible to construct a predictive model with the necessary spatial resolution (van Leusen, 2002:5-16) to predict the location or significance of individual hunter-gatherer-fisher archaeological sites, particularly as the geographic scale of the model increases or the resolution of the spatial data decreases. Nor is the traditional reliance upon individual site based assessment well suited to the development of broad scale models of significance.

This situation has led to the development of zone-based assessments of archaeological sensitivity and significance at landscape or regional scales (Altschul, 1990; McConnell, 1995, 2002; van Leusen, 2002). Rather than attempting to predict the significance of individual sites, (or indeed the presence or absence of individual sites) zone-based assessments highlight those zones within a region that are expected to contain archaeological materials of various classes, and, *a priori*, significance. It must be remembered however, that it is the interpretation of archaeological material that determines significance, and not geomorphic or ecological predictions.

For instance, the deeply stratified alluvial deposits of the Maribyrnong Valley could reasonably be expected to contain buried prehistoric sites. These comparatively rare occurrences are significant for their ability to illuminate past human behaviour in detail.

However, it is impossible to predict the exact location of these rare phenomena with any chance of success. Knowing the geomorphic context in which these sites are likely to occur means the entire geomorphic unit can be regarded as archaeologically and culturally sensitive, and therefore likely to contain significant archaeological materials. This zone-based approach provides a superior method of identifying part or whole landscapes where archaeologically significant sites may be located rather than continuing to rely solely upon sporadic site surveys.

Altschul (1990) utilised a zone-based methodology when developing the ‘red flag models’ of Mount Turnball in Arizona. Altschul (1990) viewed this approach as a more powerful tool to be used in everyday cultural resource management contexts than individual site based assessments. Altschul’s (1990) methodology consisted of simply modelling three environmental variables (elevation, slope and aspect) believed to influence archaeological site location, and then plotting the relationship between these variables and the existing State archaeological database. The result of Altschul’s (1990) project was a series of ‘favourability’ maps which corresponded well to where archaeological sites were expected to occur, and did in fact occur. In terms of end usage, management agencies were handed a tool (favourability or sensitivity maps) that allowed land managers to ‘flag’ areas of greater sensitivity (but not significance) well in advance of any development activities.

Anne McConnell (1995; 2002) developed similar zone-based models of archaeological sensitivity for management agencies in Tasmania and Victoria. McConnell’s (2002) zone-based approach to modelling archaeological sensitivity in Victorian forests is based on a similar methodology to that of Altschul’s (1990). McConnell (2002) assessed a series of environmental variables thought to have some bearing upon prehistoric Aboriginal archaeological site location. These attributes included distance to fresh water, slope, and access to flakeable stone. McConnell (2002), with the assistance of the Forest Modelling branch of the Department of Natural Resources and Environment (DNRE), created a series of sensitivity maps using GIS that are to guide DNRE in the planning of logging and general management operations in Victorian forests. Josephine McDonald also utilised a similar method of sensitivity zoning in her study of a site on the Cumberland Plain near Sydney. McDonald based the sensitivity zones in her study primarily upon the level of previous ground disturbance that was observed throughout the study area (McDonald, 1996). In this way, McDonald proposed that it was possible to identify entire landscapes that had undergone little disturbance since European settlement, and were thus more likely to contain undisturbed Aboriginal sites. While this is logically correct, the contemporary existence of undisturbed land surfaces bears no relationship whatsoever to land use choices and decisions made by Aboriginal people in the past. This method and zoning is valid however, if the aim of the project is to identify where undisturbed landscapes with potential archaeological deposits are located.

The major attraction of the zone-based methods is that valid wide-area sensitivity models can be formulated (at a 'macro scale') where much of the data critical to statistically-based models is absent or cannot be determined (i.e. site absence- vs.- presence, statistically valid samples). For instance, the attempt by Lewis, MacNeill, and Rhoads (1996) to create a predictive model of archaeological site location in East Gippsland was not successful because of limitations in the available data sets and unwarranted statistical complexity (McConnell, 2002: 29).

Considering the frustrating array of limitations that confront the majority of archaeological projects in the study area for this thesis, the sensitivity zone approach is arguably the most appropriate means of modelling the location of prehistoric archaeological materials. Rather than attempting to predict the locations of individual sites (as many models do), it is argued that a method of determining archaeological sensitivity based upon the often unquantifiable relationship between known site data and key environmental attributes is the most productive means of firstly identifying, and secondly preserving, archaeological material within the current study area.

In areas where it is possible to isolate particular geomorphic features that are known to be archaeologically sensitive, the zone-based approach is particularly useful. In the study area for this thesis (for example), the alluvial deposits of the larger waterways are known to contain Pleistocene archaeological deposits of great scientific and cultural significance. Rather than attempting the impossible task of predicting where 'individual' buried sites lie, it is far simpler to zone this entire geomorphic context as 'sensitive' and impose limits to the type and extent of land altering development activities permitted within this zone. Within the various 'zoned' areas, it will still be necessary to conduct archaeological survey and research in order to update and improve the data for the model, as well as to ensure that any archaeological material located is recorded, and afforded the full protection of the relevant CRM policies or legislation.

Establishing a predictive modelling program is not a particularly easy task. The researcher is faced with a myriad of choices, which have little bearing upon problems of an archaeological nature. The process is further complicated by the necessity of determining whether the model developed is to address management questions or provide insight into, or explanations of, human behaviour in the past. While both are equally valid pursuits, they are not always compatible aims. A management model that is designed to predict the most likely locations of prehistoric archaeological sites on a contemporary land surface is not seeking to explain why the archaeological material is located where it is. This type of model simply aims to identify where the material is likely to be, to pinpoint sites and avoid inadvertently destroying these sites through development. A model of this nature is not intended for an archaeological audience. It is intended more for the non-archaeologist, so that local government authorities or developers (for example) can identify areas that are best avoided during the planning stages of a land-altering project.

6.2. Theoretical Perspectives and Models

The use of ethnographic interpretations of Aboriginal land use and behavioural patterns in the recent past is somewhat problematic in archaeological or predictive modelling. While we have certain classes of data that provide examples or highlight certain aspects of Aboriginal behaviour at the point of contact with European society, we have little possibility of archaeologically testing the validity or applicability of this data at various points in time. Ethno-archaeologically based investigations are not uncommon in hunter-gatherer archaeology (Flood, 1988; Gould, 1977; McBryde, 1984a; Peterson, 1971, 1973), however projecting ethnographically observed behaviour (and the biases thereof) back through time into deep antiquity will always remain problematic, and is best avoided.

Without the ability to utilise ethnographic data, the construction of land use models for ethnographically unknown periods must rely on archaeological and palaeoenvironmental modelling with a logical theoretical basis. Essentially, 'archaeologists must attempt to determine independently what their data can tell them about human behaviour, and what they cannot' (Trigger, 1982: 5). In the absence of extensive archaeological information, palaeoenvironmental data can be utilised to re-construct broadly prevailing environmental conditions in time and space, and assist in the modelling of favourable habitation zones for human populations. The models presented here for the ethnographically unknown periods (i.e. Figures 6-2, 6-3, 6-5, and 6-6 below) are based primarily upon the theoretical precepts of behavioural or human ecology (Butzer, 1982) as it applies to hunter-gatherer populations.

Human or Behavioural Ecology

The underlying premise of human or behavioural ecology is that the archaeological record is one component of a human ecosystem 'within which communities once interacted spatially, economically, and socially within the environmental matrix into which they were adaptively networked' (Butzer, 1982: 222). The concept of ecosystem is important here, and must be understood as the interaction between all parts of an ecological community, including the human members of that community. Human behaviour is influenced by and in turn influences the environmental universe within which all elements of the system interact. The archaeological record is a by-product of this interaction, and may be seen as the 'result of political, economic and ecological forces working themselves out on the landscape' (Butzer, 1982:222). The Hunter-Gatherer mode of subsistence is dependant upon the biotic resources of a given area, so the 'key properties of this form of economy are ecological in nature' (Winterhalder, 2001:15).

While the political (and social) realm of behaviour in prehistory is difficult, if not impossible, to interpret from the majority of the Australian archaeological record in deep antiquity, attributes of the prevailing environmental conditions can be used to assist in the construction of models of human behaviour. In particular, the availability or distribution of resources through time and space will have had significant and predictable impacts upon Aboriginal settlement patterns and subsistence (economic) behaviour.

It is important to specifically recognise here that resource availability and distribution is not static through time, and may vary markedly through both time and space. Generalised changes in environment will have dramatically altered the resource balance through time and space thus influencing human behaviour. While 'human groups can be expected to spread out into all habitable zones' (Butzer, 1982:223), the expansion and contraction of subsistence resources would have resulted in periodic redistribution of 'habitable zones' across the landscape. The timing, density and intensity of the utilisation of habitation zones will also vary in relation to the availability of resources. During certain periods, large portions of the study area for this thesis would have been virtually uninhabitable, while at other times resources would have been comparatively abundant in those same areas.

At the height of the Last Glacial Maximum (about 18,000 BP) for example, when climatic conditions are generally considered to have been the harshest, areas of higher altitude within the thesis study area (e.g. Mt Macedon at more than 1,000 MASL) would have been very cold, dry, and windswept. Snow still occasionally falls at Mt Macedon above 1,000 metres, making these areas relatively unattractive for human habitation. The hill environments throughout the study area (i.e. between 300 MASL and 1,000 MASL) would also have all been relatively cold, barren and windswept during the LGM climatic extremes, offering little too attract human habitation. At other times however, areas of higher altitude have been more attractive for human habitation, or at least exploitation. For example, Flood (1980) has demonstrated the Aboriginal utilisation of parts of the Australian Alps in later prehistory, while McBryde (McBryde, 1978; McBryde, 1984a; McBryde, 1984b; McBryde and Harrison, 1981; McBryde and Watchman, 1976) has shown that the Mt William quarry (approximately 600 MASL) was also being utilised in recent prehistory.

The human habitation or utilization of any ecological 'niche' must be seen as part of a system of dynamic response(s) to long-term changes or trends in resource availability, distribution or preferences primarily brought about through environmental change. While these long-term changes would have been imperceptible within the span of a human lifetime, the effects of cumulative changes and the responses to those changes should theoretically be visible in the archaeological record. In the absence of archaeological and ethnographic data however, we must turn to palaeoenvironmental data to assist in the construction of predictive models.

Prevailing Environmental Conditions

The following section introduces the four generalised Aboriginal land use models, and the various sources of environmental and archaeological evidence upon which these models are based. These models are intended only as broad outlines of the environmental conditions prevalent during each of the four periods. The interpretation and reconstruction of palaeoenvironmental data must also be viewed with a certain degree of caution. The data is not particularly fine grained and the reconstructions offered are far from complete. As Butzer noted, 'modern functional ecosystems are essentially impractical for empirical study. Not surprisingly, past systems remain beyond [complete] reconstruction' (1982:19). With this in mind, the following general reconstructions of palaeoclimatic conditions for the southeastern parts of Victoria are presented.

30,000 BP

The earliest traces of the human occupation of the study area indicate that Aboriginal people were utilising the Maribyrnong Valley at least 30,000 years ago. Environmental reconstructions for the period prior to the last glacial maximum indicate that southeastern Australia was 'cool and wet with deep water in many lakes' (Wasson and Donnelly, 1991: 26-27), followed by a rapid increase in aridity and falls in temperature, with a major climatic 'threshold passed somewhere after 25,000 BP' (Dodson, Fullagar and Head, 1992). Forests and rainforests are thought to have been more extensive than today. However, the basalt plains characteristics of southern Victoria were relatively treeless (Dodson, Fullagar and Head, 1992: 117), as was much of southern Australia (Hope, 1994: 394). Palaeoecological evidence from Zone 1 of the Lancefield megafauna excavations for example, shows that *Myrtaceae* pollen (*Eucalyptus* family) occur in extremely low quantities, while *Asteraceae* (tuberous plants) and *Poaceae* (grasses) were common. *Leptospermum* (sedges) were also uncommon at Lancefield during this period. *Leptospermum* are usually associated with the steppic conditions prevalent through the LGM on the basalt plains (Ladd, 1976).

Ladd (1976) argues that the apparent contradiction of standing open water (indicating a climate broadly similar to today) and the lack of trees at the Lancefield swamp and surrounding plains (indicating drier conditions) may be a result of more extreme seasonal variations. Ladd (1976:124) proposes that summers were long, hot and very dry prohibiting tree growth on the plains, while shorter very wet winters maintained existing standing water levels. The lowest excavated strata of the Lancefield site (corresponding to Ladd's Zone 1) dates to approximately 26,000 BP. One considerable difference in the landscape of Pleistocene southeastern Australia at this time was the presence of numerous megafaunal species. The timing of the extinction of the megafauna remains elusive, as does the extent of the interaction (if any) between prehistoric Aboriginal populations and the extant megafauna.

Regional environmental and climatic variability is clearly indicated in the lake level records from southeastern Australia at this time. The lake level sequences from near coastal Victorian and South Australian lakes differ considerably from sequences obtained from inland Victorian, New South Wales and South Australian lakes (see Figure 6-1). Evidence from coastal lakes indicates that lake levels were relatively consistent from about 30,000 BP until the LGM, while the inland lakes appear to rapidly dry between 26,000 BP and 23,000 BP (Wasson, Fleming and Donnelly, 1991). This data support Ladd's (1976) view of a dry(ing) swamp at Lancefield at c. 26,000 BP, and may also go some way toward explaining why large numbers of fauna perished at the Lancefield swamp at this time.

Sea levels were approximately 50-60 metres lower than today (Chappell, 1993, 2001; Chappell and Thom, 1977), making coastal resources and shorelines a considerable distance further away from the Maribyrnong valley and environs than is presently the case. In effect, Australia was a much larger continent when sea levels were lower. Later, at the height of the LGM, when sea levels were at their lowest, the Australian landmass was approximately one-third larger than it is today (Mulvaney and Kamminga, 1999:114). Archaeological evidence suggests that Aboriginal people were occupying the Maribyrnong valley 30,000 years ago.

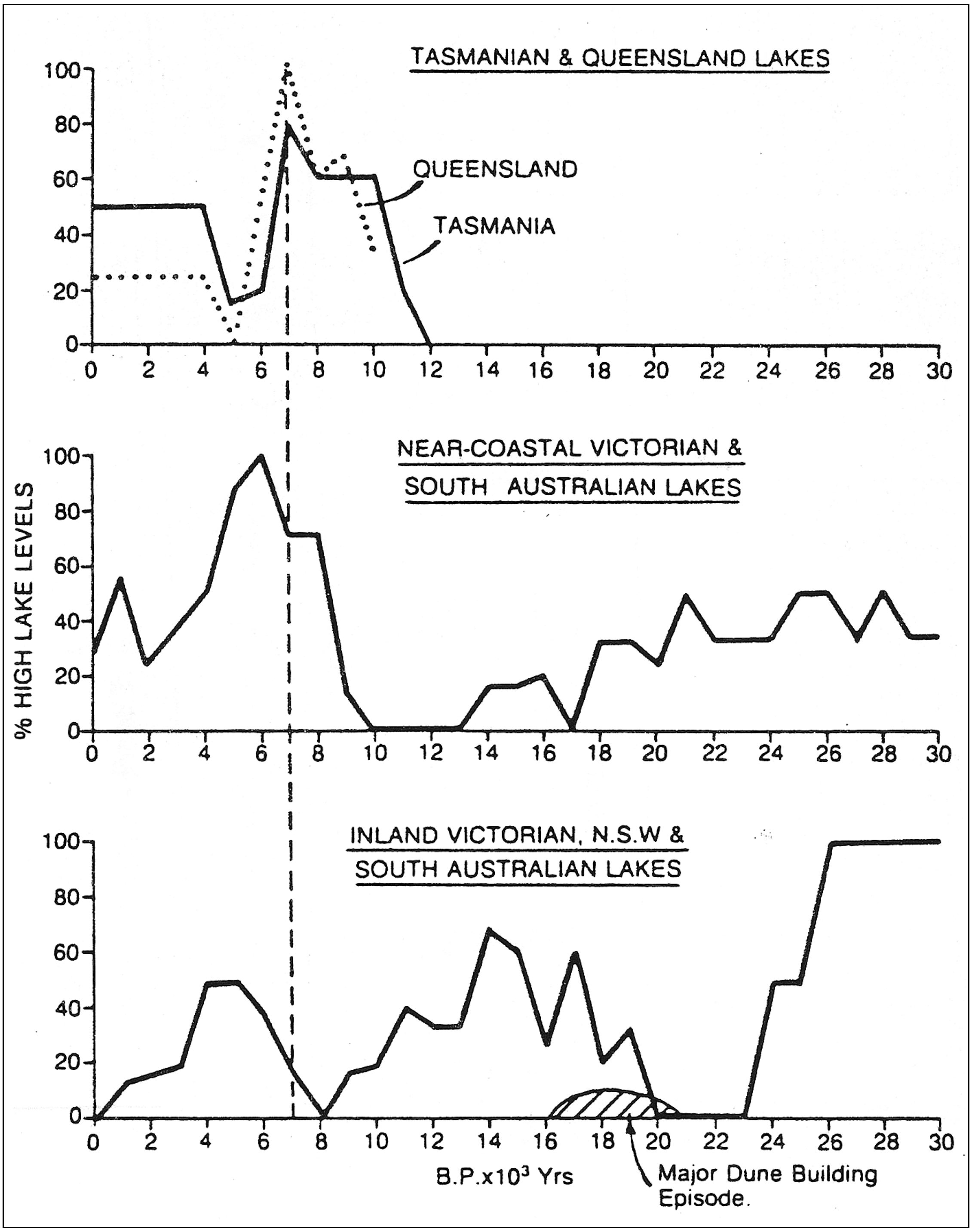


Figure 6-1: Lake level details throughout the last 30,000 years from selected Australiansites. After Wasson, Fleming and Donnelly, 1991. Note the regional variations apparent in the two lower graphics from coastal and inland Victorian and South Australian sites. In the Victorian data, it appears to have been much wetter near the coast at 7,000 BP, and again at c. 1,500 BP, than it was at the inland sites.

At this time, forest appears regionally restricted to the better-drained and watered river valleys and hills. The relevant palaeoecological evidence from the Lancefield Swamp suggests that the basalt plains were treeless, despite the expanding forests elsewhere in southeastern Australia. Grasslands dominate the plains, with *Poaceae* (grasses) and *Asteraceae* (tuberous flora) dominating the grassland taxa. Rainfall appears to have been similar to modern levels, falling mainly during the winter according to Ladd (1976). At this time, the Aboriginal inhabitants of the region experienced conditions broadly similar to those of today. Longer, drier and hotter summers however, may have concentrated occupation areas close too standing water sources for much of the year. The use of the plains may also have been restricted by climatic conditions. The hot summers would have depleted available resources and the wet winters would have waterlogged much of the plains making seasonal utilisation of these environments difficult.

Although areas such as Lancefield Swamp contained standing water, there was little timber present, restricting the attractiveness of these environments. There is a possibility that these swamp environments dried up during the very long hot summers, and only refilled during the winters. Only two quartzite artefacts have been found at the Lancefield Swamp site in the Pleistocene sediments, and these offer only a tentative (and inconclusive) glimpse of the human utilisation of this environment. The presence of the Asteraceae taxa on the plains raises the possibility that tuberous flora such as *Microseris scapigera* (Murnong) may have been a feature of Aboriginal diets from the time of the earliest known occupation of the area.

While there is a paucity of available archaeological and palaeoecological evidence, the general patterns in the available data indicate that conditions were broadly similar to those of the later Holocene period. One major localised ecological constraint upon Aboriginal populations would appear to be the lack of timber at the swamp environments. This would have greatly reduced the attractiveness of any active swamps as residential areas. However, it appears likely that the incised valleys of the region were more heavily timbered, providing adequate sources of fuel, food and shelter. The archaeological data collected for this thesis does not contribute any new information for this period, nor is the available ethnographic data applicable. The model presented below (Figure 6-2) shows a generalised view of the plain and valley landscapes that dominate the study area at 30,000 BP.

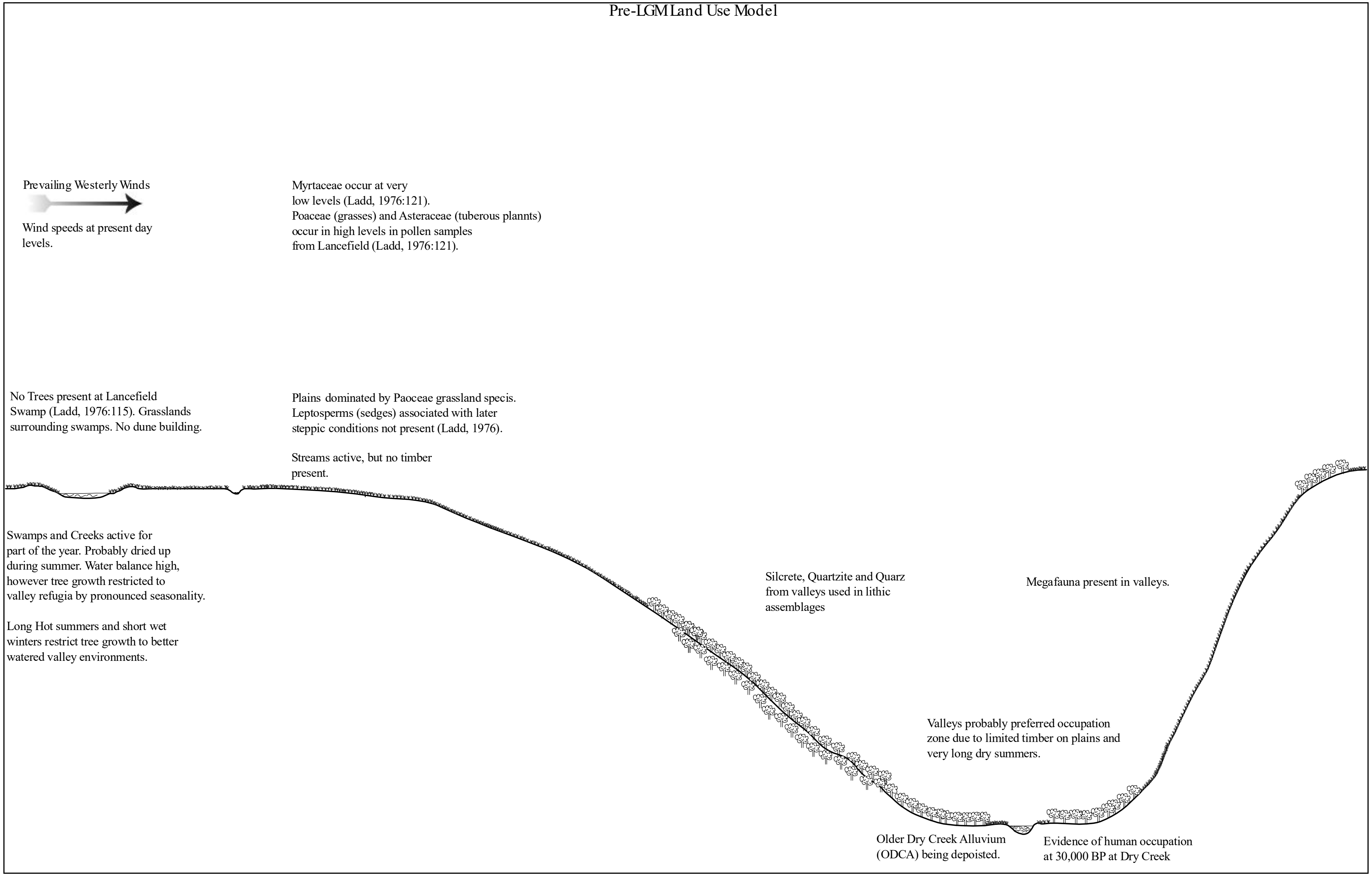


Figure 6-2: Land Use model at 30,000 BP

The Last Glacial Maximum (18,000 BP)

The period from approximately 25,000 BP to 18,000 BP is characterised as one of increasing aridity, decreasing temperatures and decreasing biological productivity. Aboriginal populations residing in the study area would not have noticed most of the effects of global climate change during the course of individual lifetimes; however over the course of the millennia either side of the LGM Aboriginal settlement patterns and land use behaviour would have undergone considerable change to accommodate the scale of environmental change taking place.

At the height of the LGM temperatures fell by between 6ºC and 10ºC, rainfall was reduced to approximately 50% of modern values, and wind speeds increased by 150% over modern equivalents (Kershaw, 1995; Wasson and Donnelly, 1991). The combination of these three factors (colder, windier, and drier) increased the rate of evaporation considerably, reducing the availability of standing fresh water. Lake levels across southeastern Australia plunged during this period of intense aridity. Vegetation patterns changed dramatically, reflecting the increased aridity and decreased temperatures. The basalt plains biotic communities of the region for example, which had been dominated by *Poaceae* and *Asteraceae* taxa prior to the LGM (Ladd, 1976), gave way too much sparser sedge and herb dominated steppic conditions (Flannery and Gott, 1984; Kershaw, 1995).

With the onset of the colder, drier and windier conditions forested areas declined rapidly, with the majority of tree species retreating to better-watered 'micro-habitats' (Kershaw, 1995: 661). Megafaunal browsers would also have been forced from the plains environments to the better-watered valleys in search of water, where they eventually went extinct at sometime before 18,000 BP (O'Connell and Allen, 1995). The greater wind speeds combined with heightened aridity led to a period of dune and lunette building across southern Australia (Wasson, Fleming and Donnelly, 1991). Major rivers generally became less active; depositing vast quantities of silt (from aeolian dust and frost shattered rocks) in alluvial deposits, such as those found in the Maribyrnong Valley – the Keilor Terraces were being deposited during this period (Bowler, 1987). The majority of the fauna existing at this time would have become dependant upon the better-watered and sheltered valleys for survival once the plains and mountainous areas became less habitable.

The plains environment would not have supported large populations of water dependant fauna for the several millennia either side of the LGM. Swamps and smaller creeks would have all but disappeared from the landscape. Indeed 'throughout southeastern Australia there is little evidence for swamp or bog communities during the height of the LGM' (Kershaw, 1995: 664), and lakes across the region were virtually dry. Colder, windier and drier conditions would have also made large tracts of the higher regions of central Victoria unattractive for both human and faunal occupation. The altered climatic regime resulted in the snowline being up to 1,000 metres lower than modern levels across southeastern Australia (Kershaw, 1995). This would have resulted in significant changes to the biotic communities of the higher altitudes, particularly the retreat of forested communities to more sheltered regions.

The archaeological record contains evidence of human occupation in the better-watered and more fertile alluvial valleys at this time. The Keilor terraces at Brimbank Park have revealed a 'distinct surge in artefact density' (Tunn, 1998: 44) occurring some time after the LGM. Munro (1997; 1998) also established that the volumetric artefact density recovered from the similar terraces at the Keilor Burial site (some 3 kilometres upstream from Brimbank Park) peaks at 31.34 artefacts/m^3, and appears to correspond with the surge in density identified by Tunn (1998).

The increase in artefact density identified by Tunn (1997; 1998) at the Green Gully, Dry Creek and Brimbank Park 1 and 2 sites reflect significant changes in human behaviour. The artefact density from the excavations of Mulvaney (1970) and Wright (1970) at approximately 18.3 metres (Reduced Level) is considerably greater than it is above this level (in the plough zone) or below in the older pre-LGM sediments, indicating a similar increase in artefact density.

This pattern may correspond (at least at a gross scale) with the pattern of environmental changes in the period during and after the LGM, and the human responses that might be expected in such conditions. As aridity and cold reduce regional bioproductivity and water availability, we could expect human populations to more intensively occupy and utilise the resources of the valley environments. It is not proposed that Aboriginal people became 'tethered' to these zones of higher bioproductivity in the way that animals may become dependant upon refugia in times of environmental stress. Rather, that Aboriginal people came to utilise these zones of higher productivity or patches (Cosgrove, Allen and

Marshall, 1990) more heavily in times of greater environmental stress, but were free to move in and out of these zones as necessary. Indeed, as the distribution of resources becomes more widespread during the later Holocene Aboriginal people are consequently using more of the landscape, but do not appear to abandon the resource rich valleys. The use of the term 'refugia' concerning human populations is somewhat inappropriate in this context as it denies human actors cognitive abilities to utilise landscapes, their ability to schedule resources, and the resourcefulness and resilience of human populations in general. The valley environments may have been refugia for floral and faunal populations throughout this period, however, humans would still have moved in and out of these environments at will, hunting or harvesting more 'ecologically tethered' (Cosgrove, Allen and Marshall, 1990) resources.

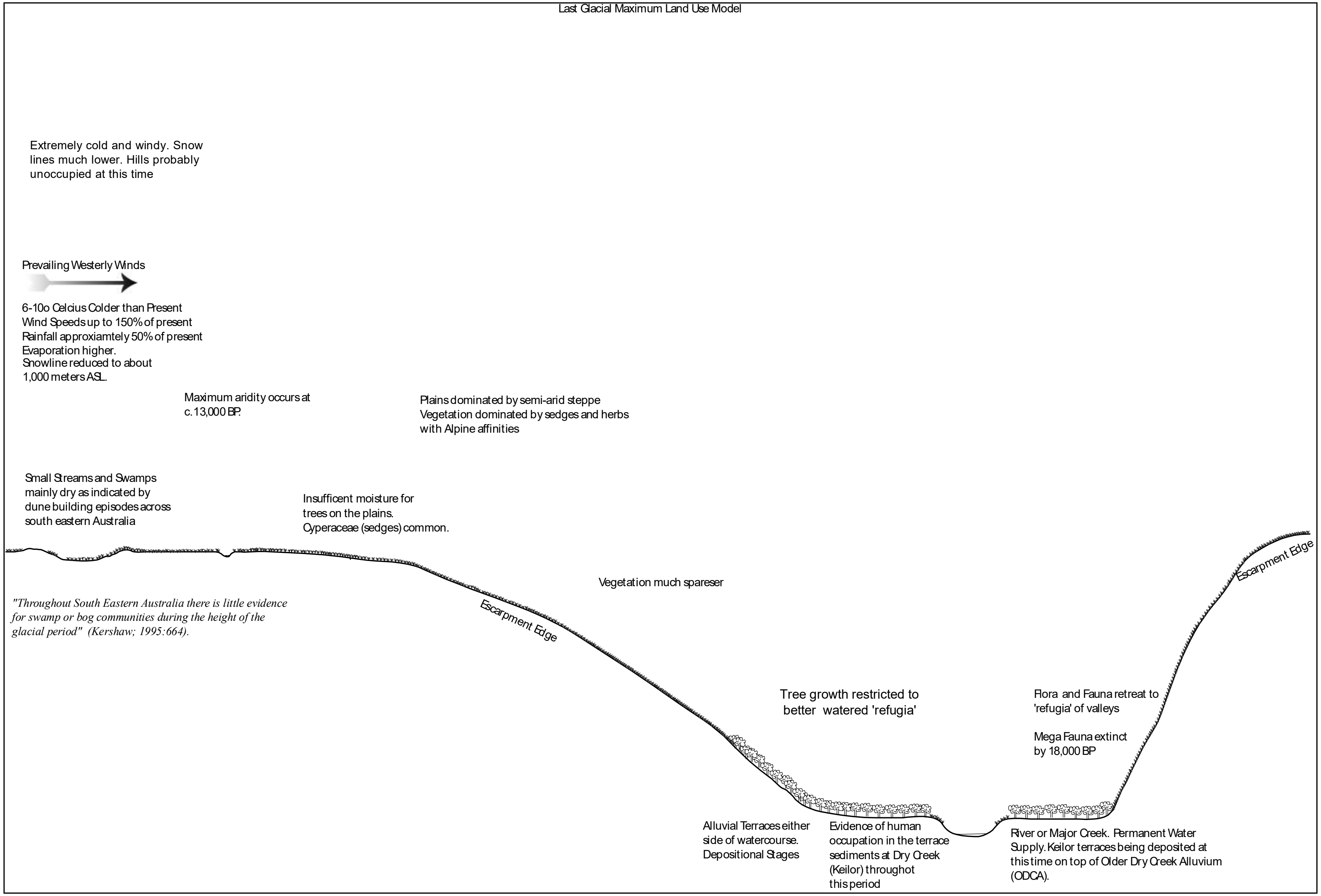


Figure 6-3: Last Glacial Maximum Land Use Model

The Pleistocene-Holocene Transition.

The Pleistocene-Holocene transition is the period of climate history arbitrarily dated to approximately 10,000 BP and denotes yet another period of rapid climatic change throughout southeastern Australia, particularly between circa 12,000 BP and 9,000 BP. (Kershaw, 1995: 666). While the Pleistocene-Holocene boundary marks a period of considerable environmental change, ‘there is little evidence that Australia witnessed any significant cultural changes contemporary with major climatic change observed in the early Holocene’ (Frankel, 1995: 653).

While there may be little evidence for cultural change, the late Pleistocene – early Holocene transition shows ‘the greatest change in pollen assemblages, and hence vegetation, within the last 18,000 years’ (Kershaw, 1995:666). Grasslands contracted, *Asteraceae* levels declined, while *Eucalyptus* and *Casuarina* expanded at the expense of the contracting grasslands (Kershaw, 1995:666). The pollen record of Lancefield Swamp, for example, revealed a surge in *Myrtaceae* pollen in zone L2 of the excavations. Simultaneously, the pollen record shows an almost identical decline in the pollen count of the *Poaceae* grassland taxa (Gillespie *et al.*, 1978). This vegetal transformation is recorded in sediments that are dated typologically by the presence of geometric microliths to around 6,000 BP (Gillespie *et al.*, 1978). There is no radiocarbon evidence to elucidate the specific timing of the taxonomic changes that occurred at Lancefield Swamp. It is plausible that the vegetation changes occurred earlier than previously thought, at about 9,000 BP, which would coincide with changes observed in the pollen records of other southeast Australian sites. Conversely, the evidence collected at Lancefield may reflect a specific series of localised environmental changes not observable elsewhere. The problems associated with the typological dating of sites via the presence or absence of certain classes of artefact has been discussed previously in Chapter 2.

The period between 12,000 BP and 9,000 BP is ‘poorly defined’ (Wasson and Donnelly, 1991: 27) in many of the southeast Australian palaeoclimatic datasets, limiting the scope of possible environmental reconstructions. Temperatures however, appear to have been moderately higher than present values, while moisture levels at sites such as Lancefield Swamp must have equalled or exceeded the 500mm minimum required for present day tree growth to support the expanded *Myrtaceae* communities found in the pollen record (Gillespie *et al.*, 1978). Rising sea levels at this time caused a significant series of alterations in the physiography of southeast Australia. As sea levels rose, vast tracts of highly productive coastal plain were permanently inundated. The land bridge joining Tasmania to the mainland was severed, and what is now Port Phillip Bay became flooded.

These changes in physiography, while gradual, must have influenced Aboriginal population distribution as perhaps 'one-seventh of the land' (Blainey, 1975: 10) simply disappeared. This reconfiguration of local populations probably took place over several millennia as the seas encroached until sea levels finally stabilised at modern levels approximately 6,000 BP (Frankel, 1995: 654). While there have been various theories as to how the marine transgression influenced coastal Aboriginal populations and resource availability (Bowdler, 1977), it is undoubtable that significant changes in population distribution must have occurred. Coastal residents would have lost extensive parts of their estates as the seas continued to rise. Whether these people were absorbed into existing territories, pushed into already occupied territories, or suffered a decline in population is unknown.

An artefact of this population redistribution can possibly be seen in the archaeological record of the Maribyrnong Valley. A comparatively sudden increase in artefact density has been described at the Green Gully (Brimbank Park) sites by John Tunn (1998: 44). Tunn compared the results his recent archaeological fieldwork at Brimbank Park to earlier excavations conducted by Mulvaney (1970) and Wright (1970). Tunn identified that a peak in artefact density occurs across three spatially discrete sites within the Keilor terrace at Brimbank Park, between 18.15m- 18.45m (1998: 44). This increase in artefact density identified by Tunn indicates some change in behaviour at these sites (Figure 6-4). It is possible that there was simply an increase in the production of stone tools, which is now visible in the archaeological record as locally increased artefact discard rates. It is equally possible that the increase in artefact density was the result of a localised readjustment in population distribution because of local environmental conditions (Bird and Frankel, 1991b). Tunn also identified a similar increase in artefact density at the Dry Creek site, some 3 kilometres away from the Green Gully (Brimbank Park) sites (1998:44). The Dry Creek data was collected from the VAS/La Trobe University excavations undertaken between 1977 and 1982, and subsequently analysed by Burke (Burke, 1990) and Munro (Munro, 1997, 1998).

While it is not possible to show discrete changes in the material culture of the area at this time, the evidence suggests that some form of localised change or adjustment was occurring in the way in which Aboriginal populations utilised this landscape.

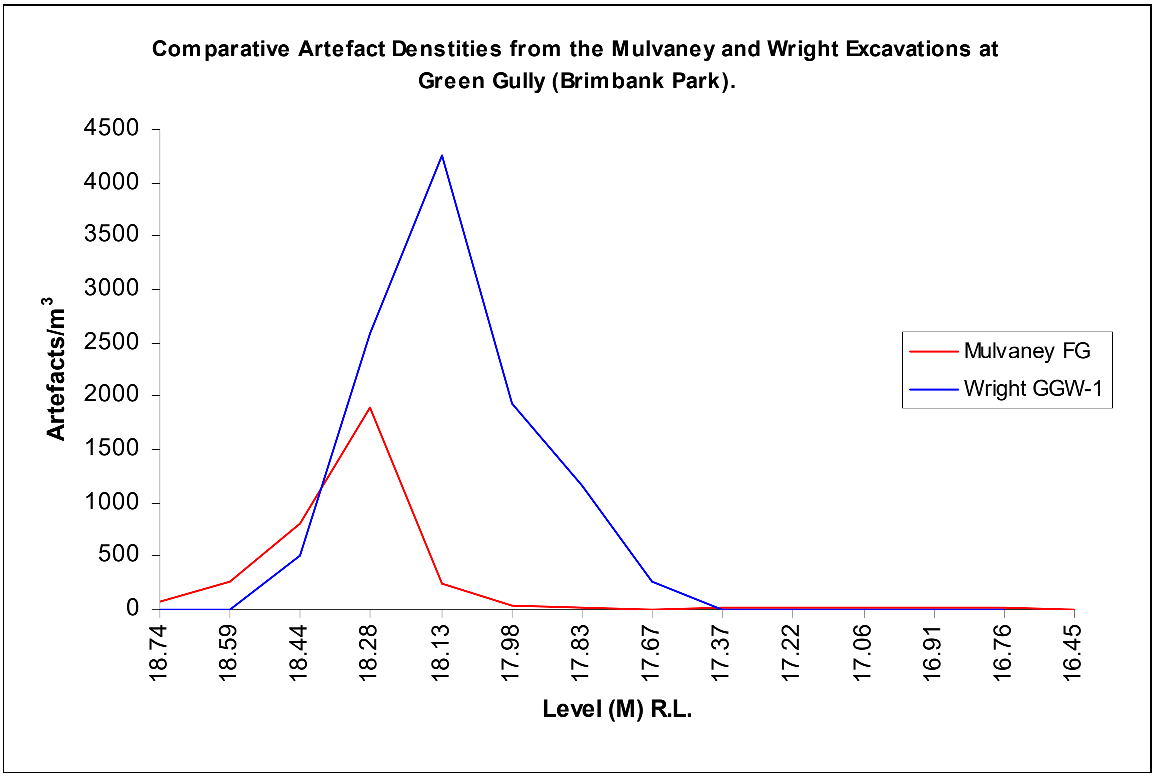


Figure 6-4: Comparative data from the excavations of Mulvaney (1970) and Wright (1970) at Green Gully (Brimbank Park). An identifiable surge in artefact density per m^3 occurs between about 18.15m (Wright) and 18.30m (Mulvaney). These discrete excavations were located approxiamtely 70 metres apart in the same 'Keilor' terrace landform. After Tunn (1998).

While it is possible that the observed increase in artefact discard could be the result of responses or readjustments to localised environmental conditions (Bird and Frankel, 1991b) this remains unproven. The terminal Pleistocene and early Holocene archaeology of the study area is best described as suffering a 'general poverty of understanding' (Frankel, 1995: 654) and requires a concerted effort to make up for the 'lack of earlier research' (Frankel, 1995: 654).

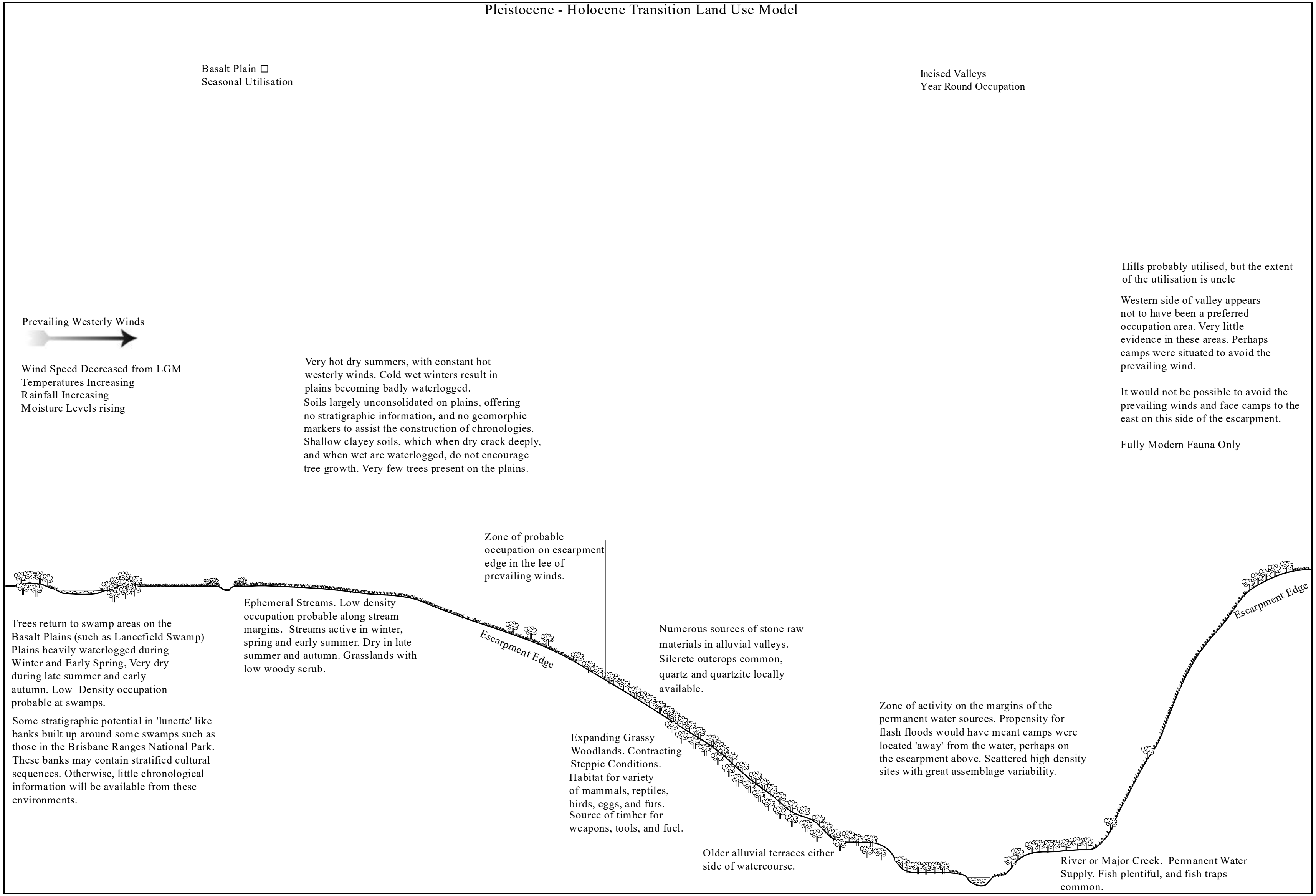


Figure 6-5: Pleistocene – Holocene Transition Land use Model

Mid to Late Holocene

The period from approximately 6,000 BP to the ethnographic present has been extensively studied throughout southeastern Australia. Climatic conditions during this period were generally similar to the present day, although considerable localised fluctuations in climatic conditions were common.

Palaeoclimatic evidence form 'maar' lakes of southwestern Victoria show that there was a 'marked increase in precipitation (and a continuing trend of rising temperatures) at the beginning of the Holocene, leading to maximum lake levels and temperatures in the mid-Holocene' (Wasson, Fleming and Donnelly, 1991: 3). Mean annual temperatures were between 0.5ºC and 2ºC higher than current levels. Pollen records suggest an increase in mesic communities, indicating a 'more favourable water balance in the soil profile' (Wasson, Fleming and Donnelly, 1991: 7). Precipitation is thought to have been in the order of 20-50% greater than current levels (Wasson, Fleming and Donnelly, 1991). After mid-Holocene peaks in temperature and moisture levels, climatic conditions appear to become cooler and drier at about 2,000 BP. Temperatures decreased by 'as much as 3ºC' (Wasson and Donnelly, 1991: 30) in southern New South Wales and Tasmania.

The palaeoclimatic record of this period however, is not easily interpreted. There are changes indicated in the data, which show high variability (or in some cases contradictions) between the climatic conditions experienced at sites within relatively close proximity. The lake level data in Figure 6-1 (above) shows that there were significant differences in the prevailing climatic conditions between coastal and inland sites throughout the Holocene. Lake levels at near-coastal sites appear to peak much earlier in the Holocene than those of the inland sites. While inland lake sites were relatively dry at approximately 8,000 BP (and were only half the levels of near-coastal lakes at about 4,000 BP) coastal lakes have maintained high levels from 8,000 BP. This data serves to highlight that regional or local variability in climatic conditions is the norm rather than the exception. Localised climatic amelioration or stress could also be expected to manifest in the archaeological record as specific behavioural episodes or technological responses that may or may not occur at other areas or times.

Sea levels stabilised at approximately 6,000 BP, and have remained relatively stable since that time. Consequently, no coastal open sites older than about 8,000 years are likely to exist anywhere on the Victorian coastline. Older sites may exist in coastal caves, such as the late Pleistocene occupational evidence at Bridgewater cave in southwestern Victoria. Population redistributions or fluctuations caused by rising sea levels between 12,000 BP to 6,000 BP would have 'levelled' out by about 6,000 BP (Bird and Frankel, 1991a; Frankel, 1988; Godfrey, 1989).

For the last 2,000 years, environmental and climatic conditions have remained relatively stable. Aboriginal populations would have had access to virtually all of the biotic resources known to have existed in the study area over the last few thousand years. While the basalt plains are still relatively arid and dry for most of the year, the presence of shallow swamps on the plains would have attracted Aboriginal subsistence activities. At no time in the last 30,000 years however, have the basalt plains been extensively timbered. Grasslands have dominated the plains for at least the last 16,000 years (Jones, 1999), with steppe-like conditions prevailing for most of the 10,000 years before the spread of the grasslands. The incised valleys dominating the south of the study area are the only landform in the region that would have consistently maintained tree cover during the last 30,000 years. Similarly, the water sources flowing through the larger incised valleys are the only ones in the region that are likely to have remained permanent through the entire 30,000-year period. Table 6-1 (below) presents the preceding data in tabular format.

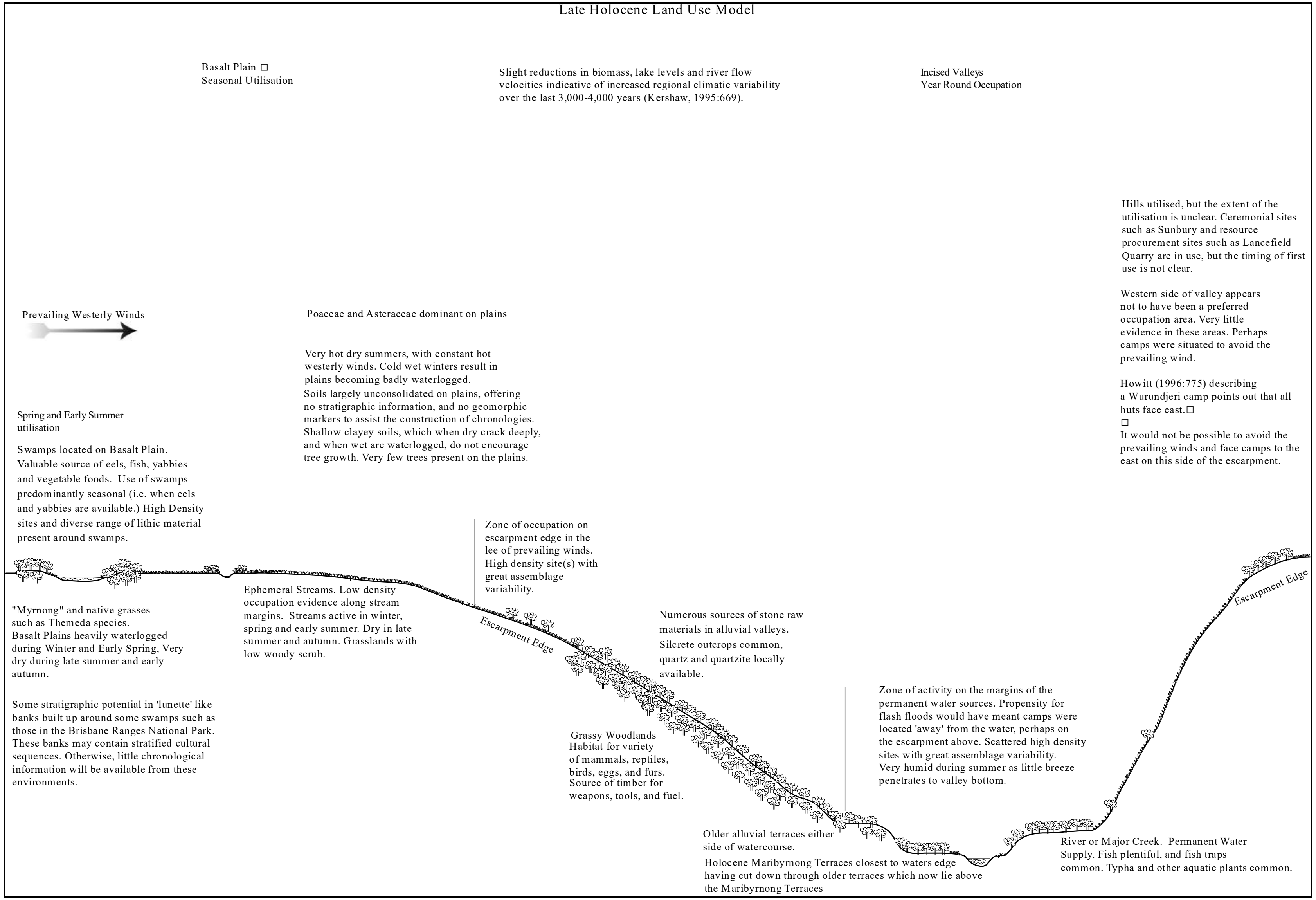


Figure 6-6: Late Holocene Land Use Model.

					Archaeological Evidence by Landform			Aboriginal Land Use by Landform		
Period	Climate	Fauna	Flora	Water	Hills	Basalt Plains	Incised Valleys	Hills	Basalt Plains	Incised Valleys
Pre- LGM (Diagram 6-2)	Wind at present day values. Long hot summers, short wet winters	Megafaunal browsers present	Mainly grasslands. No trees in pollen record at Lancefield Swamp Hills forested	Rivers permanent. Swamps and smaller creeks probably ephemeral	Unknown (?) No Dated Material	Unknown (?) No Dated Material	Occupation Indicated in alluvial sediments	Unknown (?) Possible Low Density Use	Unknown (?) Possible Low Density Use	Definite Low Density Use
LGM (Diagram 6-3)	Very Cold Very Dry Very Windy Snow at 1,000 MASL Silting in rivers Dune building	Megafauna becoming extinct? Limited by water and retreating food resources	Semi-arid steppe like conditions. Trees and grasslands retreat to refugia	Water balance at 50% of present day values. All but largest rivers dry. Swamps and creeks dry.	Unknown (?) No Dated Material	Unknown (?) No Dated Material	Occupation Established in alluvial sediments	Unlikely	Unlikely	Definite High Density Use
Pleistocene-Holocene Transition (Diagram 6-5)	Rapid climate change. Sea levels rising. Cold and Dry conditions give way to Warmer and Wetter conditions	Megafauna extinct. Fully modern fauna only	Forest expands into all environments Grasslands expand Steppe-like conditions disappear.	Maximum aridity occurs at 13,000 BP. Water then becomes more plentiful, but regionally variable.	Unknown (?) No Dated Material	Unknown (?) No Dated Material	Surge in Occupation Density on alluvial floodplain after 13,300 BP. Coincides with maximum aridity and rising sea levels? Burials and artefact scatters in alluvial sediments.	Possible (?) Low Density Use	Possible (?) Low Density Use	Definite High Density Use
Late Holocene (Diagram 6-7)	Regionally variable. Hot dry summers and short wet winters. Wetter and Warmer at 6,000 BP than at present.	Fully modern fauna only	Forests contract to modern expanse. Grasslands expand.	Sea levels stable at 6,000 BP. Warmer and Wetter at 6,000 BP. From 2,000 BP to present conditions approximate modern values.	Low Density artefact scatters, isolated artefacts, and scarred trees. Other site such as Mt William and Sunbury rings in use. No dated material. Chronology by typology.	Low Density artefact scatters, scared trees and isolated artefacts mainly located around swamps and creeks. Very low-density artefact scatters, isolated artefacts and occasional scarred trees on the plains away from water. Only one site dated too approximately 2,000 BP. All other chronologies by typology.	High Density artefact scatters. Scarred trees and isolated artefacts plentiful. Also hearths, burials, and quarries. Dated sites from alluvial sediments. No dated surface assemblages.	Definite Low Density Use	Definite Low Density Use	Definite High Density Use

Table 6-1: Summary of the major environmental events and existing archaeological evidence by landform.

6.3. Modelling Archaeological Sensitivity

The following section presents a model of archaeological sensitivity based primarily on the available archaeological evidence. One map sheet has been chosen upon which to construct the model of archaeological sensitivity as it meets many of the criteria deemed important for the modelling exercise. The VicMap 7822-1-3 1:25,000 Mapsheet was chosen for the modelling example because it:

- Covers approximately 5% of the total study area,
- Is located in the northern metropolitan area,
- Contains the important Keilor and Green Gully sites,
- Contains the OPNP and WHP fieldwork sites,
- Contains 276 registered Aboriginal sites,
- Approximately 10.5% of the total map sheet has been surveyed, and
- Has been the subject of considerable previous archaeological research.

Limitations of the GIS derived Site Data

The number of sites present in each of the geomorphic units is not a particularly strong indicator of prehistoric Aboriginal land use, as the total area of each geomorphic unit is not evenly distributed throughout the study area, nor has the survey coverage of each geomorphic unit been evenly distributed. One geomorphic unit may exhibit a higher site density than another simply because of either differing survey intensity, or differing levels of ground surface visibility. For these reasons, density of sites per geomorphic unit must be viewed with caution. Density of 'sites' per geomorphic unit makes no allowance for any preferential location choices within a specific geomorphic unit. For instance, an entire geomorphic unit may exhibit a high overall site density compared to other units, but the sites may not be evenly distributed throughout the unit. They may be clustered in the middle of the unit, or appear on the boundary between two different units. Unless the geomorphic unit in question is comparatively small, it is not possible to utilise density figures with any degree of certainty. In the current study area the 1:250,000 scale representations of geomorphic units do not offer adequate resolution to utilise geomorphic unit as a predictor value.

Figures 3-14, 3-15, and 3-16 show the relationships between site location and fresh water throughout the study area. The data sets used to analyse this relationship using GIS have been modified to remove modern water features such as drains and reservoirs. These modern features would have severely biased the 'distance to fresh water' calculations.

While all sites are relatively close to water, some site classes exhibit on obvious skewing either towards or away from water.

Nearly two thirds of the 1,005 AAV sites are within 0-100 metres of a fresh water source, and 80% within 200 metres. The different classes of sites discussed previously (i.e. Type 1, 2, or 3) display slightly different spatial pattering. The more 'complex' sites (Type 3) are clustered closer to water than the less 'complex' Type 1 sites. Larger, more complex and diverse sites would generally be the result of extended residential, processing, or manufacturing activities, or locations re-visited more often over longer periods. These activities will tend to have been spatially located close to the waterways throughout the study area. Similarly, deeply stratified sites will be found in those areas displaying suitable sediments — in this case, the river valleys. On the other hand, the sites that are most likely to be the result of ephemeral or transitory activity, such as isolated artefacts discarded by a hunting party, will commonly occur away from the more complex sites, and further into the 'hinterland' of any given area.

Geology

The overall effect of geology on the distribution of archaeological sites in the 7822-1-3 areas is difficult to determine. However, flakeable siliceous stone (i.e. silcrete) sources commonly occur at the junction of the basalt plains and the river valleys (Webb, 1995) and quartzite river cobbles are prolific in the various waterways.

Topography

The greater concentration of archaeological materials recorded at lower altitudes is problematic in the construction of any sensitivity models. It is not clear if the lack of sites at higher altitudes accurately reflects prehistoric Aboriginal behaviour patterns, or is simply a product of bias in the database. While this may be problematic at one level, only a very small amount of cultural material was located in the higher altitude survey areas for the thesis fieldwork. The effect of elevation on prehistoric Aboriginal site distribution is poorly understood, thus elevation is not a particularly strong predictor variable, particularly in areas that display relative topographic homogeneity through large tracts of the subject lands (as is the case here).

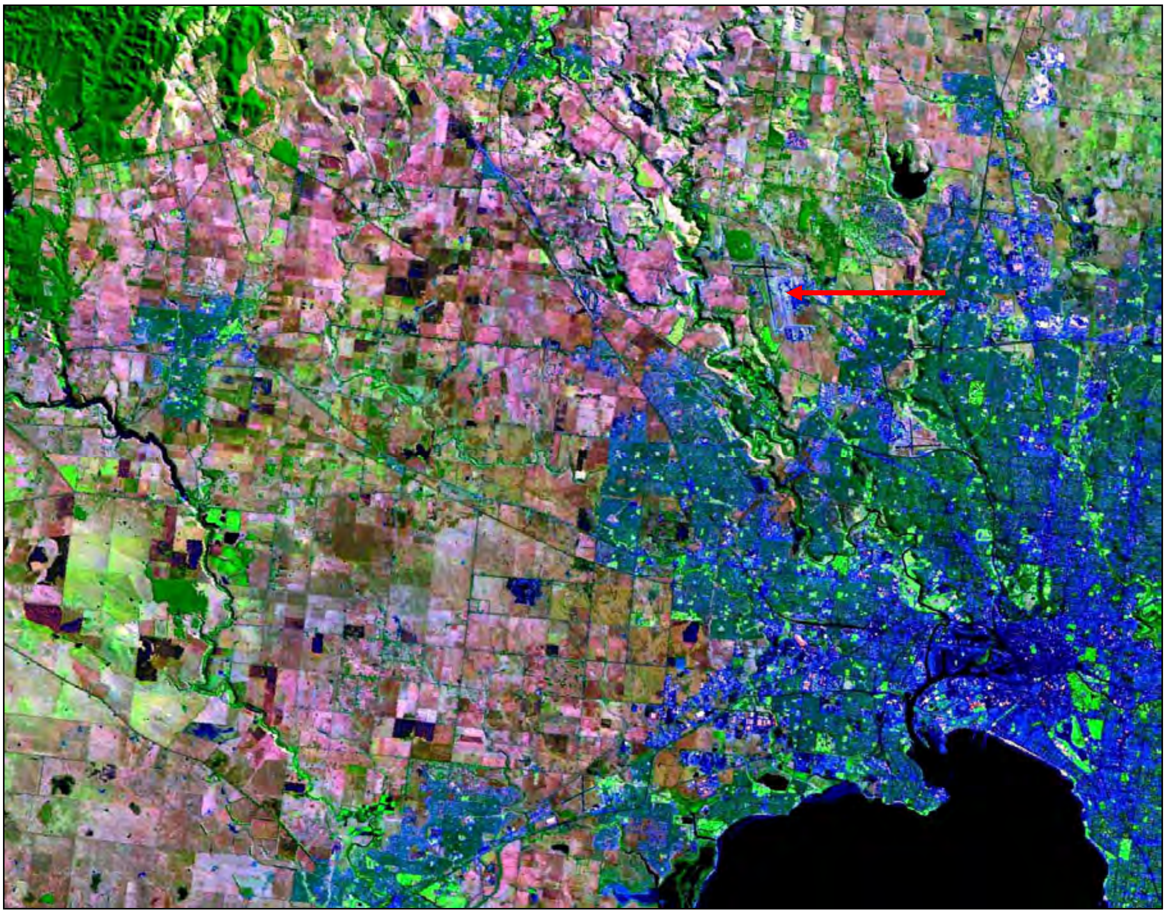


Figure 6-7: Satellite image of Melbourne with the majority of the study area falling in the centre of this image. Tullamraine airport is shown arrowed. The image shows the incised valleys present in the study area, and the otherwise flat nature of the surrounding topography.

The satellite image of the study area (Figure 6-7) clearly shows the nature of the topography throughout the study area. In the northwestern corner of the image, the landscape changes dramatically. These are the foothills of the Great Dividing Range, leading to Mount Macedon. The basalt plains dominate the remainder of the study area. The major waterways can clearly be seen in the satellite image. To the right (east), near Tullamarine airport is the Maribyrnong River, and its tributaries. To the left (west) of the image is the Werribee River. The areas shaded blue are urbanised, while those shaded green are heavily vegetated. The pink shaded areas are predominantly agricultural.

Distance to Water

Distance to fresh water is the most often used environmental variable (van Leusen, 2002) in Australian hunter-gatherer archaeological modelling. Distance to water is used here in much the same manner as in any other project. The importance of access to potable water is considered one of the primary environmental factors affecting prehistoric land use decisions.

Slope

Slope is a direct function of the topography of a region. In the present study area, slope is a variable with little real 'predictive power'. Although almost 90% of all sites within the study area are located on landforms where the slope is between 0° and 10°, over 90% of the study area exhibits a slope of between 0° and 10°. The effect of survey bias on the distribution of sites per slope class is also uncertain. While it would seem likely that Aboriginal occupation areas would be more frequently located on landforms displaying limited slope, it is not possible to quantify the relationship further. There are however, large tracts of basalt plains with slopes of 5° or less and no recorded sites. The areas displaying the greatest slope throughout the study area feature the least number of recorded sites. Again, the effect of uneven or biased survey coverage is not known.

Aspect

There are no clear patterns in the data to suggest that one 'aspect' was preferred over any other.

Previously Surveyed Areas

One problematic attribute of the various data sets is the relationship between areas previously surveyed and the apparent proximity of sites to fresh water. While the proximity to fresh water is an important factor in the location of prehistoric archaeological sites, the location and extent (availability) of this resource will have changed markedly through both time and space.

Contemporary survey coverage has tended to concentrate on those areas in close proximity to water, as most archaeologists 'know' that this is the area likely to yield the most sites. While this practice is common sense to a certain extent, it must also be remembered that a reliance on such 'expert' bias may result in an unrepresentative sample of the archaeological record (the issue of representativeness is discussed in more detail in the following chapter). For instance, the AAV digital survey data was used to determine that a large proportion of survey activity has been undertaken within 200 metres of a source of fresh water (approximately 69% - See Figure 6-8). This type of patterning may be a product of archaeological survey method rather than the result of prehistoric Aboriginal behaviour (Witter, 1992:270).

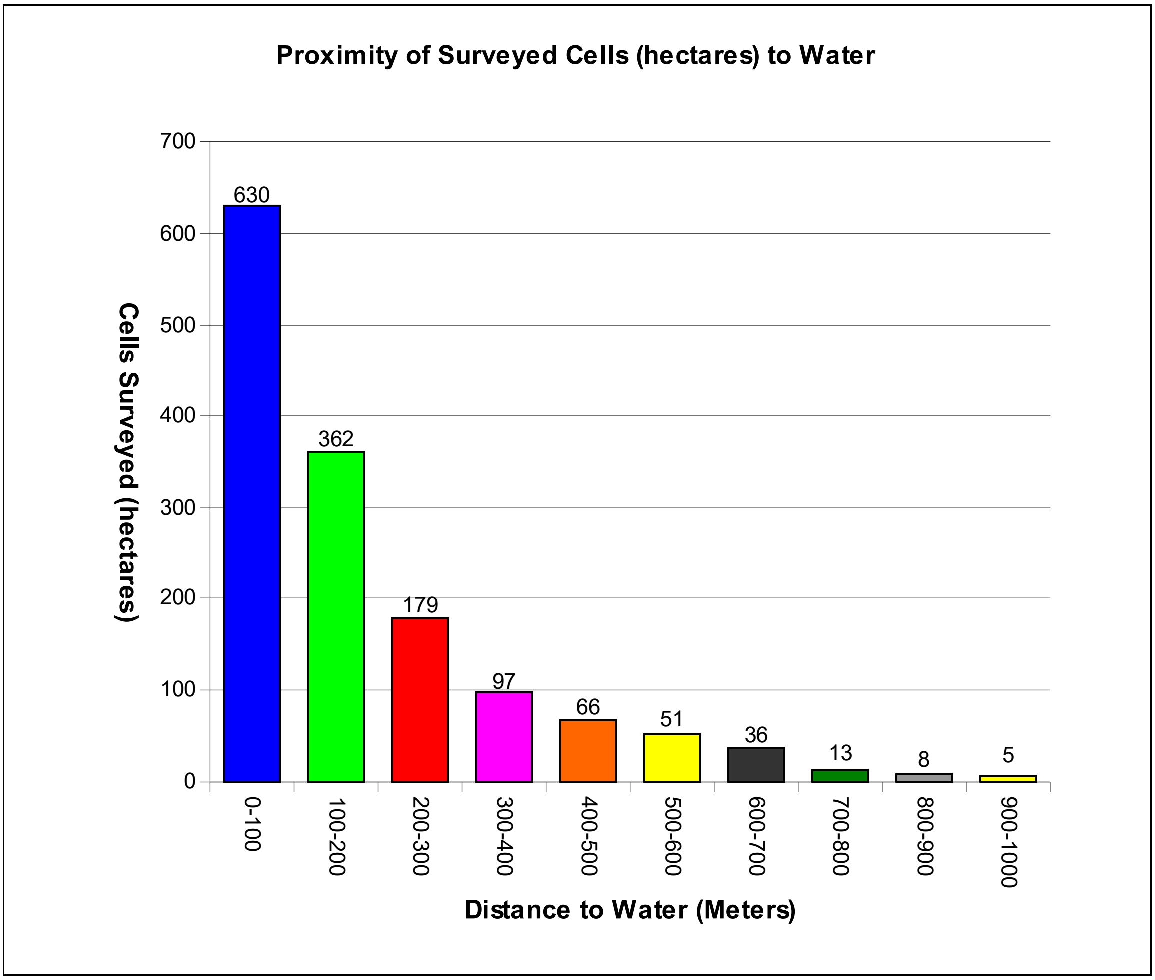


Figure 6-8: The relationship between areas surveyed and proximity to fresh water. This relationship was calculated by partitioning the areas surveyed in the 7822-1-3 mapsheet into one hecatre cells, and then utilising ArcView 3.2 to calculate how many cells fell within each 'Distance to Water' class.

Figure 6-8 shows the total area surveyed (approximately 1,447 hectares from previous work and an additional 222 hectares from this project), and the proximity of these surveyed areas to water. Figure 6-9 shows the distribution of the areas surveyed during previous projects, and the 222 hectares surveyed on the 7822-1-3-map sheet for this thesis.

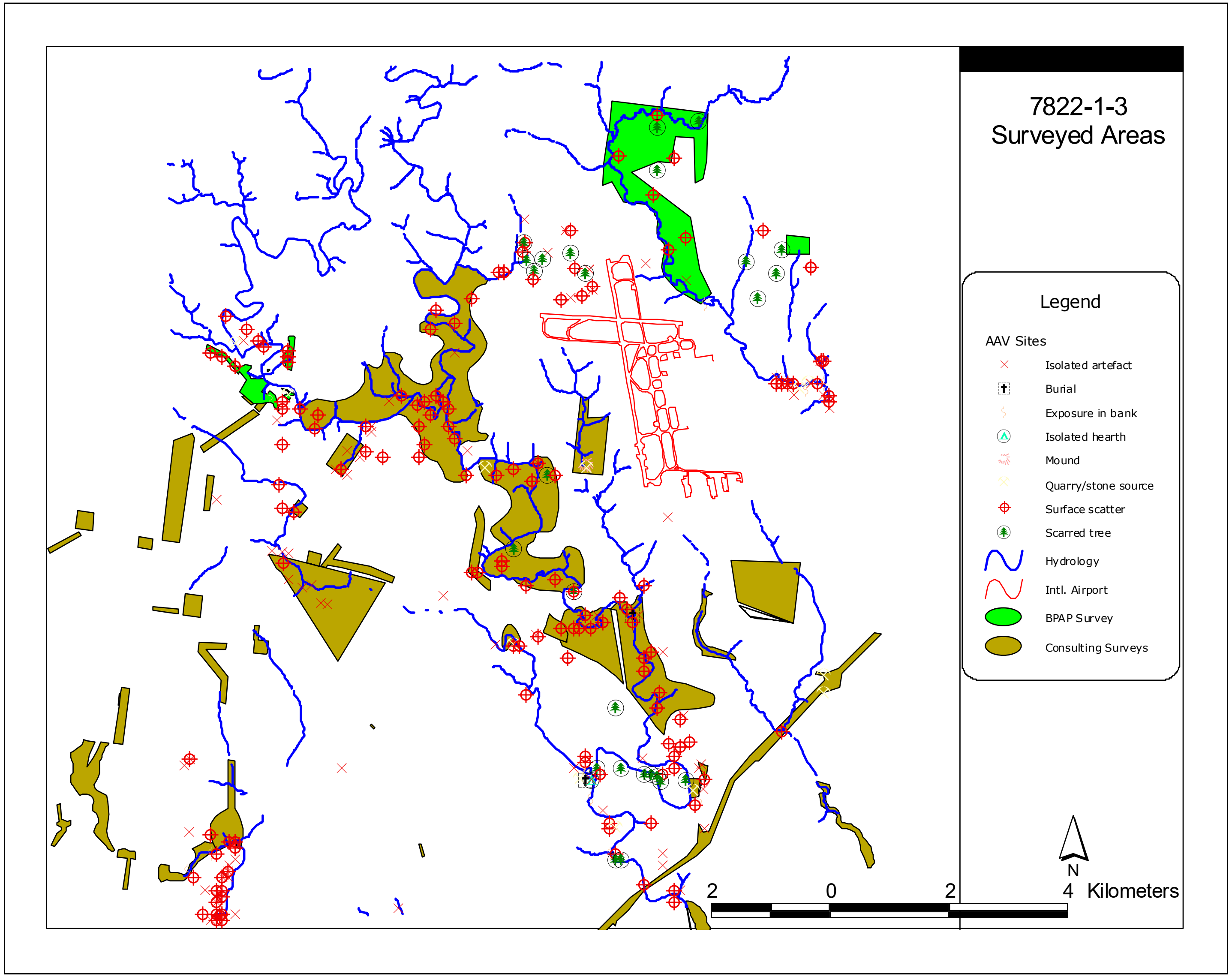


Figure 6-9: 7822-1-3 Map sheet showing the areas surveyed during this thesis, the areas previsouly surveyed during other archaeological projects, and the 273 registered archaeological sites. Note the lack of survey coverage in the north-west and southern areas.

6.4. 'Weight of Evidence' and Dempster-Shafer Models

Management is essentially about an organizational response to uncertainty and risk. If all the parameters, choices and decisions of an organizations activity were known then active management would be redundant. In this regard, the management of archaeological resources shares the same uncertainty and risk vocabulary as all other forms of resource management. Management uncertainty is 'inevitable in the decision making process' (Eastman, 2001: 23) and archaeological resource management operates within boundaries of considerable uncertainty. Uncertainty in archaeology can come from many sources. This thesis has considered several sources of uncertainty – namely uncertainty in the existing body of knowledge (i.e. no formal sampling, inconsistent survey intensity, overall lack of survey coverage, poor visibility) and uncertainty as to where other resources (sites or non-sites) are likely to be located. The ignorance of where undiscovered sites or non-sites are located introduces the risk that any existing but undiscovered archaeological resources may be destroyed through management processes that allow inappropriate activities to take place.

The biases in the various data sources for this project, including those collected specifically for this thesis, make it impossible to apply or utilise the wide range of parametric statistical techniques that are available in other archaeological pursuits (Orton, 2000; Shennan, 1997). This means that we cannot formulate answers to the questions posed here in terms of binary opposites (yes/no – site/non-site) or standard probabilities. However, the masses of available data can be combined in a manner that produces valid results for that given data. Essentially 'Weights of Evidence' techniques are a means of combining various forms of evidence to support a hypothesis or hypotheses. These forms of evidence may be binary (i.e. presence or absence of sites) or may introduce other non-binary variables, which can be difficult to assimilate into models because the values are not binary (i.e. distance to water). For the purposes of this section, sites are defined as geographic cells within the GIS that are known to contain archaeological materials and cover an area of $100m^2$ (this is essentially the same definition applied by AAV). Non-sites are the opposite of this – i.e. cells of $100m^2$ where no archaeological material is believed to occur. There are approximately 1.5 million cells of this size ($100m^2$) in a map sheet such as the 7822-1-3-map sheet.

Given the body of knowledge for the study area (the 'expert' knowledge) it is possible to begin to build a series of GIS layers that can be combined using various processes to produce a likelihood surface. A likelihood surface is not a quantitative probability statement. It does not state that a site will or will not exist at a specific point in space with a mathematical degree of precision. A likelihood surface is an indication that, on the balance of all the available evidence, a site is likely or unlikely to exist at that point in space. This type of analysis is particularly suited to cultural resource management where so many of the parametres are either impossible to define, or where previous models are based upon untested hypotheses. The weight of evidence approach allows for the use of existing evidence in a manner that utilises aspects of Bayesian statistical technique.

The GIS layers constructed here are based upon the enormous quantities of data generated by consultants and academics in the study area over the last 25 years and the data collected for this thesis. However, statements such as 'sites will occur on prominences in the landscape overlooking waterlines' are not easily turned into Boolean statements or queries for analysis in GIS. This is where the use of the raster GIS *IDRISI32* and its *'BELIEF'* module becomes indispensable. The GIS provided by AAV for this project was *ArcView 3.2*. While this is an outstanding piece of software in its own right, *IDRISI32* offers a suite of powerful tools based upon Dempster-Shafer belief theory, which is an extension of Bayesian probability theory. 'The basic assumptions of Dempster-Shafer theory are that ignorance exists in the body of knowledge, and that belief for a hypothesis is not necessarily the complement of belief for its negation' (Eastman, 2001: 34). The workings of the *IDRISI32* '*BELIEF*' module are largely beyond the scope of this thesis, however the 'Dempster-Shafer rule of combination provides an important approach to aggregating indirect evidence and incomplete information' (Eastman, 2001: 36) in GIS-based modelling.

In order to model a likelihood surface we need to decide what is being hypothesized. In this case, the relatively straightforward binary opposites ('site' and 'non-site') are the two basic elements (hypotheses) of the decision frame. Evidence to support one or other is proffered from numerous sources. In this case, the evidentiary layers are distance to water, slope, and proximity to known sites. None of these attributes is easily described by internal binary relationships (i.e. they are not interval measurements, but are more like ratio measurements). For instance, the statement 'sites will occur at between zero and 200 metres from a source of potable water' cannot easily be transformed into Boolean map algebra. Prior knowledge and experience would suggest that this is a valid statement for much of the archaeology of Australia, however this does not allow us to determine the relationship between distance to water and sites (i.e. are more sites really located closer to water than further away?).

The '*BELIEF*' module in *IDRISI32* contains numerous procedures that allow for the variable nature of the model attributes to be accounted for. When these processes are run on a 'distance to water' layer for example, the *'BELIEF'* module can be programmed to take into account that the further away from a source of potable water we move the more likely it is that each cell will be a non-site. From the sites data for the study area, we know that over 80% of all known sites occur within 200 metres of a source of potable water. The falloff in site frequency at distances greater than 200 metres from water is graphed in Figure 3-15. Site frequencies decline at distances greater than 200 metres from potable water, reaching almost zero beyond 1000 metres. The relationship of site proximity to water can be shown as a sigmoidal (s-shaped) curve (Figure 6-10).

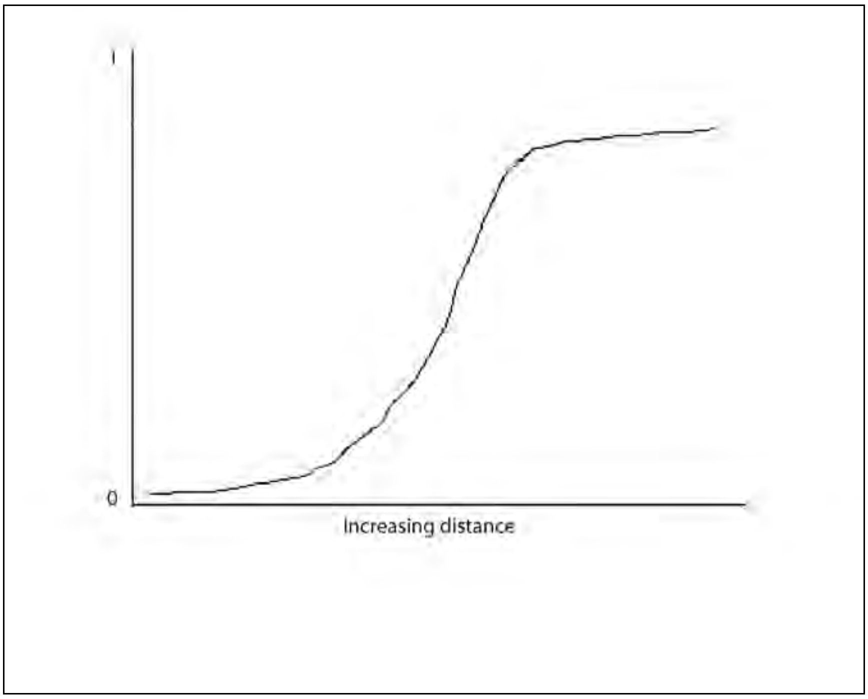


Figure 6-10: Sigmoidal curve of the distance decay of sites as distance to water increases.

Figure 6-10 shows the manner in which distance decay can be most effectively graphed. The relationship between the distance to water and the number of sites is best represented by this type of curve as there are no 'hard' boundaries delineating where site distributions and densities change or do not change. Close to water sources, the probability of encountering a non-site is low (i.e. nearer 0). As we move further away from a source of water, the probability of encountering a non-site increases to the point where it is theoretically 100%. A sigmoidal curve demonstrates this cumulative nature of distance to water and site numbers. As we move further away from the water source, the closer we are to the theoretical point at which no further sites will be found (i.e. the likelihood of a non-site approaches 100%).

Other landscape attributes may be modelled in a similar manner. Slope is the other variable for which we have a significant amount of prior or existing expert knowledge, as well as the limited (and biased) quantitative data from GIS analyses. The accumulated data suggests that sites will occur in areas where the slope is between 0^{o} and about 25^{o} and that the sites will most commonly occur near an area of topographic change (i.e. where the plains meet the hill slopes of the river valleys). The same GIS processes can be run on these attributes to create a series of 'likelihood' surfaces to be incorporated into the final weight of evidence model. The known data for the relationship between site location and slope, for instance, can be processed to create two separate surfaces that show the likelihood of the occurrence of both sites and non-sites.

Because there is a degree of uncertainty in the data, and the completed modelling exercise should reflect this, the layers must be 'scaled' or weighted to ensure that the results do not indicate 100% certainty for any predicted value. *IDRISI32* makes this process comparatively easy. Layers can be scaled (i.e. multiplied) by any factor to reflect the degree of uncertainty. For instance, the Distance to Water layer used in the modelling exercise here has been weighted using a factor of 0.8 (80%). This simply means that the known distribution of archaeological sites (i.e. approximately 80% within 200 metres of water) has been accounted for, while factoring in an estimate of the uncertainty (i.e. the other 20% that occur at varying distances greater than 200 metres from water). *'FUZZY'* logic is applied within *IDRISI32* to model those cells where it is unlikely that a site will occur (non-site). Table 6-2 presents a summary of the three layers that have been created in *IDRISI32* for incorporation into the final aggregated *'BELIEF'* model. A comprehensive discussion of the operation of the *IDRISI32 'BELIEF'* and '*FUZZY'* functions is provided by Eastman (2001).

When the various layers are entered into the *IDRISI32 'BELIEF'* module, the surface produced shows the likelihood of a cell being a non-site. Because uncertainty has been factored into this model, no values greater than 0.8 are used. Where a value of 0.8 is shown, the model predicts that there is an 80% likelihood that the cell in question will be a non-site. Where the value returned by the model is low, i.e. 20%, the model predicts that there is an 80% likelihood that the cell is a site (i.e. 20% likelihood of non-site equals an 80% likelihood of a site). Figure 6-11 presents the results of the aggregated BELIEF model. This is the likelihood surface for the 7822-1-3-map sheet. The attributes and modifications to the GIS layers are described in Table 6-2.

Layer Name	Cell Hypothesis	Description	Justification(s)
Known Site	Site	Those cell where a known site exists, plus all cells within 300 metres of a known site. FUZZY logic applied, using sigmoidal monotonically decreasing curve. The further away from a known site, the less likely it is that a cell will be a site.	Other sites will occur in close proximity to existing sites. As the distance between sites increases, so does the likelihood that a cell will be a non-site. The distribution of material from prior surveys, and from this thesis demonstrates that the presence of sites in a cell is strongly influenced by the location of other archaeological material.
Distance to Water	Non-Site	Cells greater than 300 metres to a source of potable freshwater. Cells between 0-300 metres have FUZZY logic applied using a sigmoidal monotonically increasing curve. The greater the distance away from potable water, the higher the likelihood a cell is a non-site	Distance to fresh water affects the distribution of site(s). The exact pattern is not known, although the overwhelming majority of sites in the study area (~90%) that occur within 300 metres of a permanent water source. This layer is weighted to reflect this phenomenon.
Slope	Non-Site	Cells where the slope angle exceeds 25^0 are more likely to be non-sites. Those less than 25^0 are more likely to contain sites. FUZZY logic is applied, using a sigmoidal monotonically increasing curve. Those values between $0^0$and 25^0 are weighted more heavily than those greater than 25^0.	The distribution of archaeological sites shows that sites tend to occur on slopes of between 0^0 and 25^0. This is not to say that no sites will occur on slopes greater than 25^0, rather that it is less and less likely as the slope increase. The FUZZY logic applied factors this into the aggregation of evidence.

Table 6-2: The various layers created for the 7822-1-3 map sheet, and the processes applied to them within IDRISI32

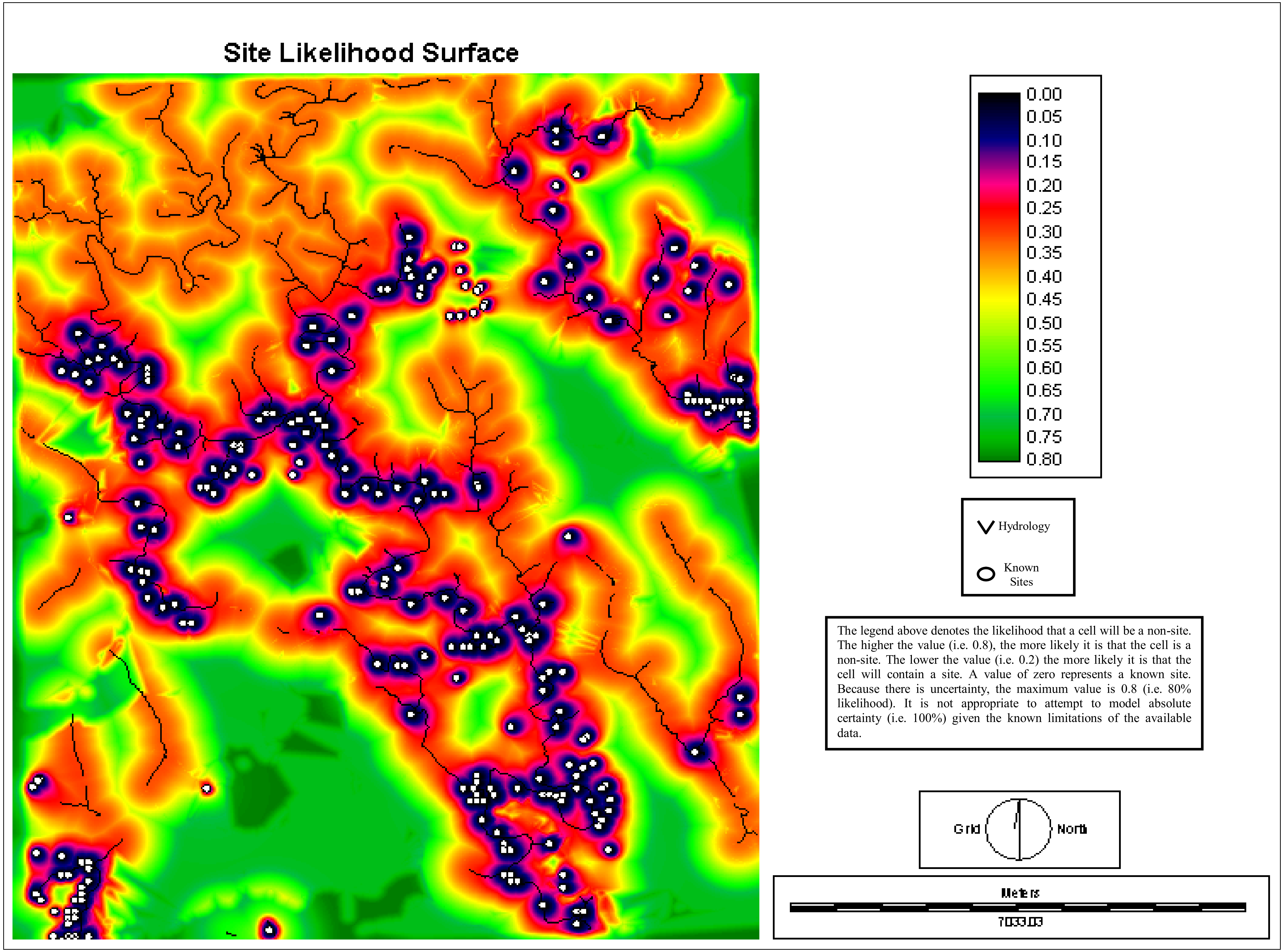


Figure 6-11: Site Likelihood Surface.

Interpreting the Model

The site likelihood surface generated from the available data should not be seen as a definitive probabilistic model. The site likelihood model is more the sum of all that is known of the archaeology of the area, complete with any inherited biases from the existing data and data collected specifically for this thesis. Interpreting this likelihood surface is relatively straightforward. The surface represents the weighted evidence of where sites are most likely to occur after the data has been processed using the '*BELIEF*' module in *'IDRISI32'*. Where the resultant value for any cell is high (i.e. >0.70) there is a high likelihood of encountering cells (remembering that each cell represents $100m^2$) that do not contain any archaeological sites (i.e. non-sites). Where the value is low (i.e. <0.20) there is a high likelihood of encountering cells that do contain archaeological sites. There are no definitive boundaries in this model, as the likelihood surface is generated as a combination of all of the evidence fed into the *'BELIEF'* module.

Other environmental and socio-cultural attributes will affect the presence or absence of archaeological sites in any area. In the current study area, for example, the location and distribution of siliceous lithic material can be used as a predictor variable for locating prehistoric silcrete quarries. The difficulty however, is that all of this material appears to outcrop within the river valley slopes already known to be significant (Webb, 1995). The river valleys are already given significant 'weight' within the model building process, so no extra 'weight' was thought to be required for the location of flakeable stone (although it is specifically acknowledged that this was an important prehistoric resource).

The incidence of naturally occurring topographic boundaries within the study area is also problematic. Again, it is specifically acknowledged that where such topographic boundaries exist (i.e. a cliff) Aboriginal land use practices and consequently archaeological site distribution will reflect this accordingly. For instance, at the Organ Pipes National Park, the eastern side of the escarpment is too steep in many places to afford easy access to the valley below. While this may not be the only reason this area was avoided by Aboriginal people in recent prehistory, the effects of differential access cannot be ignored. Nothing else is known of the effect(s) of differential access to resource zones for the entire study area, so it is difficult to incorporate this attribute into the model(s). Modelling topographic change in a region such as the current study area will always be problematic as over 90% of the area can be considered relatively flat –

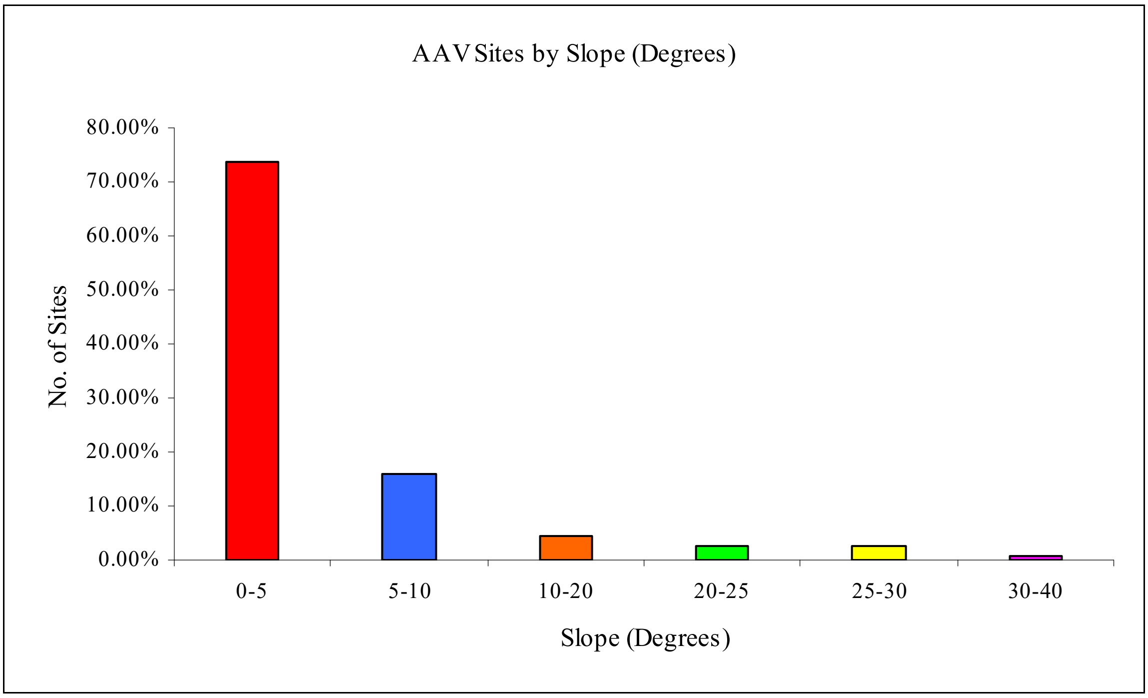


Figure 6-12: Percentage of known AAV sites per slope class (degrees). As the chart clearly shows, the majority of sites (>90%) occur at slopes less than 10^0.

and approximately 90% of all known sites occur on these relatively flat geomorphologically stable areas (Figure 6-12). The remaining 10% of the study area where 'slope' is greater than 10^0 contains the remaining 10% of sites. The model accounts for this by incorporating those cells with slopes of between 10^0 and 25^0 as moderately likely to contain sites, while those cells exhibiting slope greater than 25^0 as unlikely to contain sites. This hypothesis is supported by the distribution of known AAV sites. Although this data may be biased, the distribution of the 276 registered sites in the 7822-1-3-map sheet reflects an overall tendency toward flatter areas (i.e. between 0^0 and 10^0). This pattern is common throughout the study area.

This chapter has presented various palaeoenvironmental models of Aboriginal land use in prehistory, and an example of a sensitivity model based on Dempster-Shafer belief theory for part of the study area. The following chapter presents some final points of discussion about this project, and the conclusions reached.

Chapter Seven

7. Discussion

There is a worrying view prevalent in much of the relevant literature that GIS is somehow revolutionizing both archaeology and CRM, and in particular predictive modelling practice (Ebert, 2000: 130), and that it is capable of producing the necessary results where other methods have failed. Nothing however, could be further from the truth. Predictive modelling is by no means a new or revolutionary endeavour, and nor is GIS a new or revolutionary technology. GIS are simply databases with visual interfaces, allowing spatial data to be displayed and queried visually and mathematically rather than in the traditional tabular format.

GIS cannot create 'good' data where there is none, nor turn poor data into better data. GIS can however be used to create spurious models where inappropriate statistical techniques are applied to less than mathematically adequate data sets. GIS cannot miraculously transcend the rules of empiricism and statistical inference in the pursuit of the perfect model. Like any other analytical tool, GIS and the data it uses, are bound by the same rules as any other scientific endeavour. This empirical reality is often overlooked in the development of purely inductive (correlative) predictive models.

In the context of this thesis, databases of archaeological site location and type have been collected and maintained by AAV for over 25 years. The same rules of empiricism and statistical inference apply to this data as to any other source of archaeological or geospatial data. The majority of predictive modelling methods and techniques were developed many years before the appearance of tools like GIS. As a tool, GIS allows for masses of spatial data to be queried and manipulated in ways that were previously impossible. The underlying theoretical premises of predictive modelling however remain unchanged. GIS is not the archaeological panacea that many have claimed it to be (Ebert, 2000).

Representing spatial aspects of certain datasets is a simple undertaking with modern GIS software (i.e. mapping where things are); however attempting to introduce temporality into this process is extremely difficult if not impossible. GIS can be used to correlate modern topographic or geographic phenomena with archaeological site location – and little more – unless specific and explicit temporal data exists. While the correlations and statistical testing may provide a strong basis for causality, unless archaeological phenomena are interpreted and explained using archaeological method and reasoning, the actions of the human actors in antiquity are doomed to remain anecdotal spatial correlations at best (Ebert, 2000: 130). The importance of gathering new data cannot be stressed strongly enough. The GIS model developed here relies almost entirely upon existing data. The accuracy of the model can only be improved by the incorporation of new data, until the modelling process reaches the point where quantitative models may be possible. At present, probability based models are not possible. The data collected for this thesis was plagued with the same limitations and restrictions as the older existing data, and so could not be utilised to construct quantitative models.

Fieldwork

The extensive fieldwork undertaken for this thesis established a 'base line' data set independent of the existing data sets from across the remainder of the region. A silcrete-dominated industry was identified both in the field and in the literature despite differences apparent in raw material identification over the last 25 years. This silcrete industry features few formal tools, and was complemented by similar typological characteristics manufactured on smaller quantities of quartzite and quartz. Several other 'exotic' raw materials comprised the remainder of the assemblages. The 'exotic' materials included glass, mudstone, and ochre. Overall, silcrete comprised almost two thirds of all artefacts located during the field survey – a pattern repeated across the region through this survey and the pre-existing literature. The majority of the materials located were components of extensive surface lithic artefact scatters. Other site types recorded included stone sources at Woodlands Historic Park and numerous scarred trees. The data was collected in a consistent manner across the entire study area and the spatial data in particular was recorded with great accuracy.

Problems are created when archaeological survey projects of this nature work outside of the status quo – i.e. using non-site survey techniques instead of the normal site based survey methods. It is generally not possible to draw comparisons between most of the existing data and the new data collected for this thesis, as the two data sets are vastly different. The resolution at which the data for this thesis was collected is far greater than that of the AAV database. The manner in which the few assemblages were recorded also does not allow for easy comparison. The manner in which site boundaries were constructed by consultant archaeologists is also not known. Therefore, the spatial or areal density of assemblages could not be reconstructed from the CRM reports to compare to the densities recorded during the fieldwork for this thesis. Visibility figures are not

quantified in the majority of CRM reports, similarly preventing an assessment of the variable effects of visibility on survey results.
Extensive and continuous artefact scatters were the most common site occurrence. The highly accurate spatial data gathered from the four survey areas for this thesis facilitated an unprecedented view of these phenomena. With approximately 8,500 items recorded between OPNP and BRNP alone, it was possible to map and view these extensive and continuous artefact scatters. The continuous nature of the surface material is consistent with similar spatially continuous patterns identified in the Maribyrnong Valley. Having identified and compared these discrete but complementary archaeological patterns, archaeological sensitivity zoning techniques are viewed as the most appropriate means of modelling and conserving sensitive archaeological landscapes.

Throughout the fieldwork component of this thesis, numerous limitations were encountered which forced the project to either change course or reassess the appropriateness of the methods considered as essential when planning the fieldwork. The insurmountable problem of ground surface visibility was one such issue. While it is easy to be critical of the work of others, in the context of the wider Melbourne region, little can be done to overcome the frustrations of limited visibility. This project like most others was plagued by almost impossible field conditions where ground surface visibility was practically zero. There is virtually nothing that the field archaeologist can do in these circumstances except seek clearer ground within their area of interest. In the shallow and stony soils of the Basalt Plain, shovel-testing methods were seen as being a less than ideal techniques for locating undiscovered archaeological materials. While all practitioners in the region know of these restrictions and limitations, little actual mention of the effects of these problems is made in the reports or in Australian archaeological literature in general.

If visibility falls below 20% (Simmons and Djekic, 1981), then the survey cannot hope to effectively locate any archaeological material in any area, particularly with the low levels of survey intensity historically identified from the reports in the current study area. Visibility of less than 20% and low survey intensity essentially means that the subject area remains unsurveyed. This is not spelt out to non-archaeologists in the report literature. If surveys are undertaken in these conditions, and clearances are subsequently given for developers to proceed, then we have no way of ever knowing what or how many archaeological sites may have been destroyed. This is particularly applicable to any area of land within the 500 metre corridor either side of a source of potable water. Land within this zone should be subjected to the highest intensity survey possible, in order to attempt to combat the limitations of poor visibility. While more ‘eyes on the ground’ is not the optimum solution, at least some of the material that might otherwise be missed in a low intensity survey will be located.

Site Survey Methods

The contemporary practice of site survey in Victoria is by necessity a relatively *ad hoc* process, mostly fuelled by the demands of developers. AAV has little actual control over the majority of archaeological survey, as the location of surveys is driven by the requirements of developers. Regional survey programs conducted under the auspices of AAV have been completed in the past. The results of some of these regional surveys are analysed in this thesis. While the actual conduct of field surveys is difficult to critique, the reporting standards in Victorian survey archaeology are currently sub-standard. The large volume of reports analysed for this thesis revealed many inconsistencies in the work of the numerous archaeological practitioners operating in Victoria, making it virtually impossible to quantitatively compare the reports across the study area. The reports showed marked variations in the manner in which survey methods, site recording techniques, stone tool identification and recording and raw material identification were undertaken or reported.

Many of the reports failed to provide data regarding the spatial scale of the survey (i.e. survey area), the number of people involved, transect width (i.e. intensity), site contents, or ground surface visibility. These basic elements must be reported if there is to be any comparability between the works of the various practitioners. The practice employed by AAV of digitising the survey areas post-survey is somewhat misleading for the researcher. The digitised survey coverage layer is not the actual ground surface physically surveyed by the archaeologist(s) involved in a given project. The digitised survey coverage layer represents the external boundaries of the individual area under investigation. For instance, a 100-hectare block of land may be the subject of an archaeological investigation, whereas only 5% may actually be surveyed. The AAV survey coverage layer dramatically overestimates the actual amount of archaeological survey that has taken place in the state, and should be disregarded for predictive modelling purposes.

In order to ensure at least minimum levels of comparability across the region, and indeed the State, AAV needs to implement an imposed series of minimum standards for the conduct and reporting of archaeological surveys. The existing AAV guidelines do not offer anywhere near the level of guidance required to ensure minimum survey standards and comparability. At the very least AAV must implement an editorial panel to review archaeological reports as they are submitted. The current practice is to accept reports from consultant archaeologists as written without peer review or editorial input from AAV. If consistent standards are to be maintained across the state, then surely the peak organization responsible for the management of Aboriginal heritage has a duty of care to review consulting reports as they are filed. This would arguably be the most significant step towards standardized reporting, and increasing the otherwise poor levels of comparability between reports. The New South Wales National Parks and Wildlife Service standards and guidelines might be used as the starting point for the development of a similar set of guidelines governing archaeological and CRM practice in Victoria (Byrne, 1997). Alternatively, there are numerous overseas cultural resource management agencies that have developed extensive and thorough guidelines for the conduct and reporting of archaeological surveys which may also serve as a model for AAV (i.e. The New Jersey Historic Preservation Office Guidelines for Phase 1 archaeological investigations: Identification of Archaeological Resources, or the Appendix 14 Guidelines for Archaeological Investigations in Virginia, United States).

Predictive Models

Having demonstrated the limitations inherent in the existing AAV data, and having encountered many of the same bias inducing limitations in the field, what then are the ramifications for the development of the predictive models required of this thesis? While it was not possible to construct quantitative valid predictive models based upon inductive correlations between prehistoric site location and modern environmental data, it has been possible to construct a likelihood model based upon the existing knowledge of the prehistory of the region - the existing AAV data, newly collected archaeological data, and essential theoretical perspectives – complete with the identified limitations. The Dempster-Shafer belief theory model allows for the incorporation of any bias or ignorance in existing data sets while still producing a valid model of archaeological sensitivity.

The model(s) developed for this thesis makes use of a site likelihood approach rather than attempting to model discrete (i.e. individual) site locations. Modelling individual site locations is more problematic than zone-based modelling, and was not considered appropriate to utilise here. The zone method is a superior method of modelling the archaeological sensitivity of the relevant landscape, and overcomes the limitations inherited from biased and inconsistent data. The content of the AAV database has largely been collected over the years with no specific overarching research agenda or purpose in mind, thus limiting the utility of this database for quantitative analysis.

The likelihood method utilised here is a more appropriate modelling technique for the requirements of this thesis. The model(s) developed are to provide managers and planners with definitive 'red flag' (Altschul, 1990) statements of archaeological sensitivity to facilitate the conservation of the archaeological record in the planning decision-making process. The Aboriginal land use models developed in this thesis are the foundation of the sensitivity models. These theoretically constructed land use models are the most appropriate foundation of any modelling endeavour where explanation is as important as prediction. While all models are essentially 'reductionist' (Winterhalder, 2001: 14), the theoretically based land use models developed here in conjunction with the existing archaeological data has allowed for the creation of a detailed view of prehistoric Aboriginal settlement patterns and resource exploitation in the study area.

The construction of 'zone' based models of archaeological sensitivity is also a more appropriate method of modelling given the current trend favouring landscape-based methods and approaches in CRM (du Cros and Rhodes, 1998b). In terms of the protection offered to the archaeological record through modelling, the zone-based approach is unequivocally superior to approaches that attempt to isolate the location of individual sites within the landscape. The more 'isolationist' method of attempting to predict individual site locations is not appropriate for the modelling of hunter-gatherer archaeology where the phenomena under investigation may be as ephemeral as a simple artefact scatter. The modelling of individual site location should be restricted to archaeological phenomena that are more substantial, such as has been attempted with prediction of Mesolithic hill fort location (Lake, Woodman and Mithen, 1998; Ruggles and Medyckyi-Scott, 1996) or Neolithic Wessex (Wheatley, 1996) in the United Kingdom for example

Viewing the relevant sections of entire landscapes as archaeologically sensitive allows the relevant agencies (i.e. AAV or local government planners) to flag these areas early on in the planning and development process so that all parties are aware of the need to investigate, manage or conserve the relevant resource(s). Using a zone-based approach also avoids the undesirable situation of non-archaeologists attempting to interpret archaeological information. Models that simply highlight an area as archaeologically sensitive are more appropriate than asking non-archaeologists to interpret models which were designed with an archaeological audience in mind. Non-archaeologists should not be asked nor expected to interpret archaeological data or models at anything beyond the most rudimentary levels. If an area falls within an archaeologically sensitive zone, then this is all a LGA planner should be required to identify from any predictive model. Once the planner identifies this, then the relevant information should be referred to AAV for subsequent action. It should not be the responsibility of LGA planners to make any recommendations for the survey or management of archaeological resources. This must remain entirely within the purview of AAV where trained archaeologists are on-staff to deal with archaeological problems.

Melbourne Metropolitan Area

The models developed for this thesis are only applicable to the study area in question and should not be applied outside of this area without further research. The development of the model of archaeological sensitivity meets the essential aims outlined in the thesis research design (see Appendix 9-2). The major requirement of this project was a model of archaeological site location suitable for use by cultural resource management agencies and LGA planners. While many of the constraints encountered precluded the use of many popular quantitative modelling techniques, basing the models upon sound theoretical footings as well as the extensive existing data ensures the validity of these models and ensures that any advice framed in reference to these models can ultimately be relied upon.

Within the study area for this thesis, various recommendations can be posited regarding the sensitivity of various parts of the landscape, and how these areas should be regarded in any future planning decisions. While AAV bears ultimate responsibility for determining best practice CRM in Victoria, many of the issues raised throughout this thesis need to be addressed in order to ensure the conservation of archaeologically significant and sensitive landscapes. Ideally, no land altering activities should be allowed to occur within any of the areas displaying high likelihood of site occurrence (i.e. where likelihood of a non-site <0.20). Conversely, where the likelihood of a non-site is higher (i.e. 0.70), then only minimal archaeological investigations may be required. If, as is often the case, there is no alternative to development in the areas of high site sensitivity, then the following archaeological investigations might be recommended before granting a planning permit.

In areas of High Likelihood (i.e.<0.20).

1. High intensity pedestrian survey (i.e. maximum 5 metre transects, minimum 3-4 crew members) provided ground surface visibility is greater then 20%.
2. If visibility is less than 20%, then high intensity sub-surface testing should be employed using a random stratified sampling technique across the whole area in question.
3. An archaeologist should be on site to monitor all earthworks that will potentially disturb sub-surface archaeological materials.
4. Any site(s) or material(s) encountered should be recorded in all possible detail.
5. Salvage excavation of stratified deposits or potential archaeological deposits.

Areas displaying Moderate Likelihood (i.e. >0.20<0.70) predominantly fall on the basalt plains of the example map sheet. As such, the presence of stratified archaeological deposits throughout the majority of these areas is unlikely. However, prior to any earthworks or land altering activities:

1. Medium intensity pedestrian survey should be undertaken (i.e. maximum 10 metre transects, minimum 1-2 crew members) providing visibility is greater than 20%.
2. If visibility falls below 20%, then an intensive sample survey should be undertaken to determine the presence or absence of archaeological material across a representative sample of the area in question. If possible, surface vegetation should be removed before survey. This may be accomplished by using a mower; slasher or perhaps burning off the land is question.
3. Any site(s) or material(s) encountered should be recorded in all possible detail.
4. Salvage excavation of stratified deposits or potential archaeological deposits.

The area displaying the Lowest Likelihood (i.e. >0.70) encompasses all of the study area that is greater than about 500 metres from a major river or creek. There are less than 10% of all known sites occurring in this zone, and the sites that occur in this area are predominantly the least scientifically significant sites (i.e. isolated artefacts). Some artefact scatters and scarred trees occur in very low numbers in this zone. Before any earthworks or land altering activities: -

1. Low intensity field survey will normally be sufficient in this zone (i.e. maximum 10-20 metre transects with minimum of 1-2 people) providing visibility is greater than 20%. If visibility falls below 20%, then higher intensity survey is necessary.
2. Due to the prevailing geomorphic conditions and post-depositional disturbances encountered throughout the basalt plains, it is unlikely that stratified archaeological materials will be located in this zone. However, the areas surrounding swamps should be intensively inspected, and any material potentially containing stratified deposits should be investigated.
3. Any site(s) or material(s) encountered should be recorded in all possible detail.

The landscape approach to archaeological site conservation should continue to be promoted to planners and developers. Archaeological landscapes encompass the range of sites present in a specific area, and include material above and below the contemporary land surface. It is important that planners, developers and CRM agencies regard the archaeological landscape as being three-dimensional to conserve archaeological material located above and below the surface. Secondly, appropriate archaeological survey methods should be utilised at all times, and particularly in those areas considered to be of high archaeological sensitivity.

It is largely beyond the scope of this thesis to make recommendations or prescriptions as to how AAV should police archaeological survey methodology in Victoria, however it would be appropriate for AAV (in conjunction with the archaeological community at large) to develop and implement more stringent minimum survey requirements and standards than are currently utilised. Setting minimum standards ensures that there is a benchmark for survey quality and methodologies, which must be met or exceeded. The New South Wales National Parks and Wildlife Service (the organization with more or less the same responsibilities for Aboriginal archaeological material in New South Wales) for example, has published comprehensive standards and guidelines for the conduct of Aboriginal archaeological surveys and reporting throughout New South Wales (Byrne, 1997). Many jurisdictions employ similar minimum standards in reporting, or require archaeologists undertaking works to have obtained a minimum level of qualification before undertaking any archaeological activity. The 'Regulations

Governing the Conduct of Archaeological and Anthropological Research' in the Republic of the Marshall Islands (Spennemann, 2000) for example, requires practitioners to have obtained the minimum standard of a post-graduate degree in archaeology before undertaking any archaeological research in the Marshall Islands.

The major weaknesses or limitations of current survey archaeology in Victoria are extremely low intensity surveys and extremely poor visibility. Minimum standards should be developed by AAV to regulate the required survey intensity, and implement a minimum visibility threshold. Once visibility falls below 20% for example, (Simmons and Djekic, 1981) it is simply not worth conducting pedestrian survey, as the overwhelming majority of the ground surface is obscured. Surveying in these conditions is counter-productive, and ultimately destructive to the archaeological record.

Similarly, minimum survey intensity levels should be established by AAV in order to ensure that archaeological surveys are not conducted where the levels of survey intensity are too low. For instance, surveys reviewed in earlier chapters of this thesis revealed levels of survey intensity so low that, when combined with poor visibility, there is little likelihood of locating archaeological sites in any way other than by pure chance. Minimum requirements for the number of personnel in the field need to be established to ensure that when surveys are conducted (over larger areas in particular), the ground surface is inspected at an appropriate intensity. As discussed in Chapter 3, the survey intensity calculated for the reports previously conducted in the current study area was approximately seven times less than in a comparable study conducted in the United States (Schiffer and Wells, 1982) in a region of far higher visibility.

The data collected for this thesis must also be placed into context, and critiqued in the same manner as the other data sources reviewed. Exactly the same limitations and restrictions that plague consulting archaeologists restricted the data collection process for this project. In an ideal world, it would have been more advantageous to conduct fieldwork during the summer of 2002/2003 to take advantage of the severe drought conditions prevailing over most of South Eastern Australia. However, consulting archaeologists can seldom chose the exact timing of their projects, and must proceed as best they can. Similarly, the use of random stratified sampling techniques is perhaps best suited to smaller projects where a maximum number of factors can be controlled across relatively homogenous environments. Attempting this type of strategy across multiple field locations with differing environmental constraints was perhaps somewhat naïve or at least overly optimistic. Similarly, the utility of shovel testing during a regional survey is somewhat questionable given the sample size required to make any statistically valid inferences.

Future Research

There are many avenues for future research arising from the completion of this thesis. The immediate task is ensuring that the models of archaeological sensitivity are continually updated and tested. The simplest method to update the model(s) is with data collected from other surveys in the future. This data however must be recorded at a minimum standard of precision as recommended, and must be comparable with other new data collected from across the region. This can be achieved if AAV instigate a system of minimum reporting standards.

Ground surface visibility is perhaps the single greatest limitation encountered in the field during any surface survey of the study area. Little research has been conducted in the study area on the effects of survey intensity on site location probabilities, the effects of artefact obtrusiveness on discovery rates, or the effects of quadrant versus transect survey methods on site discovery rates (e.g. Cowgill, 1990; Gallant, 1986; Hansen, 1984; Hasenstab and Lacy, 1984; Nance, 1981; Plog, 1976; Wandsnider and Camilli, 1992; Whalen, 1990; Zubrow, 1984). The archaeological survey methods employed in the current study area have been continually employed for over 25 years without any form of testing or research on the efficiency or efficacy of these methods.

The archaeology of the study area is still poorly known, with research on the Pleistocene having all but ceased. While this situation is a product of both Aboriginal and archaeological politics and contemporary economics, a tremendously significant archaeological resource lies less than 20 kilometres away from the CBD of a major capital city, and less than 20 kilometres away from a major university archaeology department. There are still a great many questions about the prehistoric Aboriginal occupation of the study area that remain unanswered.

Site Unseen

This thesis has followed a circuitous route to completion, navigating the intellectual space and practical demands of an industry sponsor on the one hand, and the rigour expected of an academic project on the other. This project is perhaps best viewed as the point of origin for further research and development of archaeological modelling and management in the Melbourne Metropolitan area. Any future research however, will need to contend with the same limitations and restrictions as this project has unless changes are made in the way archaeological resource management is undertaken. These changes are mainly methodological, but are essential if archaeological data collected in the future is to be comparable both within and between regions.

While probability based quantitative models may arguably have been the optimum outcome from this thesis, the biases present in both the existing and newly collected data prohibited the development of quantitative models. Regardless of the manner in which biased data is processed or manipulated, it will always remain biased. In this case, there is very little that can be done to combat the non-representative sampling procedures that have been used for most of the last 25 years. Indeed, in most cases, the archaeologist(s) has had little or no choice, as the nature of the study area and economic considerations precluded the use of more quantitative field survey techniques. Thus, the available data could not be utilized to create probabilistic statements of site location. The use of Dempster-Shafer belief theory however, alleviated some of these problems, allowing for the construction of a predictive model that has both ‘bias’ and ‘ignorance’ factored in from the outset.

In conclusion, given all of the limitations discussed in this thesis, the model of archaeological sensitivity developed is the most appropriate and efficient method of ensuring that the archaeology of the study area can be incorporated into local government authority planning schemes, and thus enjoys a far greater level of protection and active management than ever before. If the archaeological modelling system developed here is adopted and incorporated into local government planning schemes it will constitute a powerful and effective tool to aid in the discovery and conservation of Aboriginal archaeological material throughout the study area into the 21st century.

Bibliography

8. Bibliography

Aboriginal and Torres Strait Islander Cultural Heritage Protection Act (Cth) 1984

Archaeological and Aboriginal Relics Preservation Act (Vic). 1972

Aboriginal Affairs Victoria (1996) *Aboriginal Use of Water Related Resources in Victoria*. Aboriginal Affairs Victoria. Melbourne.

Aboriginal Affairs Victoria (1997) *Guidelines for Conducting and Reporting Upon Archaeological Surveys in Victoria*. Aboriginal Affairs Victoria. Melbourne.

Allen, J. (1989) Excavations at Bone Cave, south central Tasmania, January-February 1989. *Australian Archaeology*. **28** Pp: 105-106.

Allen, K. (1990) Modelling Early Historic Trade in the Eastern Great Lakes using geographic information systems. In Allen, K., Green, S., and Zubrow, E. (Eds.). *Interpreting Space: GIS and Archaeology*. Pp. 319-329. Taylor & Francis. London.

Altschul, J. H. (1990) Red Flag Models: the use of modelling in management contexts. In Allen, K. M., Green, S. W., and Zubrow, E. B. W. (Eds.). *Interpreting space: GIS and archaeology*. Pp. 226-238. Taylor and Francis. London.

Ammerman, A. J. (1985) Plow-Zone Experiments in Calabria, Italy. *Journal of Field Archaeology*. **12** Pp: 33-40.

Anderson, J. R. (1972) *The Quaternary Geology and Sedimentology of the Gallus Sites at Keilor, Victoria*. Unpublished B.Sc. (Hons) Thesis. School of Geology. University of Melbourne. Melbourne.

Anon (2000) *History of the Mn/Model Project.* Minnesota Department of Transport, On-Line Report hosted by the Minnesota Department of Transport at http://www.mnmodel.dot.state.mn.us/pages/history.html.

Attenbrow, V. (1988) *The Upper Mangrove Creek Catchment: A Study of Quantitative Changes in the Archaeological Record*. Unpublished PhD Thesis. School of Archaeology. University of Sydney. Sydney.

Bahn, P. (1992) *Collins Dictionary of Archaeology*. Harper Collins. Glasgow.

Barlow, J. (1999) *The Sedimentology and Geomorphology of the Maribyrnong River Terraces at Keilor, Victoria*. Unpublished B.Sc. (Hons) Thesis. Department of Earth Sciences. La Trobe University. Melbourne.

Barnham, C. (1998) An Illustrated Checklist of Freshwater Fishes of Victoria. In Barnham, C. (Ed.) *Fisheries Notes*. Department of Natural Resources and Environment. Melbourne.

Barwick, D. E. (1984) Mapping the Past: An atlas of Victorian Clans: 1835-1904. Part 1. *Aboriginal History*. **8** (2) Pp: 100-131.

Bell, D., and Presland, G. (1977) *Maribyrnong Valley Metropolitan Park Archaeological Survey*. Melbourne Metropolitan Board of Works. Melbourne.

Berryman, A., and Frankel, D. (1984) Archaeological investigations of mounds on the Wakool River, near Barham, New South Wales: a preliminary account. *Australian Archaeology*. Pp: 21-30.

Bickford, A., and Sullivan, S. (1984) Assessing the Research Significance of Historic Sites. In Sullivan, S., and Bowdler, S. (Eds.). *Site Survey and Significance assessment in Australian Archaeology*. Proceedings of the 1981 Springwood Conference on Australian Prehistory. Pp.19-26. Department of Prehistory, Research School of Pacific Studies, Australian National University. Canberra.

Binford, L. R. (1964) A Consideration of Archaeological Research Design. *American Antiquity*. **29** (4) Pp: 425-441.

Bird, C. F. M., and Frankel, D. (1991a) Chronology and Explanation in Western Victoria and south-east South Australia. *Archaeology in Oceania*. **26** Pp: 1-16.

Bird, C. F. M., and Frankel, D. (1991b) Problems in constructing a prehistoric regional sequence: Holocene south-east Australia. *World Archaeology*. **23** (2) Pp: 179-192.

Bird, C. F. M., and Frankel, D. (1998) Pleistocene and Early Holocene Archaeology in Victoria. A view from Gariwerd. *The Artefact*. Pp: 48-62.

Bird, C. F. M., Frankel, D., and Van Waarden, N. (1988) New radiocarbon determinations from the Grampians-Gariwerd region, western Victoria. *Archaeology in Oceania*. **33** (1) Pp: 31-36.

Blainey, G. (1975) *Triumph of the Nomads*. A history of ancient Australia. Macmillan. Melbourne.

Boot, P., and Kuskie, P. (1996) Consultancy and Thesis - What's the difference? Two approaches to archaeological survey of Jumping Creek Valley, Queanbeyan. *Australian Archaeology*. **43** Pp: 23-28.

Bowdler, S. (1977) The Coastal Colonization of Australia. In Allen, J., Golson, J., and Jones, R. (Eds.). *Sunda and Sahul: Prehistoric Studies in Southeast Asia, Melanesia and Australia*. Pp. 205-246. Department of Prehistory, Australian National University. Canberra.

Bowdler, S. (1981) Unconsidered Trifles? Cultural resource management, environmental impact statements, and archaeological research in New South Wales. *Australian Archaeology*. **12** Pp: 123-133.

Bowdler, S. (1984) Archaeological Significance as a Mutable Quality. In Sullivan, S., and Bowdler, S. (Eds.). *Site Survey and Significance Assessment in Australian Archaeology*. Proceedings of the 1981 Springwood Conference on Australian Prehistory. Pp. 1-9. Department of Prehistory, Research School of Pacific Studies, Australian National University. Canberra.

Bowler, J. M. (1969) The Keilor Terraces: An assessment of geological problems. *The Artefact*. **14** Pp: 1-16.

Bowler, J. M. (1970) Alluvial Terraces in the Maribyrnong Valley Near Keilor, Victoria. *Memoirs of the National Museum of Victoria*. **30** Pp: 15-58.

Bowler, J. M. (1987) Water and Sand: Climate in Ancient Australia. In Mulvaney, D. J., and White, J. P. (Eds.). *Australians to 1788*. Pp. 25-45. Fairfax, Syme and Weldon Associates. Sydney.

Bowler, J. M., Mulvaney, D. J., Casey, D. A., and Darragh, T. A. (1967) Green Gully Burial. *Nature*. **213** Pp: 152-154.

Bowman, M. (2001) *Introduction to Victoria's Key Environment and Planning Law: A community Guide to Victoria's decision making process about environment and planning issues*. The Environment Defenders Office (Victoria) Ltd. Melbourne.

Brooks, A., Hudak, G. J., Gibbon, G., and Hobbs, E. (2000) Management Summary. In *Mn/Model: A Predictive Model of Pre-contact Archaeological Site Location for the State of Minnesota*. Pp. 2-8. Department of Transport. St Paul, Minnesota.

Brown, P. (1987) Pleistocene homogeneity and Holocene size reduction: the Australian human skeletal evidence. *Archaeology in Oceania*. **22** Pp: 41-67.

Brown, P. (2002) *Kow Swamp*. Internet Resource located at: http://www-personal.une.edu.au/~pbrown3/KowS.html

Brown, S., and Lane, S. (1997) *Moorabool Water Treatment Project: An Archaeological Survey*. A report to Barwon Water. Melbourne.

Brown, S., Lane, S., and du Cros and Associates. (1997) *Brimbank City Council. Aboriginal Cultural Heritage Strategy. Background Document*. A report to Brimbank City Council. Melbourne.

Brownhill, W. R., and Wynd, I. (1990) *The history of Geelong and Corio Bay*. Geelong Advertiser. Geelong.

Bunce, D. (1859) *Travels with Dr. Leichardt*. Oxford University Press. Melbourne.

Burke, C. (1989) *The Keilor Archaeological Site: A report to the Wurrundjeri Tribe Land and Compensation Cultural Heritage Council Inc*. Victoria Archaeological Survey. Melbourne.

Burke, C. (1990) *Analysis of the lithic assemblage from the Keilor archaeological site. Site Number 7822/010*. Victoria Archaeological Survey. Occasional Report No. 30. Melbourne.

Butzer, K. (1982) *Archaeology as Human Ecology*. Cambridge University Press. Cambridge.

Byrne, D. (1983) *The Five Forests. An archaeological and anthropological investigation*. A report to National Parks and Wildlife Service. New South Wales. Sydney.

Byrne, D. (Eds.)(1997). *Standards Manual for Archaeological Practice in Aboriginal Heritage Management*. Sydney. New South Wales National Parks and Wildlife Service.

Canning, S. (1999) *"Contested Space" - the role of Social Value in the assessment of Cultural Significance.* Unpublished B.App.Sci (Hons) Thesis. Faulty of Science and Agriculture, School of Environmental and Information Sciences. Charles Sturt University. Albury.

Canti, M., and Meddens, F. (1998) Mechanical Coring as an Aid to Archaeological Projects. *Journal of Field Archaeology*. **25** Pp: 97-105.

Carr, G. W., Peake, P., Muir, A. M., Ward, L. A., Craige, N. M., and Van de Graaff, R. (1996) *Woodlands Historic Park Restoration Plan*. National Parks Service, Department of Conservation and Natural Resources. Melbourne.

Casey, D. A., and Darragh, T. A. (1970) Excavation of the Green Gully burial. *Memoirs of the National Museum of Victoria*. **30** Pp: 3-14.

Chappell, J. (1993) Late Pleistocene coasts and human populations in the Australia region. In Spriggs, M., Yen, D., Ambrose, W., et al. (Eds.). *A Community of Culture: The People and Prehistory of the Pacific*. Occasional Papers in Prehistory No. 21,. Department of Prehistory, RSPacS, ANU. Canberra.

Chappell, J. (2001) Sea level through the last glacial cycle. *Science*. **292** Pp: 679-685.

Chappell, J., and Thom, B. (1977) Sea Levels and Coasts. In Allen, J., Golson, J., and Jones, R. (Eds.). *Sunda and Sahul. Prehistoric Studies in Southeast Asia, Melanesia, and Australia*. Pp. 275-291. Academic Press. London.

Chartkoff, J. L. (1978) Transect Interval Sampling in Forests. *American Antiquity*. **43** (1) Pp: 46-53.

Church, T., Brandon, R. J., and Burgett, G. R. (2000) GIS Application in Archaeology: Method in search of theory. In Wescott, K. L., and Brandon, R. J. (Eds.). *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit*. Pp. 135-155. Taylor and Francis. London.

Clark, I. D. (1990) *Aboriginal Languages and Clans: An Historical Atlas of Western and Central Victoria 1800-1900*. Monash Publications in Geography Number 37. Monash University. Melbourne.

Clarke, A. (1994) Romancing the stones: the cultural construction of an archaeological landscape in the Western District of Victoria. *Archaeology in Oceania*. **29** (1) Pp: 1-15.

Clarke, D. L. (1973) Archaeology: The Loss of Innocence. *Antiquity*. **47** Pp: 6-18.

Cochrane, G. W., Quick, G. W., and Spencer-Jones, D. (1995) *Introducing Victorian Geology*. Geological Society of Australia (Victoria Division). Melbourne.

Connolly, T. J., and Baxter, P. W. (1983) The Problem with Probability: Alternative Methods for Forest Survey. *Tebiwa*. **20** Pp: 22-34.

Cosgrove, R. (1989) Thirty Thousand Years of Human Colonization in Tasmania: new Pleistocene Dates. *Science*. **243** Pp: 1703-1705.

Cosgrove, R. (1995a) *The Illusion of Riches: Scale, Resolution and explanation in Tasmanian Pleistocene Human behaviour*. BAR International Series. BAR. Oxford.

Cosgrove, R. (1995b) Late Pleistocene behavioural variation and time trends: the case from Tasmania. *Archaeology in Oceania*. **30** Pp: 83-104.

Cosgrove, R., Allen, J., and Marshall, B. (1990) Palaeo-ecology and Pleistocene human occupation in south central Tasmania. *Antiquity*. **64** Pp: 59-78.

Cosgrove, R., Frankel, D., and Van Waarden, N. (1997) *Linking Aboriginal Cultural Heritage Data and Planning: developing methods for the incorporation of archaeological data into the statutory planning process*. Australian Research Council Strategic Partnerships with Industry - Research and Training (SPIRT) Grant Application La Trobe University and Aboriginal Affairs Victoria, Melbourne.

Coutts, P. J. (1976) *The Prehistory of Victoria: A Review*. Records of the Victoria Archaeological Survey. Number 2. Melbourne.

Coutts, P. J. (1981a) Coastal Archaeology in Victoria. Part 1: The Morphology of Coastal Archaeological Sites. *Proceedings of the Royal Society of Victoria*. **92** (1-2) Pp: 67-80.

Coutts, P. J. (1981b) *Readings in Victorian Prehistory. Volume 2: The Victorian Aboriginals 1800-1860*. Victoria Archaeological Survey. Melbourne.

Coutts, P. J. (1984) *Coastal Archaeology in South-Eastern Victoria*. Ministry for Planning and Environment. Records of the Victoria Archaeological Survey. Occasional Reports Series Number 14. Melbourne.

Coutts, P. J. F., and Cochrane, R. M. (1977) *The Keilor Archaeological Area*. Victoria Archaeological Survey. Government Printer. Melbourne.

Coutts, P. J. F., Frank, R. K., and Hughes, P. (1978) *Aboriginal Engineers of the Western District, Victoria*. Records of the Victorian Archaeological Survey. Number 7. Melbourne.

Coutts, P., and Lorblanchet, M. (1982) *Aboriginals and Rock Art in the Grampians, Victoria, Australia*. Records of the Victoria Archaeological Survey. Number 12. Melbourne.

Coutts, P. J., Witter, D. C., and Parsons, D. (1977) Impact of European Settlement on Aboriginal Society in Western Victoria. *Science*. **8** (6) Pp: 194-205.

Coutts, P. J. F., and Witter, D. C. (1977) *A Guide to Recording Archaeological Sites in Victoria*. Records of the Victorian Archaeological Survey. Number 3. Melbourne.

Cowgill, G. L. (1990) Toward Refining Concepts of Full-Coverage Survey. In Fish, S. K., and Kowalewski, S. A. (Eds.). *The Archaeology of Regions: A Case for Full Coverage Survey*. Pp. 249-259. Smithsonian Institution Press. Washington.

Dalla Bona, L. (1994) *Cultural Heritage Resource Predictive Modelling Project. Volume 1: Introduction to the Research*. Ministry of Natural Resources. Ontario.

Dancey, W. S. (1974) The Archaeological Survey: A Reorientation. *Man in the Northeast*. **8** Pp: 98-112.

Dean, J. S. (1990) Intensive Archaeological Survey of Long House Valley, Northeastern Arizona. In Fish, S. K., and Kowalewski, S. A. (Eds.). *The Archaeology of Regions: A Case for Full Coverage Survey*. Pp. 173-188. Smithsonian Institution Press. Washington.

Department of Infrastructure (2000) *State Planning Policy Framework - Clause 15 'Heritage'*. Department of Infrastructure. Melbourne.

Delicado, P. (1998) Statistics in Archaeology: New Directions. In Barcelò, J., Briz, I., and Vila, A. (Eds.). *New Techniques for Old Times: CAA98*. Pp. 29-37. Archeopress. Oxford.

Dodson, J., Fullagar, R. L. K., and Head, L. (1992) Dynamics of environment and people in the forested crescents of temperate Australia. In Dodson, J. (Ed.) *The Naive Lands: Prehistory and Environmental Change in Australia and the South-West Pacific*. Pp. 115-159. Longman Cheshire. Sydney.

Dortch, C. E. (1996) Prehistory Down Under: archaeological investigations of submerged Aboriginal sites at Lake Jasper, Western Australia. *Antiquity*. **70** Pp: 116-123.

Diamond, J. (1997) *Guns, Germs, and Steel. A short history of everybody for the last 13,000 years*. Jonathan Cape. London.

du Cros, H. (1989) *The Western Region: Melbourne Metropolitan Area. An Archaeological Survey*. Occasional Report No. 27.Victoria Archaeological Survey. Melbourne.

du Cros, H. (1990) *The Sydenham Corridor: A Cultural Heritage Study*. Victoria Archaeological Survey. Occasional Report No. 25. Melbourne.

du Cros, H. (1991) *The Werribee Corridor: An Archaeological Survey*. Aboriginal Affairs Victoria. Occasional Report No. 39. Melbourne.

du Cros, H. (1993) A recent excavation of an inland Aboriginal site near Gisborne, Victoria. *Australian Archaeology*. **37** Pp: 60.

du Cros, H. (1995) *An Archaeological Investigation of Two Archaeologically Sensitive Areas, Jacksons Hill, Sunbury, Victoria*. A report to Collie Planning and Development Services Pty Ltd and the Urban Land Authority. Melbourne.

du Cros, H., and Porch, N. (1996) *An Archaeological Investigation of a Third archaeologically sensitive area, Jacksons Hill, Sunbury, Victoria*. A report to Collie Planning and Development Services Pty Ltd and the Urban Land Authority. Melbourne.

du Cros, H., and Rhodes, D. (1998) *Aboriginal Archaeological Sensitivities study of the Waterways and Floodplains of Greater Melbourne*. A Report to Melbourne Water Corporation. Biosis Research Pty Ltd. Melbourne.

du Cros, H. (2002) Much more than stone and bones: Australian Archaeology in the late twentieth century. Melbourne University Press. Melbourne.

Duncan, J. (1998) *Investigations of the Co-existence of Humans and Megafauna at Keilor, Victoria*. Unpublished B. A. (Hons) Thesis. Department of Archaeology. La Trobe University. Melbourne.

Dunnell, R. C. (1992) The Notion Site. In Rossignol, J., and Wandsnider, L. (Eds.). *Space, Time and Archaeological Landscapes*. Pp. 21-41. Plenum Press. New York.

Dunnell, R. C., and Dancey, W. S. (1983) The Siteless Survey: A regional scale data collection strategy. In Schiffer, M. B. (Ed.) *Advances in Archaeological Method and Theory*. Volume 6 Pp. 267-287. Academic Press. New York

Dunnell, R. C., and Simek, J. F. (1995) Artifact Size and Plow Zone Processes. *Journal of Field Archaeology*. **22** Pp: 305-319.

Eastman, J. R. (2001) *IDRISI32 Release 2: Guide to GIS and Image Processing*. Clark Labs, Clark University. Worcester, MA.

Ebert, J. (1988) Modelling Human Systems and "Predicting" the archaeological record: The unavoidable relationship between Theory and Method. *American Archaeology*. **7** (1) Pp: 3-8.

Ebert, J. (1992) *Distributional Archaeology*. University of New Mexico. Albuquerque.

Ebert, J. (2000) The State of the Art in 'Inductive' Predictive Modelling: Seven Big Mistakes (and lots of smaller ones). In Westcott, K. L., and Brandon, R. J. (Eds.). *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit*. Pp. 129-134. Taylor & Francis. London.

Ecology Australia Pty Ltd (1996) *Woodlands Historic Park Restoration Plan*. A report to the Department of Conservation and Natural Resources. Melbourne.

Egloff, B. (1988) *Deer Park Aboriginal Sites Archaeological Investigations*. Victoria Archaeological Survey. Melbourne.

Ellender, I. (1988) *The Springfield Gorge Burial: A report to the Wurrundjeri Tribe Land and Compensation Cultural Heritage Council Inc*. Victoria Archaeological Survey. Melbourne.

Ellender, I. (1991a) *The City of Doncaster and Templestowe. The archaeological survey of Aboriginal Sites.* Aboriginal Affairs Victoria. Occasional Report No. 43. Melbourne.

Ellender, I. (1991b) *The Plenty Valley Corridor: An Archaeological Survey of Aboriginal Sites.* Occasional Report No. 40.Victoria Archaeological Survey. Melbourne.

Essling, J. (1999) *Analysis of the Lithic Assemblage from Lake Wartook, Gariwerd, Victoria.* Unpublished B. A. (Hons) Thesis. Department of Archaeology. La Trobe University. Melbourne.

Flannery, T. (1994) *The Future Eaters*. Reed. Melbourne.

Flannery, T. F., and Gott, B. (1984) The Spring Creek locality, southwestern Victoria, a late surviving megafaunal assemblage. *Australian Zoologist*. **21** (4) Pp: 385-422.

Flood, J. (1974) Pleistocene Man at Clogg's Cave: His Tool Kit and Environment. *Mankind*. **9** Pp: 175-188.

Flood, J. (1980) *The Moth Hunters: Aboriginal Prehistory of the Australian Alps*. Australian Institute of Aboriginal Studies. Canberra.

Flood, J. (1984) More or less significant: a national perspective on assessing the significance of archaeological sites. In Sullivan, S., and Bowdler, S. (Eds.). *Site surveys and significance assessment in Australian archaeology.* Pp. 55-60. Department of Prehistory, Research School of Pacific Studies. Australian National University. Canberra.

Flood, J. (1988) No Ethnography, No Moth Hunters. In Meehan, B., and Jones, R. (Eds.). *Archaeology with Ethnography: An Australian Perspective*. Pp. 270-276. Australia Institute of Aboriginal Studies. Canberra.

Flood, J. (1989) *Archaeology of the Dreamtime. The story of Prehistoric Australia and its People*. Angus and Robertson. Sydney.

Foley, R. (1981a) A Model of Regional Archaeological Structure. *Proceedings of the Prehistoric Society*. **47** Pp: 1-17.

Foley, R. A. (1978) Incorporating Sampling in to Initial Research Design: Some Aspects of Spatial Archaeology. In Cherry, J. F., Gamble, C., and Shennan, S. (Eds.). *Sampling in Contemporary Archaeology*. Pp. 49-66. BAR. London.

Foley, R. A. (1981b) *Off-Site Archaeology and Human adaptation in Eastern Africa. An analysis of Regional Artefact density in the Ambosele, Southern Kenya*. BAR (International Series) Volume 97. Tempus Repartum, Oxford.

Foley, R. A. (1981c) Off-Site Archaeology: An alternative approach for the short-sited. In Hodder, I., Isaac, G. L., and Hammond, N. (Eds.). *Patterns of the Past: Studies in honour of David Clarke*. Pp. 157-183. Cambridge University Press. Cambridge.

Frankel, D. (1982a) An Account of the Aboriginal use of the Yam Daisy. *The Artefact*. **7** (1-2) Pp: 43-45.

Frankel, D. (1982b) Earth Rings at Sunbury, Victoria. *Archaeology in Oceania*. **17** (2) Pp: 89-97.

Frankel, D. (1988) Characterizing change in prehistoric sequences: a view from Australia. *Archaeology in Oceania*. **23** Pp: 41-48.

Frankel, D. (1991) *Remains to be Seen. Archaeological Insights into Australian Prehistory*. Longman. Melbourne.

Frankel, D. (1995) The Australian transition: real and perceived boundaries. *Antiquity*. **69** Pp: 649-655.

Fullagar, R. L. K. (1986) *Use-wear and residues on stone tools: functional analysis and its application to two southeastern Australian archaeological assemblages.* Unpublished PhD Thesis. Archaeology Department, School of Humanities. La Trobe University. Melbourne.

Fuller, S. L., Rogge, A. E., and Gregonis, L. (1976) *Orme Alternatives: the Archaeological Resources of Roosevelt Lake and Horseshoe Reservoir*. Arizona State Museum Archaeological Series No.98. Arizona State University. Tempe.

Fyfe, M. (2002)*"Melbourne's Green Lungs Fight for Breath"* The Age. Melbourne. Monday June 3rd, 2002. Pp: 1-4.

Gaffney, V., and van Leusen, M. (1995) Postscript - GIS, environmental determinism and archaeology: a parallel text. In Lock, G. R. (Ed.) *Archaeology and Geographical Information Systems: A European Perspective*. Pp. 367-382. Taylor & Francis. London.

Gallant, T. W. (1986) 'Background Noise' and Site Definition: A contribution to Survey Methodology. *Journal of Field Archaeology*. **13** Pp: 403-418.

Gallus, A. (1969) Paleolithic Stratigraphy of the Maribyrnong River Terraces and its Bearings on the Problem of the Presence of Homo Sapiens and Middle Pleistocene Man in Australia. *The Artefact*. **15** Pp: 1-4.

Gallus, A. (1974) A Summary of the results of excavations by the Archaeological Society of Victoria at Keilor (near Melbourne) as per April 1974. *The Artefact*. **33** Pp: 1-9.

Gallus, A. (1976) The Middle and Early Upper Paleolithic Pleistocene Stone Industries at the Dry Creek Archaeological Sites near Keilor, Australia. *The Artefact*. **1** (2) Pp: 75-108.

Gallus, A. (1983) Excavations at Keilor, Victoria. Report No.3. Excavations in the 'D' clay. *The Artefact*. **8** (1-2) Pp: 11-42.

Gaughwin, D. (1981) *Sites of archaeological significance in the Westernport Catchment.* Environmental Studies Series No.367. Ministry for Conservation. Melbourne.

Gellibrand, J. T. (1836) Joseph Tice Gellibrand. Campbell Street [Hobart Town] 18 April 1836. Memorandum of a trip to Port Phillip. In Bride, T. (Ed.) *Letters from Victorian Pioneers Being a series of Papers on the Early Occupation of the Colony, the Aborigines, etc.* Pp. 6-35. William Heinemann. Melbourne.

Gibbon, G. (1998) Archaeological Predictive Modelling: An Overview. In Minnesota Department of Transport (Ed.) *Mn/Model: A Predictive Model of Pre-contact Archaeological Site Location for the State of Minnesota*. Minnesota Department of Transport. St. Paul.

Gill, E. D. (1953) Fluorine Tests in Australia on the Keilor Skull and a tertiary marsupial. *Nature.* **72** Pp: 409-411.

Gill, E. D. (1953b) Fluorine Tests in Australia on the Keilor Skull and a tertiary marsupial. *Nature.* **72** Pp: 409-411.

Gill, E. D. (1954) Notes and News: Keilor Man. *Antiquity*. **28** Pp: 110-113.

Gill, E. D. (1955) The age of Keilor Man. *Anthropos*. **50** (1-3) Pp: 417.

Gill, E. D. (1966) Provenance and age of the Keilor cranium: Oldest known human skeletal remains in Australia. *Current Anthropology*. **7** (5) Pp: 581-584.

Gill, E. D. (1978) Palaeoecological Changes in Victoria and Bass Strait as a Backdrop for the Marsupial Megafauna and Aboriginal Colonization. *The Artefact*. **3** (2) Pp: 67-75.

Gillespie, R., Horton, D. R., Ladd, P. G., Macumber, P. G., Rich, T. H., Thorne, R., and Wright, R. V. S. (1978) Lancefield Swamp and the extinction of the Australian Megafauna. *Science*. **200** Pp: 1044-1048.

Godfrey, M. C. (1989) Shell midden chronology in southwestern Victoria: reflections of change in prehistoric population and subsistence. *Archaeology in Oceania*. **24** Pp: 65-69.

Godfrey, M. C., Bird, C. F. M., Frankel, D., Rhoads, J. W., and Simmons, S. (1996) From time to time: Radiocarbon information on Victorian archaeological sites held by Aboriginal Affairs Victoria. *The Artefact*. **19** Pp: 3-51.

Gott, B. (1982) Ecology of Root Use by the Aborigines of Southern Australia. *Archaeology in Oceania*. (17) Pp: 59-67.

Gott, B. (1983) Murnong - Microseris scapigera: a study of a staple food of Victorian Aborigines. *Australian Aboriginal Studies*. **2** Pp: 2-18.

Gott, B. (1999) Koorie Use and Management of the Plains. In Jones, R. (Ed.) *The Great Plains Crash: Proceedings of a Conference on the Grasslands and Grassy Woodlands of Victoria*. Pp. 41-45. Indigenous Flora and Fauna Association. Victorian Institute of Technology. Melbourne.

Green, E. L. (1973) Location analysis of prehistoric Maya sites in Northern British Honduras. *American Antiquity*. **38** (3) Pp: 279-293.

Gould, R. A. (1977) Ethno-archaeology: or where do models come from? In Wright, R. V. S. (Ed.) *Stone tools as Cultural Markers*. Pp. 162-168. Humanities Press. New Jersey.

Hall, R. (1989) *Merri Creek Parklands: Aboriginal and Historical Heritage Survey*. Report to the Merri Creek Bicentennial Committee. Melbourne.

Hansen, E. (1984) The Whole is Greater Than the Sum of Its Parts: Small-Scale Surveys and Regional-Level Research. *American Archaeology.* **4** (1) Pp: 35-43.

Hasenstab, R. J., and Lacy, D. M. (1984) The Reporting of Small-Scale Survey Results for Research Purposes: Suggestions for Improvement. *American Archaeology*. **4** (1) Pp: 43-49.

Head, L. (1984) *Environment as Artefact: a Palaeoecological contribution to the Prehistory of South Western Victoria*. Unpublished PhD Thesis. Department of Geography. Monash University. Melbourne.

Head, L. (1987) The Holocene Prehistory of a Coastal Wetland System: Discovery Bay, Southeastern Australia. *Human Ecology*. **15** (4) Pp: 435-462.

Head, L. (1989) Using Palaeoecology to date Aboriginal Fish Traps at Lake Condah. *Archaeology in Oceania*. **24** Pp: 110-115.

Higgs, E. S., and Vita-Finzi, C. (1972) Prehistoric Economies: A Territorial Approach. In Higgs, E. S. (Ed.) *Papers in Economic Prehistory*. Pp. 27-36. Cambridge University Press. Cambridge.

Hills, E. S. (1975) *Physiography of Victoria*. Whitcombe & Tombs. Marrickville.

Hiscock, P. (1983) Stone tools as cultural markers?: the last two decades of stone artefact analysis in Australian archaeology. *Australian Archaeology*, no. **16** Pp: 48-56.

Hiscock, P. (1985) The need for a taphonomic perspective in stone artefact analysis. *Queensland Archaeological Research*. **2** Pp: 82-97.

Hiscock, P. (1988) *Prehistoric Settlement Patterns and Artefact Manufacture at Lawn Hill, Northwest Queensland*. Unpublished PhD Thesis. Department of Anthropology and Sociology. University of Queensland. Brisbane.

Hiscock, P. (1993) The end of points. In Sullivan, M., Brockwell, S., and Webb, A. (Eds.). *Archaeology in the North: Proceedings of the 1993 Australian Archaeological Association Conference, North Australia Research Unit (ANU).* Pp. 72-83. Australian National University. North Australia Research Unit. Canberra.

Hiscock, P., and Attenbrow, V. (1998) Early Holocene backed artefacts from Australia. *Archaeology in Oceania*. **33** Pp: 49-62.

Hiscock, P. and Mitchell, S. (1993) *Stone artefact quarries and reduction sites in Australia: Towards a type profile.* Australian Heritage Commission. Australian Government Publishing Service.

Hoffman, C. (1993) Close-interval Core Sampling: Tests of a Method for Predicting Internal Site Structure. *Journal of Field Archaeology*. **20** Pp: 461--473.

Holdaway, S. (1995a) Archaeological Analysis and the role of statistics: A reply to Veth. *Archaeology in Oceania*. **30** Pp: 137-138.

Holdaway, S. (1995b) A review of Islands in the Interior. The Dynamics of Prehistoric Adaptations within the Arid Zone of Australia. *Archaeology in Oceania*. **30** Pp: 43-45.

Holdaway, S. (1995c) Stone artefacts and the Transition. *Antiquity*. **69** Pp: 784-797.

Holdaway, S., and Stern, N. (In Prep.) *Written in Stone: Decoding the Australian Flaked Stone Record*. La Trobe University. Melbourne.

Holdaway, S., and Wandsnider, L. (2001) Desert Swapping vs. Desert Hopping: Long-term Place Use Histories from Interior Desertic Australia and North America. Society of American Archaeology Conference Paper. New Orleans.

Holdaway, S., Witter, D. C., Fanning, P., Musgrave, R., Cochrane, G., Doelman, T., Greenwood, S., Pigdon, D., and Reeves, J. (1998) New approaches to open site spatial archaeology in Sturt National Park, New South Wales, Australia. *Archaeology in Oceania*. **33** Pp: 1-19.

Hope, G. S. (1994) Quaternary Vegetation. In Hill, R. S. (Ed.) *History of the Australian Vegetation: Cretaceous to Recent*. Pp. 368-389. Cambridge University Press. Cambridge.

Horton, D. R. (1976) Lancefield: The Problem of Proof in Bone Analysis. *The Artefact*. **1** (3) Pp: 129-143.

Horton, D. R., and Wright, R. V. S. (1981) Cuts on Lancefield Bones: Carnivorous thylacoleo, not humans, the cause. *Archaeology in Oceania*. **16** Pp: 73-80.

Howell, T. L. (1993) Evaluating the Utility of Auger Testing as a Predictor of Subsurface Artifact Density. *Journal of Field Archaeology*. (20) Pp: 475--484.

Hughes, P. J., and Sullivan, M. E. (1984) Environmental approaches to assessing archaeological significance. In Sullivan, S., and Bowdler, S. (Eds.). *Site Survey and Significance assessment in Australian archaeology.* Proceedings of the 1981 Springwood Conference on Australian Prehistory. Pp. 34-47. Department of Prehistory, Research School of Pacific Studies. Australian National University.

Hutchet, B. M. J. (1990) *Modelling and Australian Prehistory*. Unpublished B.A. (Hons) Thesis. Department of Archaeology and Palaeoanthropology. University of New England. Armidale.

Hutchet, B. M. J. (1991) Theories and Australian Prehistory: The Last Three Decades. *Australian Archaeology*. **33** Pp: 44-51.

Hutchet, B. M. J. (1993) Modelling and Australian Prehistory. *Australian Archaeology*. **36** Pp: 12-16.

Isaac, G. (1989) Small is Informative: The application of the study of mini-sites and the least effort criteria in the interpretation of the Early Pleistocene archaeological record at Koobi Fora, Kenya. In Isaac, G. (Ed.) *The Archaeology of Human Origins*. Pp. 258-268. Cambridge University Press. New York.

Isaac, G. L., and Harris, J. W. K. (1975) *The Scatter Between the Patches*. Paper Presented to the Kroeber Society, Berkeley. May 1975.

Jeffery, P. J. (1981) *A Study of the Land in the Catchments to the North of Melbourne*. Soil Conservation Authority. Melbourne.

Johnson, H., and Witter, D. (1996) *Cultural Resources Database for the Murray. Summary Report of Stage III*. A Report to the Murray Darling Basin Commission. New South Wales National Parks and Wildlife Service.

Jones, G. T., and Beck, C. (1992) Chronological Resolution in Distributional Archaeology. In Rossignol, J., and Wandsnider, L. (Eds.). *Space, Time and Archaeological Landscapes*. Pp. 167-192. Plenum Press. New York.

Jones, R. (1968) The Geographical Background to the Arrival of Man in Australia and Tasmania. *Archaeology and Physical Anthropology in Oceania*. **3** Pp: 186-215.

Jones, R. (1977) Man as an element of a continental fauna: the case of the sundering of the Bassian bridge. In Allen, J., Golson, J., and Jones, R. (Eds.). *Sunda and Sahul. Prehistoric Studies in Southeast Asia, Melanesia, and Australia*. Pp. 317-386. Academic Press. London.

Jones, R. N. (1995) *Modelling hydrologic and climatic controls of closed lakes, Western Victoria.* Unpublished PhD Thesis. University of Melbourne. Melbourne.

Jones, R. N. (1999) Natural and Human Influences on the Distribution and Extent of Victorian Lowland Grasslands. In Jones, R. (Ed.) *The Great Plains Crash: Proceedings of a Conference on the Grasslands and Grassy Woodlands of Victoria*. Pp. 19-39. Indigenous Flora and Fauna Association. Victorian Institute of Technology. Melbourne.

Joyce, E. B., and Anderson, J. R. (1976) Late Quaternary geology and environment at the Dry Creek Archaeological Sites near Keilor, Australia. *The Artefact*. **1** (2) Pp: 47-74.

Judge, W. J., Ebert, J., and Hitchcock, R. K. (1975) Sampling in Regional Archaeological Survey. In Mueller, J. W. (Ed.) *Sampling in Archaeology*. Pp. 82-123. The University of Arizona Press. Tucson.

Kamermans, H., and Rensink, E. (1999) GIS in Paleolithic Archaeology: A Case Study from the Netherlands. In Dingwall, L. (Ed.) *Computer Applications and Quantitative Methods in Archaeology*. "Archaeology in the age of the Internet: Proceedings of the 25th Anniversary Conference", University of Birmingham, April 1997. Archeopress. Oxford.

Kamminga, J. (1982) *Over the Edge: Functional analysis of Australian Stone Tools.* Occasional Papers in Anthropology. University of Queensland. St Lucia.

Keble, R. A., and Macpherson, J. H. (1946) The Contemporaneity of the River Terraces of the Maribyrnong River, Victoria with those of the Upper Pleistocene in Europe. *Memoirs of the National Museum*. **14** Pp: 52-63.

Kershaw, A. P. (1995) Environmental Change in Greater Australia. *Antiquity*. **69** Pp: 656-675.

Kintigh, K. W. (1988) The Effectiveness of Sub-Surface Testing: A Simulation Approach. *American Antiquity*. **53** (4) Pp: 686-707.

Kintigh, K. W. (1990) Comments on the case for Full-Coverage Survey. In Fish, S. K., and Kowalewski, S. A. (Eds.). *The Archaeology of Regions: A Case for Full Coverage Survey*. Pp. 237-242. Smithsonian Institution Press. Washington.

Kirk, R. L. (1981) *Aboriginal Man Adapting*. Oxford University Press. Oxford.

Kohler, T. A. (1988) Predictive Locational Modelling: History and Current Practice. In Judge, J. W., and Sebastian, L. (Eds.). *Quantifying the Present and Predicting the Past: Theory, Method and Application of Archaeological Predictive Modelling.* Pp. 19-60. U.S. Department of the Interior, Bureau of Land Management. Denver, Colorado.

Krakker, J. J., Shott, M., and Welch, P. D. (1983) Design and Evaluation of Shovel-Test Sampling in Regional Archaeological Survey. *Journal of Field Archaeology*. **10** Pp: 469-480.

Kvamme, K. (1988a) Development and Testing of Quantitative Models. In Judge, J. W., and Sebastian, L. (Eds.). *Quantifying the Present and Predicting the Past: Theory, Method and Application of Archaeological Predictive Modelling*. U.S. Department of the Interior, Bureau of Land Management. Denver, Colorado.

Kvamme, K. (1988b) Using existing Archaeological survey data for model building. In Judge, J. W., and Sebastian, L. (Eds.). *Quantifying the Present and Predicting the Past: Theory, Method and Application of Archaeological Predictive Modelling*. U.S. Department of the Interior, Bureau of Land Management. Denver, Colorado.

Ladd, P. G. (1976) Past and Present Vegetation of the Lancefield Area, Victoria. *The Artefact*. **1** (3) Pp: 113-127.

Lake, M. W., Woodman, P. E., and Mithen, S. J. (1998) Tailoring GIS software for archaeological applications: an example concerning viewshed analysis. *Journal of Archaeological Science*. **25** (1) Pp: 27-38.

Land Conservation Council (1985) Report on the Melbourne Area District 1 - Review. Land Conservation Council. Melbourne.

Lane, S., and Sciusco, L. (1996) *Keilor Park Drive Archaeological Survey and Subsurface Testing.* A report to Russell Kennedy and Melbourne Parks and Waterways. Melbourne.

Langford, R. F. (1983) Our Heritage - Your Playground. *Australian Archaeology*. **16** Pp: 1-6.

Learmonth, T. (1853) Thomas Learmonth, Buninyong (Yarrowee River, adjoining Buninyong), 11 August, 1853. In Bride, T. F. (Ed.) *Letters from Victorian Pioneers Being a series of Papers on the Early Occupation of the Colony, the Aborigines, etc*. William Heinemann. Melbourne.

Lewis, A., MacNeill, R., and Rhoads, J. (1996) *East Gippsland Aboriginal Cultural Site Modelling.* Department of Conservation and Natural Resources, Aboriginal Affairs Victoria, and Centre for Resource and Environmental Studies, ANU. Melbourne.

Lightfoot, K. G. (1986) Regional Surveys in the Eastern United States: The strengths and weaknesses of implementing subsurface testing programs. *American Antiquity*. **51** (3) Pp: 484-504.

Lightfoot, K. G. (1989) A Defence of Shovel-test Sampling: A Reply to Shott. *American Antiquity*. **54** (2) Pp: 413-416.

Llewelyn-Davies Kinhill Pty Ltd. (1975) Maribyrnong River Catchment Preliminary Environmental Study. Melbourne Metropolitan Board of Works. Melbourne.

Lourandos, H. (1976) Aboriginal Settlement and Land Use in South Western Victoria: A Report on Current Fieldwork. *The Artefact*. **4** Pp: 174-193.

Lourandos, H. (1977) Aboriginal Spatial Organization and Population: South Western Victoria Reconsidered. *Archaeology and Physical Anthropology in Oceania*. **12** (3) Pp: 202-225.

Lourandos, H. (1980) Change or Stability? Hydraulics, hunter-gatherers and population in temperate Australia. *World Archaeology*. **2** (3) Pp: 245-264.

Lourandos, H. (1983) Intensification: a Late Pleistocene-Holocene archaeological sequence from Southwestern Australia. *Archaeology in Oceania*. **18** Pp: 81-97.

Lourandos, H. (1997) *Continent of Hunter-Gatherers. New Perspectives in Australian Prehistory*. Cambridge University Press. Cambridge.

Lovis, W. A. (1976) Quarter Sections and Forests: An example of Probability Sampling in the Northeastern Woodlands. *American Antiquity*. **41** (3) Pp: 364-372.

Lunt, I. D. (1998) Two Hundred Years of Land-use and Vegetation change in a Remnant Coastal Woodland in Southern Australia. *Australian Journal of Botany*. **46** Pp: 629-647.

Lynch, B. M. (1980) Site artifact density and the effectiveness of shovel probes. *Current Anthropology*. **21** (4) Pp: 516-517.

Mahony, D. J. (1943) The Problem of Antiquity of Man in Australia. *Memoirs of the National Museum*. **13** Pp: 7-56.

Marquis-Kyle, P., and Walker, M. (1992) *The Illustrated Burra Charter*. Australia ICOMOS. Sydney.

Marshall, B. (1996a) *Archaeological Investigations (Subsurface) along the proposed route for Sections 2 and 3 of the Northbourne Branch Sewer at Campbellfield.* A report to Melbourne Water. Melbourne.

Marshall, B. (1996b) *An Archaeological Survey of the Proposed Bolobek Residential Subdivision at Mount Macedon*. A report to Tomkinson Surveyors and Engineers. Melbourne.

Marshall, B., and Wines, D. (1998) *An Aboriginal Artefact Scatter (AAV Site No 7722-234) At St Thomas's Roman Catholic Church , Steiglitz Historic Park*. A Report to the Wathaurong Aboriginal Community, Aboriginal Affairs Victoria Heritage Services Branch, Parks Victoria, and the Steiglitz Historic Park Friends Group. Melbourne.

Marshall, L. G. (1974) Late Pleistocene mammals from the 'Keilor Cranium Site', southern Victoria, Australia. *Memoirs of the National Museum of Victoria*. **30** Pp: 59-77.

Matson, R. G., and Lipe, W. D. (1975) Regional Sampling: A Case Study of Cedar Mesa, Utah. In Mueller, J. W. (Ed.) *Sampling in Archaeology*. Pp. 124-143. The University of Arizona Press. Tucson.

MacNeill, R. (1998) *GIS on the Brink: GIS Applications at Aboriginal Affairs Victoria*. Paper presented at AURISA '98 - the 26th Annual Conference of AURISA. Perth, Western Australia, November 1998.

McBryde, I. (1978) Wil-im-ee Moor-ring': Or, Where do axes come from? *Mankind*. **11** Pp: 354-382.

McBryde, I. (1979) Petrology and Prehistory: Lithic Evidence for exploitation of Stone Resources and Exchange Systems in Australia. In Clough, T., and Cummins, W. (Eds.). *Stone Axe Studies*. Pp. 113-124. CBA. London.

McBryde, I. (1984a) Exchange in Southeastern Australia: an ethnohistorical perspective. *Aboriginal History*. **8** Pp: 132-153.

McBryde, I. (1984b) Kulin greenstone quarries: the social contexts of production and distribution for the Mt William site. *World Archaeology*. **16** (2) Pp: 267-285.

McBryde, I., and Harrison, G. (1981) Valued Goods or Valuable Stone? In Leach, F., and Davidson, J. (Eds.). *Archaeological Studies of Pacific Stone Resources*. Pp. 183-208. BAR Monograph. Oxford.

McBryde, I., and Watchman, A. (1976) The Distribution of Greenstone Axes in Southeastern Australia: A Preliminary Report. *Mankind*. **10** Pp: 163-174.

McConnell, A. (1995) *Archaeology Potential Zoning: A strategy for the Protection of Aboriginal Archaeological Sites in Tasmanian State Forests*. Final report. Forestry Tasmania. Hobart.

McConnell, A. (2002) *Aboriginal Heritage Management in Victorian Forests*. Draft Project Report Volume 2. Central Highlands Region. Department of Natural Resources and Environment. Melbourne.

McDonald, J. (1996) The Conservation of Landscapes: A Strategic Approach to Cultural Heritage Management. In Ulm, S., Lilley, I., and Ross, A. (Eds.) *Australian Archaeology: Proceedings of the 1995 Australian Archaeological Association Conference*. Pp. 113-121. University of Queensland. St Lucia.

McManamon, F. P. (1984) Discovering Sites Unseen. In Schiffer, M. (Ed.) *Advances in Archaeological Method and Theory*. Pp. 223-292. Academic Press. Orlando.

McNiven, I. J. (1998) Aboriginal settlement of the saline lake and volcanic landscapes of Corangamite Basin, western Victoria. *The Artefact*. **21** Pp: 63-94.

McNiven, I., Marshall, B., Allen, J., Stern, N., and Cosgrove, R. (1993) The Southern Forests Archaeological Project: An Overview. In Smith, M. A., Spriggs, M., and Fankhauser, B. (Eds.). *Sahul in Review: Pleistocene Archaeology in Australia, New Guinea and Island Melanesia*. Pp. 213-224. Department of Prehistory, RSPS, Australian National University. Canberra.

Melbourne and Metropolitan Board of Works (1984) *Maribyrnong River Plan 1984*. Melbourne Metropolitan Board of Works, Melbourne.

Moon, H. (1993) *Archaeological Predictive Modelling: An Assessment*. Resources Inventory Committee, British Columbia. Victoria.

Morwood, M. J., and L'Oste Brown, S. (1995) Chronological changes in stone artefact technology. In Morwood, M. J. (Ed.) *Quinkan prehistory: the archaeology of Aboriginal art in SE Cape York Peninsula*. Pp. 161-177. Tempus. St Lucia.

Mulvaney, D. J. (1964) Prehistory of the Basalt Plains. *Proceedings of the Royal Society of Victoria*. **77** Pp: 427-432.

Mulvaney, D. J. (1970) Green Gully Revisited: The Later Excavations. *Memoirs of the National Museum of Victoria*. **30** Pp: 59-71.

Mulvaney, D. J., and Kamminga, J. (1999) *Prehistory of Australia*. Allen and Unwin. Sydney.

Munro, M. (1997) *Analysis of Stone Material from the Keilor Site*. Unpublished M.A. (Prel.). Thesis. School of Archaeology. La Trobe University. Melbourne.

Munro, M. (1998) The stone artefact assemblage from Keilor. *The Artefact*. **21** Pp: 19-34.

Murray, T. (1996) Contact Archaeology: Shared Histories? Shared Identities? In Hunt, S., and Lydon, J. (Eds.). *Nailing the debate: Interpretation in Museums*. Pp. 199-213. Historic Houses Trust of NSW. Sydney.

Murray, T., and Walker, M. J. (1988) Like WHAT? A Practical Question of Analogical Inference and Archaeological Meaningfulness. *Journal of Anthropological Archaeology*. **7** Pp: 248-287.

Nance, J. D. (1981) Statistical Fact and Archaeological Faith: Two Models in Small-Sites Sampling. *Journal of Field Archaeology*. **8** Pp: 151--165.

Nance, J. D., and Ball, B. F. (1986) No Surprises? The reliability and validity of test pit sampling. *American Antiquity*. **51** (3) Pp: 457-483.

Nance, J. D., and Ball, B. F. (1989) A Shot in the Dark: Shott's comments on Nance and Ball. *American Antiquity*. **54** (2) Pp: 405-412.

Natural Resources and Environment (1996) *Flora Information Systems database of Victorian Plant distribution records.* Department of Natural Resources and Environment. Melbourne.

Natural Resources and Environment (1997) *Atlas of Victorian Wildlife*. Department of Conservation and Natural Resources. Melbourne.

Neuman, W. L. (1997) *Social Research Methods: Qualitative and Quantitative Approaches*. Allyn and Bacon. Boston.

Nicholson, B. A. (1983) A Comparative Evaluation of Four Sampling Techniques and of the Reliability of Microdebitage as a Cultural Indicator in Regional Surveys. *Plains Anthropologist*. **28** Pp: 273-281.

Nicholson, O. (1998) Sub-surface testing at the former CSIRO land, Maribyrnong. A report to John Chivers and Associates. Melbourne.

O'Connell, J. F., and Allen, J. (1995) Human Reactions to the Pleistocene-Holocene transition in Greater Australia: A Summary. *Antiquity*. **69** Pp: 855-862.

Orchiston, D. W., Miller, R. N., and Glenie, R. C. (1977) A history of Nineteenth Century investigations at the Lancefield Megafaunal Site. *The Artefact*. **2** (3) Pp: 105-122.

Orton, C. (2000) *Sampling in Archaeology*. Cambridge Manuals in Archaeology. Cambridge University Press. Cambridge.

Ossa, P., Marshall, B., and Webb, C. (1995) New Guinea II Cave: a Pleistocene site on the Snowy River, Victoria. *Archaeology in Oceania*. **30** (1) Pp: 22-35.

Packard, P. (1991) *Sites and Sampling in the South East Forests. Research Design, Sampling Methodologies and Sample Selection for a proposed Site Survey Report*. New South Wales National Parks and Wildlife Service and the Forestry Commission of New South Wales. Sydney.

Pardoe, C., and Martin, S. (2001) *Murrumbidgee Province Aboriginal Cultural Heritage Study*. A report to New South Wales National Parks and Wildlife Service. Griffith.

Parks Victoria (1997) *Brisbane Ranges National Park Management Plan.* Parks Victoria. Melbourne.

Parks Victoria (1998a) *Organ Pipes National Park Management Plan*. Parks Victoria. Melbourne.

Parks Victoria (1998b) *Woodlands Historic Park Management Plan*. Parks Victoria. Melbourne.

Peterson, N. (1971) Open Sites and the Ethnographic Approach to the Archaeology of Hunter-Gatherers. In Mulvaney, D. J., and Golson, J. (Eds.). *Aboriginal Man and Environment in Australia*. Pp. 239-248. Australian National University Press. Canberra.

Peterson, N. (1973) Camp site location amongst Australian hunter-gatherers: archaeological and ethnographic evidence for a key determinant. *Archaeology and physical anthropology in Oceania*. **8** (3) Pp: 173-193.

Plog, F. (1990) Some thoughts on Full-Coverage Surveys. In Fish, S. K., and Kowalewski, S. A. (Eds.). The Archaeology of Regions: A Case for Full Coverage Survey. Pp. 243-248. Smithsonian Institution Press. Washington.

Planning and Environment Act (Vic) 1987

Plog, F., and Hill, J. (1971) Explaining Variability in the Distribution of Sites. In Gummerman, G. J. (Ed.) *The Distribution of Prehistoric Population Aggregates*. Prescott College Anthropological Papers. Prescott, Arizona.

Plog, S. (1976) Relative Efficiencies of sampling techniques for archaeological surveys. In Flannery, K. V. (Ed.) *The Early Mesoamerican Village*. Pp. 136 -158. Academic Press. New York.

Plog, S., Plog, F., and Wait, W. (1978) Decision Making in Modern Survey. In Schiffer, M. B. (Ed.) *Advances in Archaeological Method and Theory*. Pp. 383-420. Academic Press. New York

Presland, G. (1983) *An archaeological survey of the Melbourne Metropolitan area*. Victoria Archaeological Survey. Melbourne.

Presland, G. (1994) *Aboriginal Melbourne: The Lost Land of the Kulin People*. McPhee Gribble Publishers. Melbourne.

Read, D. W. (1975) Regional Sampling. In Mueller, J. W. (Ed.) *Sampling in Archaeology*. Pp. 45-60. The University of Arizona Press. Tucson.

Read, D. W. (1986) Sampling Procedures for Regional Surveys: a Problem of Representativeness and Effectiveness. *Journal of Field Archaeology*. **13** Pp: 477-491.

Redman, C. L. (1987) Surface Collection, Sampling, and Research Design: A Retrospective. *American Antiquity*. **52** (2) Pp: 249-265.

Rhoads, J. (1986) *Bellarine Peninsula: Archaeological Site Assessment and Management Study*. University of Sydney. Sydney.

Rhoads, J. W. (1992) Significant sites and non-site archaeology: a case study from southeast Australia. *World Archaeology*. **24** Pp: 198-217.

Rhoads, J. W., and Bird, C. F. M. (2000) An Archaeological Survey of the Southwest Wimmera. A report to Aboriginal Affairs Victoria. Melbourne.

Rhodes, D. (1990) *City of Keilor Archaeological Survey*. Report to the Western Region Commission Inc. City of Keilor, Melbourne, Victoria.

Rhodes, D., and Murphy, A. (1994) Report on Archaeological Survey and Sub-Surface Testing at the BHP Property, Mickleham Road, A report to Tract Consultants nd BHP. Greenvale. Melbourne.

Richards, T. (1998) *A Predictive Model of Aboriginal Site Distribution in the Otway Range*. Aboriginal Affairs Victoria. Occasional Report No.49. Melbourne.

Richards, T., and Jordan, J. (1996) Aboriginal Archaeological Investigations in the Barwon Drainage Basin. Aboriginal Affairs Victoria. Melbourne.

Richards, T., and Sutherland, P. (1995) Surface and Sub-surface archaeological survey of the proposed Wildwood Road Soil removal project near Deep Creek, Bulla. A report to David J, Allan and Associates. Melbourne.

Rindos, D. (1989) Diversity, Variation and Selection. In Leonard, R. D., and Jones, G. T. (Eds.). *Quantifying Diversity in Archaeology*. Pp. 13-23. Cambridge University Press. London.Cowgill, G. L. (1990) Toward Refining Concepts of Full-Coverage Survey. In Fish, S. K., and Kowalewski, S. A. (Eds.). *The Archaeology of Regions: A Case for Full Coverage Survey.* Pp. 249-259. Smithsonian Institution Press. Washington.

Ebert, J. (2000) The State of the Art in 'Inductive' Predictive Modelling: Seven Big Mistakes (and lots of smaller ones). In Westcott, K. L., and Brandon, R. J. (Eds.). *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit.* Pp. 129-134. Taylor & Francis. London.

Gallant, T. W. (1986) 'Background Noise' and Site Definition: A contribution to Survey Methodology. *Journal of Field Archaeology.* **13** Pp: 403-418.

Hansen, E. (1984) The Whole is Greater Than the Sum of Its Parts:Small-Scale Surveys and Regional-Level Research. *American Archaeology.* **4** (1) Pp: 35-43.

Hasenstab, R. J., and Lacy, D. M. (1984) The Reporting of Small-Scale Survey Results for Research Purposes: Suggestions for Improvement. *American Archaeology.* **4** (1) Pp: 43-49.

Nance, J. D. (1981) Statistical Fact and Archaeological Faith: Two Models in Small-Sites Sampling. *Journal of Field Archaeology.* **8** Pp: 151--165.

Plog, S. (1976) Relative Efficiencies of sampling techniques for archaeological surveys. In Flannery, K. V. (Ed.) *The Early Mesoamerican Village.* Pp. 136 -158. Academic Press. New York.

Roberts, R. G., Flannery, T. F., Ayliffe, L. K., Yoshida, H., Olley, J. M., Prideaux, G. J., Laslett, G. M., Baynes, A., Smith, M. A., Jones, R., and Smith, B. L. (2001) New Ages for the Last Australian Megafauna: Continent-Wide Extinction About 46,000 Years Ago. *Science.* **292** Pp: 1888-92.

Tunn, J. (1997) *Pleistocene Landscapes of Brimbank Park, Keilor, Victoria.* Unpublished B.A. (Hons) Thesis. School of Archaeology. La Trobe. Melbourne.

Wandsnider, L., and Camilli, E. L. (1992) The Character of Surface Archaeological Deposits and its Influence on Survey Accuracy. *Journal of Field Archaeology.* **19** Pp: 169-188.

Whalen, M. E. (1990) Sampling Versus Full-Coverage Survey: An Example from Western Texas. In Fish, S. K., and Kowalewski, S. A. (Eds.). *The Archaeology of Regions: A Case for Full Coverage Survey.* Pp. 219-236. Smithsonian Institution Press. Washington.

Zubrow, E. (1984) Small Scale Surveys: A Problem for Quality Control. *American Archaeology.* **4** (1) Pp: 16-27.

Robins, R. (1997) Patterns in the Landscape: A Case Study in Nonsite Archaeology from Southwest Queensland. *Memoirs of the Queensland Museum, Cultural Heritage Series*. **1** (1) Pp: 23-56.

Roper, D. C. (1979) The Method and Theory of Site Catchment Analysis: A Review. In Schiffer, M. B. (Ed.) *Advances in Archaeological Method and Theory*. Pp. 119-140. Academic Press. New York.

Rosengren, N. (1999) Geology and Geomorphology of Victoria's Grassland Regions. In Jones, R. N. (Ed.) *The Great Plains Crash: Proceedings of a Conference on the Grasslands and Grassy Woodlands of Victoria*. Pp. 7-10. Indigenous Flora and Fauna Association. Victorian Institute of Technology. Melbourne

Ross, A. (1981) Holocene environments and prehistoric site patterning in the Victorian Mallee. *Archaeology in Oceania*. **16** Pp: 145-154.

Ross, A. (1985) Archaeological Evidence for population change in the middle to late Holocene in southeastern Australia. *Archaeology in Oceania*. **20** Pp: 81-89.

Ross, A. (1986) Aboriginal Archaeology in South Eastern Australia. In Ross, A. (Ed.) *Planning For Aboriginal Site Management*. New South Wales National Parks and Wildlife Service. Sydney.

Rowan, J. (1990) *Land Systems of Victoria.* Land Conservation Council and The Department of Conservation and Natural Resources, Melbourne.

Rowland, M. J. (1983) Aborigines and environment in Holocene Australia: Changing Paradigms. *Australian Aboriginal Studies*. **2** Pp: 62-77.

Rowland, M. J. (1989) Population increase, intensification or a result of preservation? Explaining site distribution patterns on the coast of Queensland. *Australian Aboriginal Studies*. (2) Pp: 32-42.

Rowley-Conwy, P. (2001) Time, Change and the Archaeology of hunter-gatherers: how original is the 'Original Affluent Society'? In Panter-Brick, C., Layton, R. H., and Rowley-Conwy, P. (Eds.). *Hunter-Gatherers. An Interdisciplinary Perspective*. Pp. 39-72. Cambridge University Press. Cambridge.

Royal Automobile Club of Victoria (Inc.), and VicRoads (2000) *VicRoads Country Street Directory of Victoria*. Royal Automobile Club of Victoria (Inc.). Melbourne.

Ruggles, C. L. N., and Medyckyi-Scott, D. J. (1996) Site Location, Landscape, and Symbolic Astronomy: A Scottish Case Study. In Maschner, H. (Ed.) *New Methods, Old Problems: Geographic Information Systems in Modern Archaeological Research*. Occasional Paper No. 23. Pp. 127-146. Center for Archaeological Investigations, Southern Illinois University. Carbondale.

Schell, P. (1994) *An Archaeological survey of the Brisbane Ranges*. A report to the Wathaurong Co-operative Ltd. Aboriginal Affairs Victoria. Melbourne.

Schiffer, M. B., and Wells, S. J. (1982) Archaeological Surveys: Past and Future. In Schiffer, M. B. (Ed.) *Hohokam and Patayan: Prehistory of Southwestern Arizona*. Pp. 345-383. Academic Press. New York.

Shaw, A. G. L. (1996) *A History of the Port Phillip District: Victoria before Separation*. The Miegunyah Press. Melbourne.

Shennan, S. (1997) *Quantifying Archaeology*. Edinburgh University Press. Edinburgh.

Shott, M. (1985) Shovel-Test Sampling as a Site Discovery Technique: a Case Study from Michigan. *Journal of Field Archaeology*. **12** Pp: 457-468.

Shott, M. (1989) Shovel-Test Sampling in Archaeological Survey: Comments on Nance and Ball, and Lightfoot. *American Antiquity*. **54** (2) Pp: 396-404.

Shott, M. (1995) Reliability of Archaeological Records on Cultivated Surfaces: A Michigan Case Study. *Journal of Field Archaeology*. **22** Pp: 475-490.

Sim, R. (1990) Prehistoric sites on King Island in the Bass Strait: Results of an Archaeological Survey. *Australian Archaeology*. (31) Pp: 34-43.

Simmons, S., and Djekic, A. (1981) *Alcoa Portland Aluminum Smelter Supplementary Archaeological Survey*. Environmental Studies Report Number 2. Victoria Archaeological Survey. Melbourne.

Simmons, S., and Ossa, P. (1978) *Interim Report on the Keilor Excavation - May 1978*. Records of the Victoria Archaeological Survey No. 8. Ministry Of Conservation. Melbourne.

Smith, A. (1995a) *Archaeological Survey Methods for Forested Environments Supplementary Study: the Post-Operational Survey*. A report to Forestry Tasmania and the Australian Heritage Commission. Australian Heritage Commission. Canberra.

Smith, A. (1995b) *Archaeological Survey Methods for Forested Environments: an Assessment*. A report to Forestry Tasmania and the Australian Heritage Commission. Australian Heritage Commission. Canberra.

Smith, J. M. B. (1986) Biogeography of Australian Flora and Fauna. In Recher, H., Lunney, D., and Dunn, I. (Eds.). *A Natural Legacy: Ecology in Australia*. Pp. 14-30. Maxwell Macmillan. Sydney.

Smith, L. (1991) Berwick-Pakenham Corridor: The Archaeological Survey of Aboriginal Sites. Victoria Archaeological Survey and the Victorian Ministry of Planning and Environment. Melbourne.

Smith, L. (1993) Site Classifications and definitions of Representativeness in Australian Cultural Resource Management. In Anon (Ed.) *Representativeness and Aboriginal Archaeological Sites: Report of the Representativeness Workshop held by the Australian Heritage Commission.* Pp. 25-33. Australian Heritage Commission. Canberra.

Society for Growing Australian Plants (1995) *Plants of Melbourne's Western Plains: A Gardner's guide to the original flora*. Society for Growing Australian Plants. Melbourne.

Spennemann, D. H. R. (1995) *Site Visibility and Site Survey Bias in Cultural Resource Management: A preliminary Analysis of the 1993 survey reports held by Aboriginal Affairs Victoria*. Charles Sturt University. Johnstone Centre for Parks, Recreation and Heritage. Report No.19. Albury.

Spennemann, D. H. R. (2000) *Cultural Heritage Legislation in the Republic of the Marshall Islands. Regulations Governing the Conduct of Archaeological and Anthropological Research in The Republic*. Internet Resource located at: http://marshall.csu.edu.au/html/RMILAW/Reg_Research.html

Stein, J. K. (1986) Coring Archaeological Sites. *American Antiquity*. **51** (3) Pp: 505-527.

Steward, J. (1938) *Basin-plateau aboriginal socio-political groups*. Bureau of American Ethnology Bulletin 120. Washington, D.C.

Stone, G. D. (1981) On artifact density and shovel probes. *Current Anthropology*. **22** (2) Pp: 182-183.

Sturt, E. P. S. (1853) Evelyn Pitfield Stirling Sturt, Lonsdale Street, 20 October, 1853. In Bride, T. (Ed.) *Letters from Victorian Pioneers Being a series of Papers on the Early Occupation of the Colony, the Aborigines, etc*. William Heinemann. Melbourne.

Sullivan, H. (1981) An Archaeological survey of the Mornington Peninsula, Victoria. Victorian Archaeological Survey and the Victorian Ministry of Conservation. Occasional Report Series No.6. Melbourne.

Sullivan, H. (1984) Mornington Peninsula Archaeological Survey. In Sullivan, H., and Bowdler, S. (Eds.). *Site Survey and Significance Assessment in Australian Archaeology*. Proceedings of the 1981 Springwood Conference on Australian Prehistory. Pp. 119-126. Department of Prehistory, Research School of Pacific Studies. Australian National University. Canberra.

Sullivan, S., and Bowdler, S. (1984) *Site Survey and Significance Assessment in Australian Archaeology*. Proceedings of the 1981 Springwood Conference on Australian Prehistory. Department of Prehistory, Research School of Pacific Studies, Australian National University. Canberra.

Sundstrom, L. (1993) A Simple Mathematical Procedure for Estimating the Adequacy of Site Survey Strategies. *Journal of Field Archaeology*. **20** Pp: 91--96.

Sutherland, P., and Richards, T. (1994) Shire of Bulla Aboriginal Archaeological Study. A report to the Shire of Bulla. Shire of Bulla. Melbourne.

Sutton, C. S. (1916) A Sketch of the Keilor Plains Flora. *Victorian Naturalist*. **33** Pp: 112-123.

Tainter, J. A., and Lucas, G. J. (1983) Epistemology of the significance concept. *American Antiquity*. **48** (4) Pp: 707-719.

Thomas, D. H. (1972) A Computer Simulation Model of Great Basin Shoshonean Settlement Patterns. In Clarke, D. L. (Ed.) *Models in Archaeology*. Pp. 671-704. Methuen. London.

Thomas, D. H. (1975) Nonsite Sampling in Archaeology: Up the Creek without a Site. In Mueller, J. W. (Ed.) *Sampling in Archaeology*. Pp. 61-81. The University of Arizona Press. Tucson.

Thomas, D. H. (1978) The Awful Truth about Statistics in Archaeology. *American Antiquity*. **43** (2) Pp: 231-244.

Thomas, W. (1854) Brief Account of the Aborigines of Australia Felix. In Bride, T. (Ed.) (1969) *Letters from Victorian Pioneers Being a series of Papers on the Early Occupation of the Colony, the Aborigines, etc*. Pp. 397-437. William Heinemann. Melbourne.

Thorne, A. G. (1977) Separation or Reconciliation? Biological clues to the development of Australian Society. In Allen, J., Golson, J., and Jones, R. (Eds.). *Sunda and Sahul. Prehistoric Studies in Southeast Asia, Melanesia, and Australia*. Pp. 187-204. Academic Press. London.

Thorne, A. G. (1980) The Longest Link: Human Evolution in Southeast Asia and the Settlement of Australia. In Fox, J. J., Garnaut, R. C., McCawley, P. F., et al. (Eds.). *Indonesia: Australian Perspectives*. Pp. 35-44. Research School of Pacific Studies, A.N.U. Canberra.

Thorne, A. G., and Macumber, P. G. (1972) Discoveries of Late Pleistocene Man at Kow Swamp, Australia. *Nature*. **238** (5363) Pp: 316-319.

Trigger, B. (1982) Ethnoarchaeology: Some Cautionary Considerations. In Tooker, E. (Ed.) *Ethnography by Archaeologists*. Proceedings of the American Ethnological Society, 1978. Pp. 1-17. American Ethnological Society. Washington, DC.

Trigger, B. (1989) *A History of Archaeological Thought*. Cambridge University Press. Cambridge.

Tunn, J. (1997) *Pleistocene Landscapes of Brimbank Park, Keilor, Victoria*. Unpublished B.A. (Hons) Thesis. School of Archaeology. La Trobe. Melbourne.

Tunn, J. (1998) Pleistocene Landscapes of Brimbank Park, Keilor, Victoria. *The Artefact*. **21** Pp: 35-47.

Van de Velde, P. (2001) An Extensive Alternative to Intensive Survey: Point Sampling in the Riu Mannu Survey Project, Sardinia. *Journal of Mediterranean Archaeology*. **14** (1) Pp: 24-52.

van Leusen, M. (2002) *Pattern to Process: Methodological Investigations into the formation and Interpretation of Spatial Patterns in Archaeological Landscapes*. Unpublished PhD Thesis. Groningen Institute for Archaeology. University of Groningen. Groningen, The Netherlands.

Van Waarden, N. (1986) *An Archaeological Survey of the You Yangs, Victoria*. Ministry for Planning and Environment. Victoria Archaeological Survey Occasional Reports Series Number 23. Melbourne.

Veth, P. (1993) *Islands in the interior. The Dynamics of Prehistoric Adaptations within the Arid Zone of Australia*. Archaeological Series 3. International Monographs in Prehistory. Ann Arbor.

Vinnicombe, P. (1984) Single Sites or Site Complexes: A case study from the north of the Hawkesbury River. In Sullivan, S., and Bowdler, S. (Eds.). *Site Survey and Significance Assessment in Australian Archaeology*. proceedings of the 1981 Springwood Conference on Australian Prehistory. Pp: 107-118. Department of Prehistory, Research School for Pacific Studies, Australian National University. Canberra.

Vita-Finzi, C., and Higgs, E. S. (1970) Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis. In Coles, J. (Ed.) *Proceedings of the Prehistoric Society*. Pp. 1-37.

Wandsnider, L., and Camilli, E. L. (1992) The Character of Surface Archaeological Deposits and its Influence on Survey Accuracy. *Journal of Field Archaeology*. **19** Pp: 169-188.

Warren, R. (1990a) Predictive Modelling in Archaeology: A Primer. In Allen, K. M., Green, S. W., and Zubrow, E. B. W. (Eds.). *Interpreting space: GIS and Archaeology*. Pp. 90-111. Taylor & Francis. London ; New York.

Warren, R. (1990b) Predictive Modelling of archaeological site location: A case study in the Midwest. In Allen, K., Green, S., and Zubrow, E. (Eds.). *Interpreting Space: GIS and Archaeology*. Pp. 201-215. Taylor and Francis. London.

Warren, R. E., and Asch, D. L. (2000) A Predictive Model of Archaeological Site Location in the Eastern Prairie Peninsula. In Wescott, K. L., and Brandon, R. J. (Eds.). *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit*. Pp. 5-32. Taylor & Francis. London.

Wasson, R. J., and Donnelly, T. H. (1991) *Palaeoclimatic Reconstructions for the Last 30,000 Years in Australia - A contribution to prediction of future climate*. CSIRO Division of Water Resources, Canberra.

Wasson, R. J., Fleming, P. M., and Donnelly, T. H. (1991) *Palaeoclimatic of Australia at 6000 years BP*. CSIRO Division of Water Resources, Canberra.

Weaver, F. (1991) The Moonee Ponds Creek Archaeological Survey. A report to The Board of Works, Department of Planning and Housing. Melbourne.

Webb, C. (1995) The Identification and Documentation of Silcrete Quarries. Aboriginal Affairs Division of the Victorian Department of Health and Community Services. Melbourne.

Westcott, K. L. (2000) Introduction. In Wescott, K. L., and Brandon, R. J. (Eds.). *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit*. Pp. 1-4. Taylor & Francis. London.

Westcott, K. L., and Kuiper, J. (2000) Using a GIS to Model Prehistoric Site Distributions in the Upper Chesapeake Bay. In Wescott, K. L., and Brandon, R. J. (Eds.). *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit*. Pp. 59-72. Taylor & Francis. London.

Whalen, M. E. (1990) Sampling Versus Full-Coverage Survey: An Example from Western Texas. In Fish, S. K., and Kowalewski, S. A. (Eds.). *The Archaeology of Regions: A Case for Full Coverage Survey*. Pp. 219-236. Smithsonian Institution Press. Washington.

Wheatley, D. (1996) The use of GIS to Understand Regional Variation in Earlier Neolithic Wessex. In Maschner, H. (Ed.) *New Methods, Old Problems: Geographic Information Systems in Modern Archaeological Research*. Occasional Paper No. 23. Pp. 75-103. Centre for Archaeological Investigations, Southern Illinois University. Carbondale.

Wheatley, D. (In Press) *Making Space for an Archaeology of Place*. University of Southampton. Pp: 1-24.

Whitehouse, R. (1983) *The MacMillan Dictionary of Archaeology*. MacMillan Press. London.

Williams, E. (1984) Documentation and Archaeological Investigation of an Aboriginal 'Village' Site in South Western Victoria. *Aboriginal History*. **8** (2) Pp: 173-188.

Williams, E. (1987) Complex Hunter-Gatherers: A view from Australia. *Antiquity*. **61** Pp: 310-321.

Winter, T. (1837) Letter from Hobart. In Bride, T. F. (Ed.) (1969) *Letters from Victorian Pioneers Being a series of Papers on the Early Occupation of the Colony, the Aborigines, etc.* William Heinemann. Melbourne.

Witter, D. C. (1977) Survey Methods and Victorian Archaeology. In Coutts, P. J. (Ed.) *Records of the Victoria Archaeological Survey No.1*. Pp. 80-102. Ministry for Conservation. Melbourne.

Winterhalder, B. (2000) Models. In Terrell, J. E. (Ed.) *Darwin and Archaeology: A Handbook of Key Concepts*. Pp. 201-223. Bergin & Garvey Publishers. Westport, Connecticut.

Winterhalder, B. (2001) The behavioral ecology of hunter-gatherers. In Rowley-Conwy, P. (Ed.) *Hunter-Gatherers. An Interdisciplinary Perspective*. Pp. 13-38. Cambridge University Press. Cambridge.

Witter, D. C. (1984) Providing a Regional context for Management Archaeology. In Sullivan, S., and Bowdler, S. (Eds.). *Site Survey and Significance Assessment in Australian Archaeology*. Proceedings of the 1981 Springwood Conference on Australian Prehistory. Pp. 48-54. Department of Prehistory, Research School of Pacific Studies. Australian National University. Canberra.

Witter, D. (1992) *Regions and Resources*. Unpublished PhD Thesis. Department of Prehistory. Australian National University. Canberra.

Witter, D. C., and Simmons, S. (1978) *The Keilor Excavations: First Season 1977/78*. Records of the Victoria Archaeological Survey 8. Ministry Of Conservation. Melbourne.

Wobst, M. (1978) The Archaeo-Ethnology of Hunter-Gatherers or the Tyranny of the ethnographic record in Archaeology. *American Antiquity*. **43** Pp: 303-309.

Woodman, P. E., and Woodward, M. (2002) The use and abuse of statistical methods in archaeological site location modelling. In Wheatley, D. (Ed.) *Contemporary Themes in Archaeological Computing*. Pp. 22-27. Oxbow. Oxford.

Wright, R. V. S. (1970) Flaked Stone Material from GGW-1. *Memoirs of the National Museum of Victoria*. **30** Pp: 79-92.

Wright, R. V. S. (1977) *Stone tools as Cultural Markers: Change, Evolution and Complexity*. Prehistory and Material Culture Series No.12. Australian Institute of Aboriginal Studies. Canberra.

Wroe, S., and Field, J. (2001) Mystery of Megafaunal Extinctions Remains. *Australasian Science*. **22** (8) Pp: 21-25.

Wunderly, J. (1943) The Keilor Fossil Skull: Anatomical Description. *Memoirs of the National Museum.* **13** Pp: 57-70.

Xiberras, A. (1991) An archaeological survey of the Organ Pipes National Park. A report to the Victoria Archaeological Survey. Melbourne.

Zubrow, E. (1990) Modelling and Prediction with Geographic Information Systems: A demographic example from prehistoric and historic New York. In Allen, K., Green, S., and Zubrow, E. (Eds.). *Interpreting Space: GIS and Archaeology*. Pp. 307-317. Taylor & Francis. London.

8.1. Personal Communications

Cusack, J (2002) Registrar, Aboriginal Affairs Victoria.

Simmons, S (2000) Senior Archaeologist, Aboriginal Affairs Victoria.

Appendices

9. Appendices

9.1. Fieldwork Results from each locale.

This section outlines the artefact data collected from each of the four survey areas. This data is summarised and presented as a regional data set in Chapter 5.

Brisbane Ranges National Park (BRNP)

The first session of fieldwork resulted in the location and recording of 3,503 artefacts and one scarred tree.

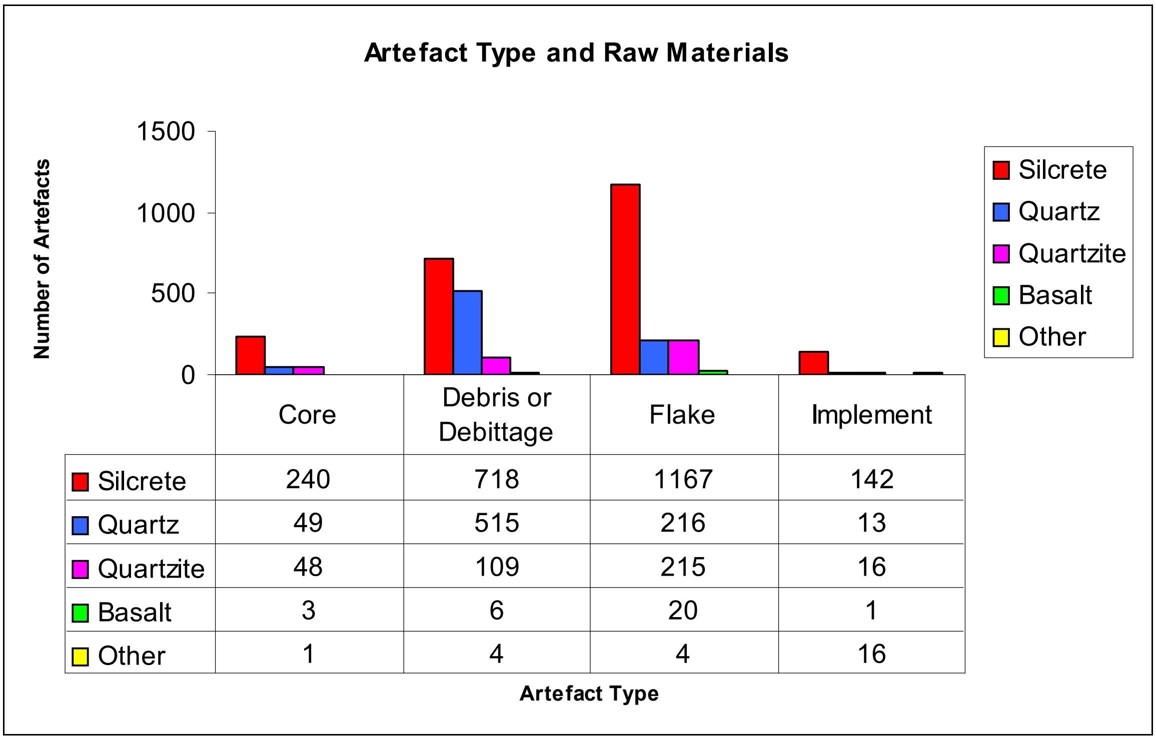


Figure 9-1: Artefact types and Raw materials -BRNP.

Artefact Type	N	%	Basalt	Silcrete	Other	Quartz	Quartzite
Debris or Débitage	1,352	38.60	6	718	4	515	109
Core	341	9.73	3	240	1	49	48
Flake	1,622	46.30	20	1,167	4	216	215
Implement	188	5.37	1	142	16	13	16
Total	3,503		30	2,267	25	793	388
(% of Total)			(0.85)	(64.71)	(0.71)	(22.63)	(11.07)

Table 9-1: Percentages of each type of artefact class and raw material - BRNP.

Silcrete flakes are the dominant item recorded at BRNP, representing 33.31% of all material recorded.

During the BRNP survey, 341 cores were recorded. The dominant raw material was silcrete (70.4%), followed by quartz (14.4%) and quartzite (14.1%).

Raw Material	N	%	Class 1	Class 2	Class 3	Class 4	Class 5
Silcrete	240	70.38	48	167	23	0	2
Basalt	3	0.88	0	2	1	0	0
Quartz	49	14.37	8	33	5	2	1
Quartzite	48	14.08	3	31	12	2	0
Other	1	0.29	0	1	0	0	0
Totals	341		59	234	41	4	3
(% of Totals)			(17.3)	(68.6)	(12.0%)	(1.2)	(0.9)

Table 9-2: Core raw material and size classes - BRNP.

Class 2 silcrete cores are the dominant item here, representing 48.97% of the total number of cores recorded.

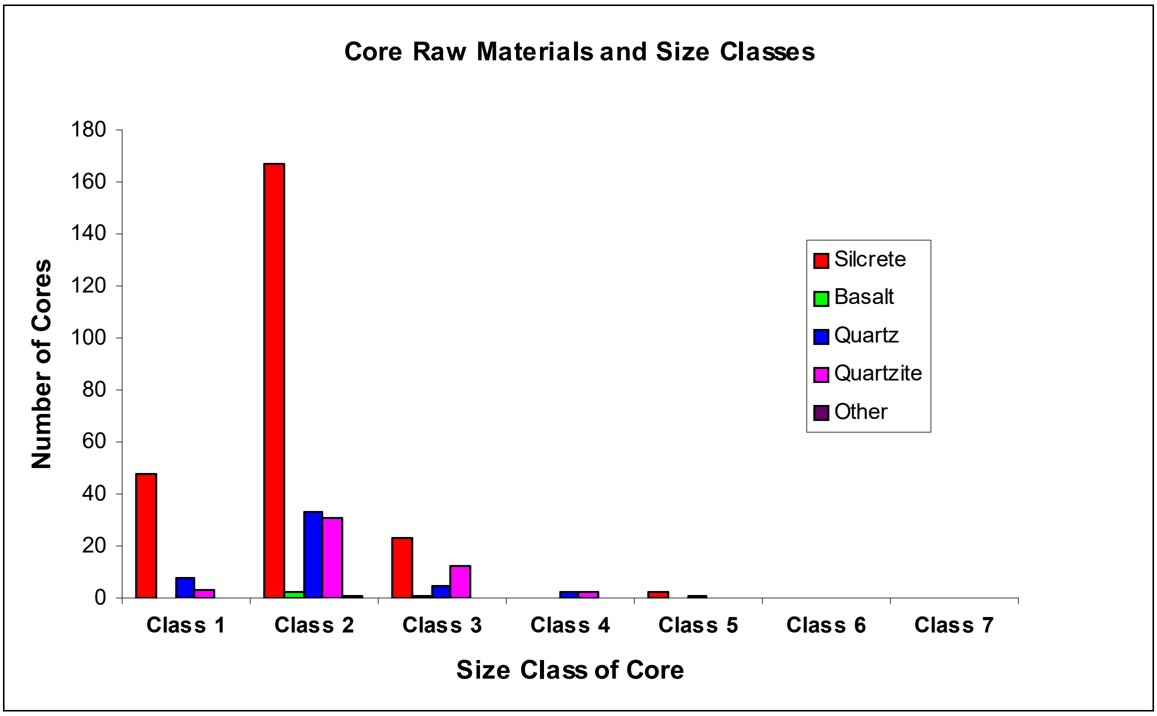


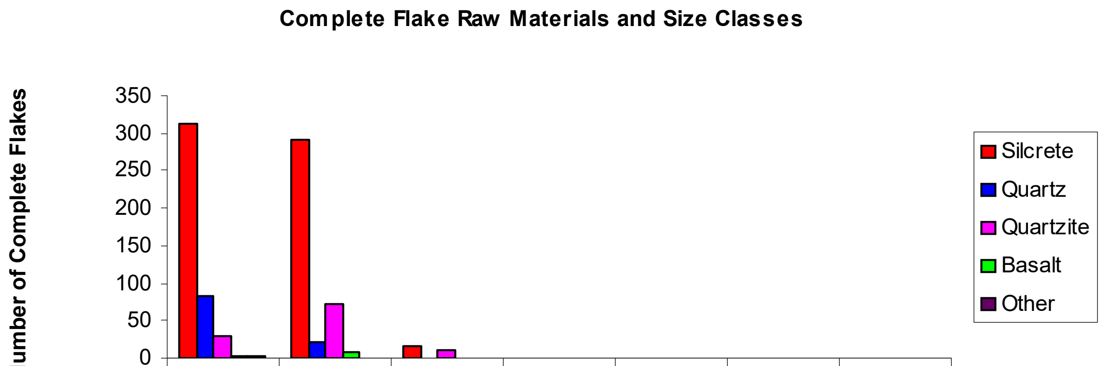
Figure 9-2: Core raw materials and number of cores per size class - BRNP.

The majority of cores of all raw materials fall in the Class 2 size category (68.6%), while 17.3% fall in Class 1, and 12.0% fall in Class 3. Only seven cores are larger than Class 3. There was no cortex present on 76.8% of cores at BRNP.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=341	262	10	12	2	18	5	11	3	8	0	5	1	0	0	2	0	2	0	0	0	0

Table 9-3: Cores Percentage of Cortex - BRNP

1,622-flaked pieces were recorded in the BRNP session. This category is further divided into either complete flakes (n=846) or broken flakes (n= 776).



	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Silcrete	313	290	16	0	0	0	0
Quartz	82	21	1	0	0	0	0
Quartzite	29	71	10	0	0	0	0
Basalt	4	7	0	0	0	0	0
Other	2	0	0	0	0	0	0

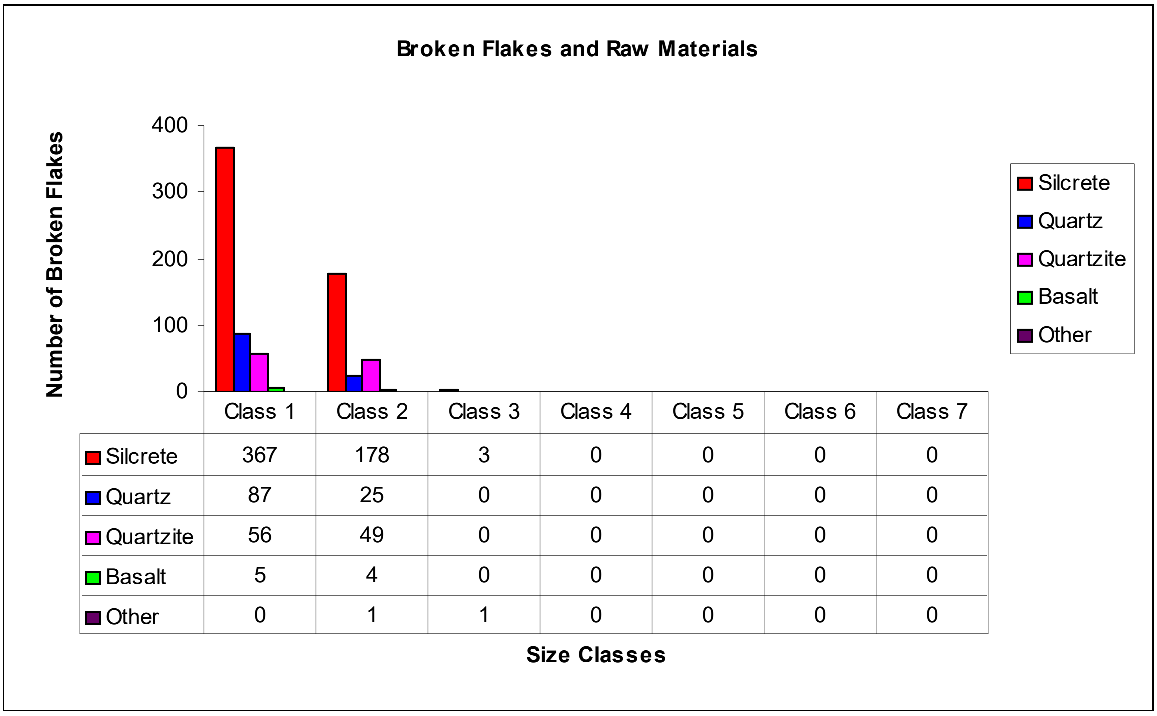
Figure 9-3: Complete Flake raw material and size classes - BRNP.

Silcrete is the most common raw material in the complete flake category of artefacts (73.2%), followed by Quartzite (13.0%) and Quartz (12.3%). Basalt and Other account for 1.5% cumulatively. Of the 846 complete flakes recorded, 15 showed evidence of secondary retouch (14 = silcrete, 1= quartz). The majority (93%) of complete flakes exhibited no cortex (n=787). 50.8% of Complete Flakes were size class 1, 45.9% size class 2, and only 3.1% were larger than size class 2.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=846	787	10	15	4	11	6	3	1	2	1	4	0	1	0	0	0	2	0	1	0	0

Table 9-4: Complete Flake Percentage of cortex - BRNP.

Of the 1,622-flaked pieces recorded, some 776 of these were broken pieces.



	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Silcrete	367	178	3	0	0	0	0
Quartz	87	25	0	0	0	0	0
Quartzite	56	49	0	0	0	0	0
Basalt	5	4	0	0	0	0	0
Other	0	1	1	0	0	0	0

Figure 9-4: Broken Flake size classes and raw materials – BRNP

Eight (1%) of the broken flaked pieces showed evidence of secondary retouch, while the overwhelming majority of the these broken flaked pieces did not display any cortex (94.4%). 66.4% of broken flakes were size class 1, 33.1% size class 2, and 0.5% size class 3.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=776	733	6	11	0	8	5	1	0	4	0	8	0	0	0	0	0	0	0	0	0	0

Table 9-5: Broken Flaked Pieces Cortex - BRNP.

There was a variety of implements located during this stage of the survey. Of the 3,503 artefacts identified, 188 (5.37%) of them have been classified as implements. Each class of implement will be analysed separately below.

Implement	N	%
Blade	93	49.4
Scraper	34	18.1
Backed Piece	27	14.4
Thumbnail Scraper	9	4.8
Hammer stone	7	3.7
Geometric Microlith	6	3.2
Grindstone	6	3.2
Other	6	3.2
Total	188	100

Table 9-6: Implements - BRNP.

1. Blades

Raw Material	N	%	Class 1	Class 2	Class 3	Class 4
Silcrete	83	89.25	65	17	0	1
Quartz	3	3.23	3	0	0	0
Quartzite	7	7.53	5	1	1	0
Total	93		73	18	1	1
(% of Total)			(78.5)	(19.4)	(1.1)	(1.1)

Table 9-7: Blade raw materials and size classes - BRNP.

Of the 93 blades recorded, silcrete was the most common raw material (89.3%). The majority of blades were also quite small, with 78.5% of blades being size class 1. Three of the blades were retouched, while none displayed any cortex.

2. Geometric Microlith

Raw Material	N	%	Class 1	Class 2
Silcrete	6	100	5	1
Total	6		5	1
(% of Total)			(83.3)	(16.7)

Table 9-8: Geometric Microliths raw materials and size class - BRNP.

A small number of geometric microliths was recorded (n=6). These six artefacts displayed no retouch or cortex.

3. Backed Pieces

Raw Material	N	%	Class 1	Class 2
Silcrete	23	85.19	18	5
Basalt	1	3.70	0	1
Quartzite	3	11.11	1	2
Total	27		19	8
(% of Total)			(70.4)	(29.6)

Table 9-9: Backed Pieces raw materials and size classes - BRNP.

Silcrete (85.19%) was again the dominant raw material in the backed pieces class of artefacts. All of these pieces were retouched, and none exhibited any cortex.

4. Scrapers and Thumbnail Scrapers.

Raw Material	N	%	Class 1	Class 2	Class 3	Class 4	Class 5
Silcrete	27	62.79	13	12	1	1	0
Quartz	10	23.26	9	1	0	0	0
Quartzite	5	11.63	1	3	1	0	0
Other	1	2.33	0	0	0	0	1
Total	43		23	16	2	1	1
(% of Total)			(53.5)	(37.2)	(4.7)	(2.3)	(2.3)

Table 9-10: Scrapers and Thumbnail scrapers raw materials and size classes - BRNP.

Silcrete (62.8%) again dominates as the most common raw material in the scrapers and thumbnail scrapers categories. Thirty-one of the scrapers showed evidence of retouch, while 6.9% displayed cortex.

5. Hammer Stones

Raw Material	N	%	Class 2	Class 3	Class 4
Quartzite	1	14.29	0	1	0
Other	6	85.71	4	1	1
Total	7		4	2	1
(% of Total)			(57.1)	(28.6)	(14.3)

Table 9-11: Hammer stone raw materials and size classes - BRNP.

The raw material class ‘other’ is the most common material on which hammer stones were manufactured. The class ‘other’ was used when the recorders were unsure of the exact type of stone material being observed. All hammer stones displayed cortex.

6. Grindstones

Raw Material	N	%	Class 3	Class 4	Class 5
Other	6	100.00	1	3	2
Total	6		1	3	2
(% of Total)			(16.7)	(50.0)	(33.4)

Table 9-12: Grinding Stones raw materials and size classes - BRNP.

These larger pieces had to display evidence of grinding to be classed as grinding stones. The evidence had to be either concave or convex smoothing on one or more surfaces not consistent with the normal polishing caused by water movement. Only six pieces were recorded during the BRNP survey, but all exhibited sufficient use polishing to classify each as a grindstone. All grindstones displayed cortex.

7. Other

Raw Material	N	%	Class 1	Class 2	Class 3	Class 4	Class 5
Silcrete	3	50.00	1	1	1	0	0
Other	3	50.00	1	0	2	0	1
Total	6		2	0	3	0	1
(% of Total)			(33.4)	(0)	(50)	(0)	(16.7)

Table 9-13: Other artefact raw materials and size classes - BRNP.

The category of ‘other’ is essentially those pieces that were either misreported in the field, or were erroneously entered into the database. These items did however exist as individual artefacts as the log files from the differential GPS attached a unique identification number to each recorded item. Therefore, they are not duplicate items, however nothing more can be determined about them. This represents a more than acceptable data-loss rate of 0.2% (6 of 3,503).

Raw Material	N	%	Class 1	Class 2	Class 3	Class 4
Silcrete	718	53.10	501	200	17	0
Quartz	515	38.09	369	139	7	0
Quartzite	109	8.06	57	48	3	1
Basalt	6	0.59	3	3	0	0
Other	4	0.29	2	2	0	0
Total	1,352		932	392	27	1
(% of Total)			(68.9)	(28.9)	(1.9)	(0.1)

Table 9-14: Debris or débitage raw materials and size classes - BRNP.

Silcrete is the most common raw material (53.1%) in the debris or débitage category. The majority (68.9%) of pieces are small (class 1), and do not display any cortex (91.7%). Quartz (38.1%) is also well represented in the debris or débitage category.

Silcrete dominates the BRNP assemblage, accounting for almost two-thirds (64.7%) of all the artefacts located. The assemblage is characterised by small too very small artefacts (96.4% are Size Class 1or Size Class 2), made on silcrete (64.7%), Quartz (22.6%), or Quartzite (11.1%). Although a range of artefact types was found during the survey, there were only a very small proportion (5.4%) of identifiable formal tools in the assemblage. The remainder of the assemblage consisted of flakes, broken flakes, cores, or flaking debris.

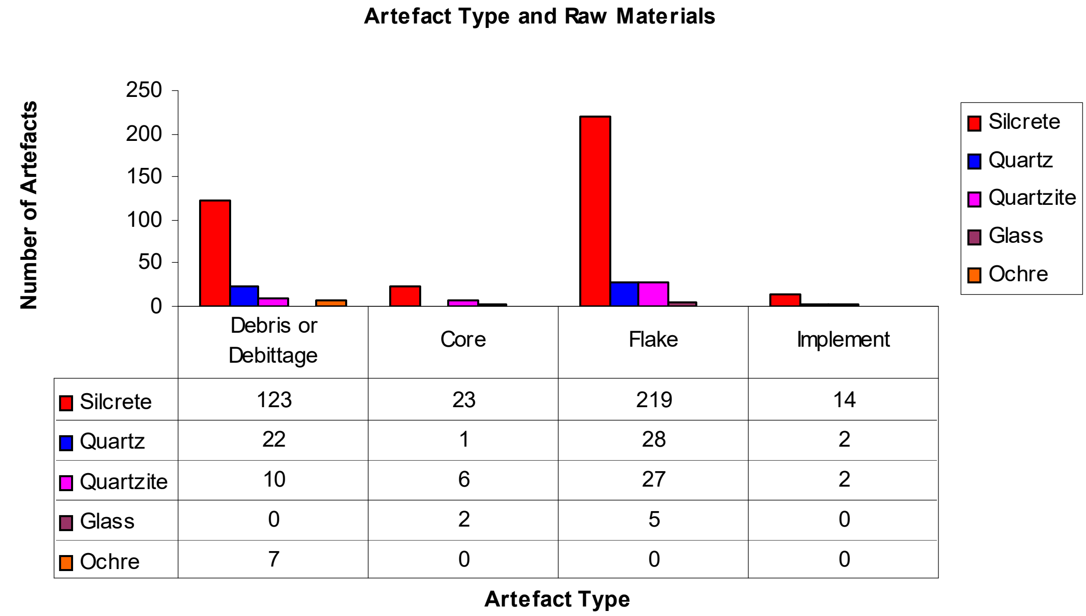
Size Class	Basalt	Silcrete	Other	Quartz	Quartzite	Total
1	12	1,331	4	558	154	2,059
2	17	871	8	219	203	1,318
3	1	61	4	13	28	107
4	0	2	4	2	3	11
5	0	2	5	1	0	8
Total	30	2,267	25	793	388	3,503
(% of Total)	(0.86)	(64.7)	(0.7)	(22.6)	(11.1)	(100)

Table 9-15: Size Classes of all artefacts and raw materials - BRNP.

Of the 3,503 artefacts recorded, 91.2% displayed no cortex, indicating a relatively heavily reduced assemblage.

Deep Creek

The second fieldwork session conducted at various locations along the Deep Creek resulted in the recording of 497 items of Aboriginal cultural material – 491 artefacts, one isolated hearth and five scarred trees. Visibility was extremely limited throughout the majority of the Deep Creek survey areas.



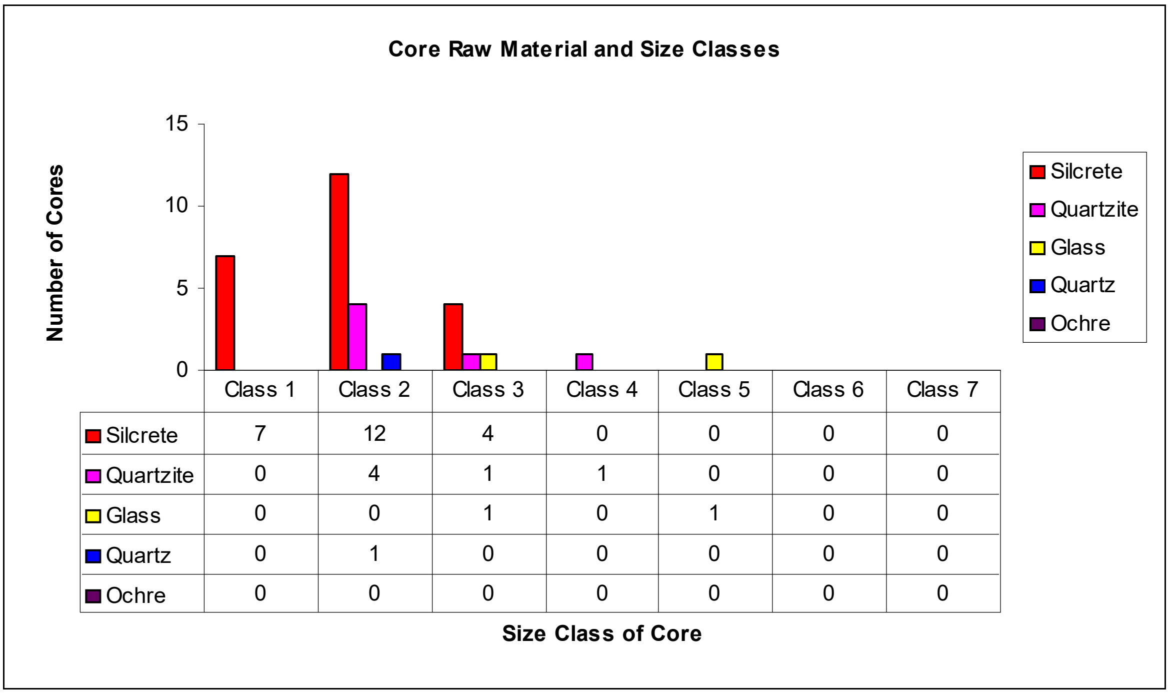
	Debris or Debittage	Core	Flake	Implement
Silcrete	123	23	219	14
Quartz	22	1	28	2
Quartzite	10	6	27	2
Glass	0	2	5	0
Ochre	7	0	0	0

Figure 9-5: Artefact types and raw materials - Deep Creek.

Artefact Type	N	%	Silcrete	Quartz	Quartzite	Glass	Ochre
Debris or débitage	161	32.79	123	22	10	0	7
Core	32	6.52	23	1	6	2	0
Flake	279	56.82	219	28	27	5	0
Implement	18	3.67	14	2	2	0	0
Total	491		379	53	45	7	7
(% of total)			(77.2)	(10.8)	(9.2)	(1.4)	(1.4)

Table 9-16: Percentage of each type of artefact and raw material recorded - Deep Creek.

A total of 32 cores were recorded. Of these, 71.88% were silcrete, while 18.75% were quartzite, 6.25% glass, and 3.13% quartz.



	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Silcrete	7	12	4	0	0	0	0
Quartzite	0	4	1	1	0	0	0
Glass	0	0	1	0	1	0	0
Quartz	0	1	0	0	0	0	0
Ochre	0	0	0	0	0	0	0

Figure 9-6: Core raw materials and cores per size - Deep Creek.

Silcrete Class 2 Cores are most numerous (37.5%), while 68.7% of cores displayed no cortex.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=32	22	0	0	2	0	1	2	0	4	0	0	0	0	0	1	0	0	0	0	0	0

Table 9-17: Core Percentage of cortex - Deep Creek.

276-flaked pieces were recorded during the Deep Creek section of the survey. This has been further divided into complete flakes (n=31) or broken flakes (n=242).

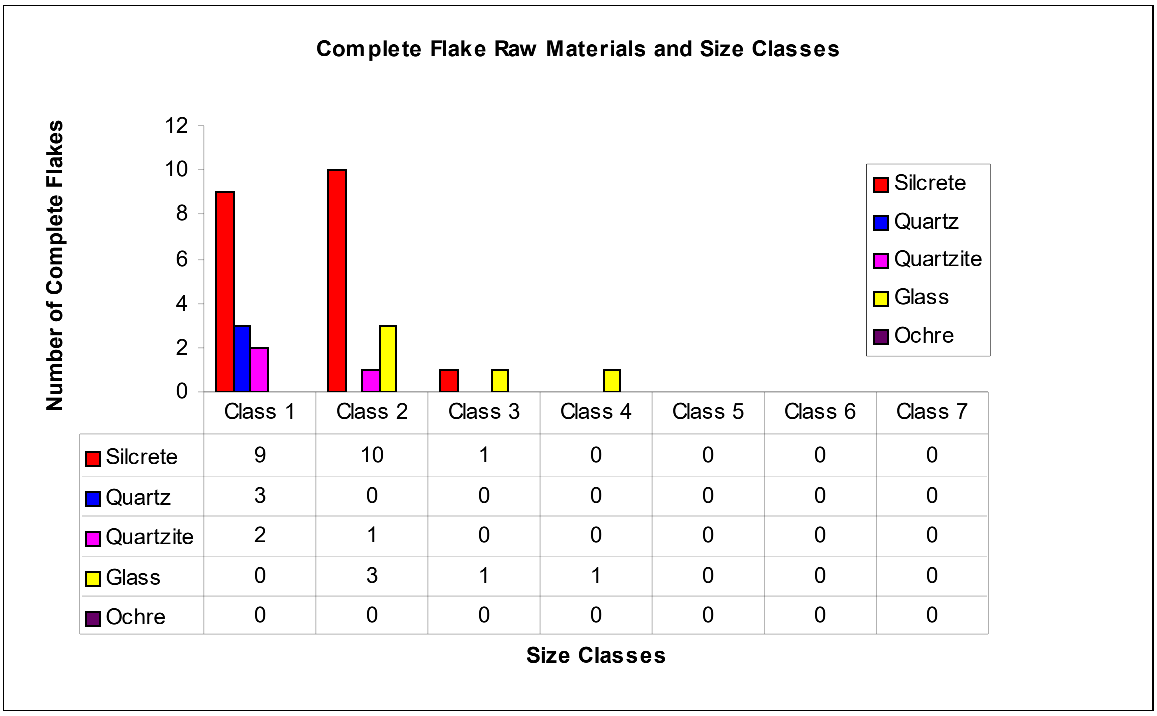


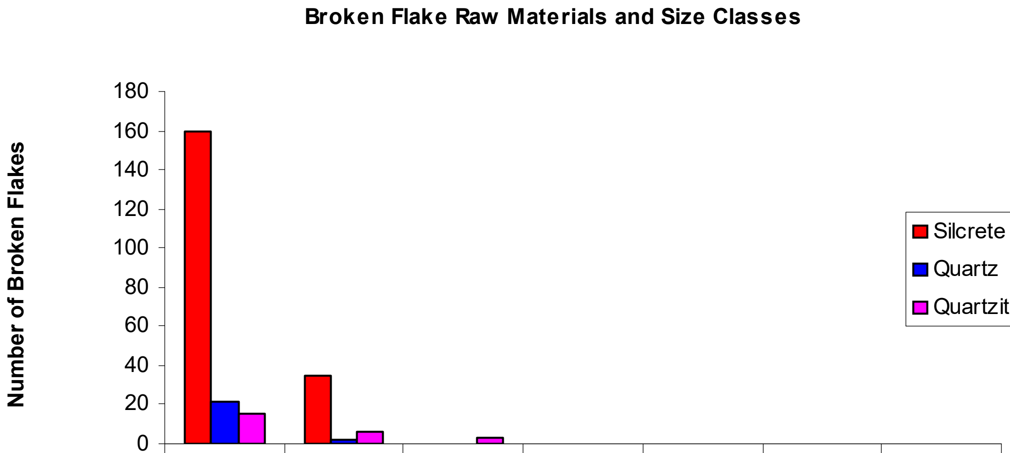
Figure 9-7: Complete Flakes raw material and size classes – Deep Creek.

Silcrete is the most common raw material (65.0%) for complete flakes, while glass (16.2%), quartz (9.7%) and quartzite (9.7%) are also represented. 87.1% of complete flakes displayed no cortex.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=31	27	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Table 9-18: Complete Flake Percentage of Cortex - Deep Creek.

242 broken flakes were recorded during the Deep Creek survey.



	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Silcrete	160	35	0	0	0	0	0
Quartz	21	2	0	0	0	0	0
Quartzite	15	6	3	0	0	0	0

Figure 9-8: Broken flake raw materials and size classes - Deep Creek.

Silcrete is the most common raw material for broken flakes (80.6%), followed by quartzite (9.9%) and quartz (9.5%). 81% of all broken flakes are size class one, while only 1.2% was larger than size class 2. 95.4% of broken flakes displayed no cortex.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=242	231	2	3	1	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0

Table 9-19: Broken Flake Percentage of cortex - Deep Creek.

Twenty-two formal tools were identified during the Deep Creek survey.

Artefact Type	N	Silcrete	Quartz	Quartzite
Blade	1	0	1	0
Geometric Microlith	2	2	0	0
Scraper	14	11	1	2
Backed Piece	4	4	0	0
Other	1	0	1	0
Total	22	17	3	2
(% of Total)		(77.3)	(13.6)	(9.1)

Table 9-20: Formal Tools - Deep Creek.

Artefact Type	N	Class 1	Class 2
Blade	1	1	0
Geometric Microlith	2	2	0
Other	1	1	0
Scraper	14	7	7
Backed Piece	4	3	1
Total	22	14	8
(% of Total)		(63.6)	36.4)

Table 9-21: Size Classes of formal tools - Deep Creek.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=22	20	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 9-22: Formal Tools Percentage of cortex - Deep Creek.

90.9% of all implements displayed no cortex, while 63.6% were size class 1.

Debris or waste constitutes approximately 33.2% of the assemblage (n=163).

Raw Material	N	Class 1	Class 2	Class 3
Silcrete	124	117	7	0
Quartz	23	21	2	0
Quartzite	10	7	3	0
Ochre	6	1	3	2
Total	163	146	15	2
(% of Total)		(89.6)	(9.2)	(1.2)

Table 9-23: Debris and size classes - Deep Creek.

89.6% of the debris recorded displayed no cortex, and 89.6% of the debris was size class 1. The significantly lower quantity of material located during the Deep Creek survey session can be attributed almost entirely to (a) the extremely poor visibility in those areas were some cultural material was expected to be located, and (b) the overall spatial patterning of Aboriginal archaeological sites which favours the river and creek systems where visibility was poorest. On the large expanses of ploughed plains surveyed, virtually no cultural material was located. As Figure 8-13 (below) shows, only 2 artefacts were located at any distance away from the permanent water supply of Deep Creek. The two artefacts are located in the lower left-hand corner of Figure 8-13. These two artefacts were size class 2 silcrete cores, located over 500 metres apart, and over 950 metres from the nearest source of permanent water. The remainder of the cultural material recorded during the Deep Creek survey session was located in close proximity to the Deep Creek.

While visibility along the creek was generally very poor, the large tracts of the plains land unit surveyed displayed very good visibility. Over 160 hectares of the basalt plains were surveyed, with only the two-previously mentioned silcrete cores being found. The plains were surveyed intensively, using closely spaced transects, in newly ploughed and/or grazed paddocks. The lack of cultural material located is difficult to explain in any other way than that the area enjoyed less frequent Aboriginal visitation in prehistory. Even when taking plough zone process into account (as discussed elsewhere in this thesis), the quantity of cultural material likely to be present on the expanses of basalt plain is low. It appears that the majority of the somewhat limited evidence of cultural activity occurs within approximately 100 metres of the Deep Creek.

Organ Pipes National Park (OPNP)

The Organ Pipes National Park session resulted in the discovery of the greatest amount of cultural material of the surveyed areas. Some 5,060 pieces of Aboriginal cultural material were recorded during this phase of the field survey.

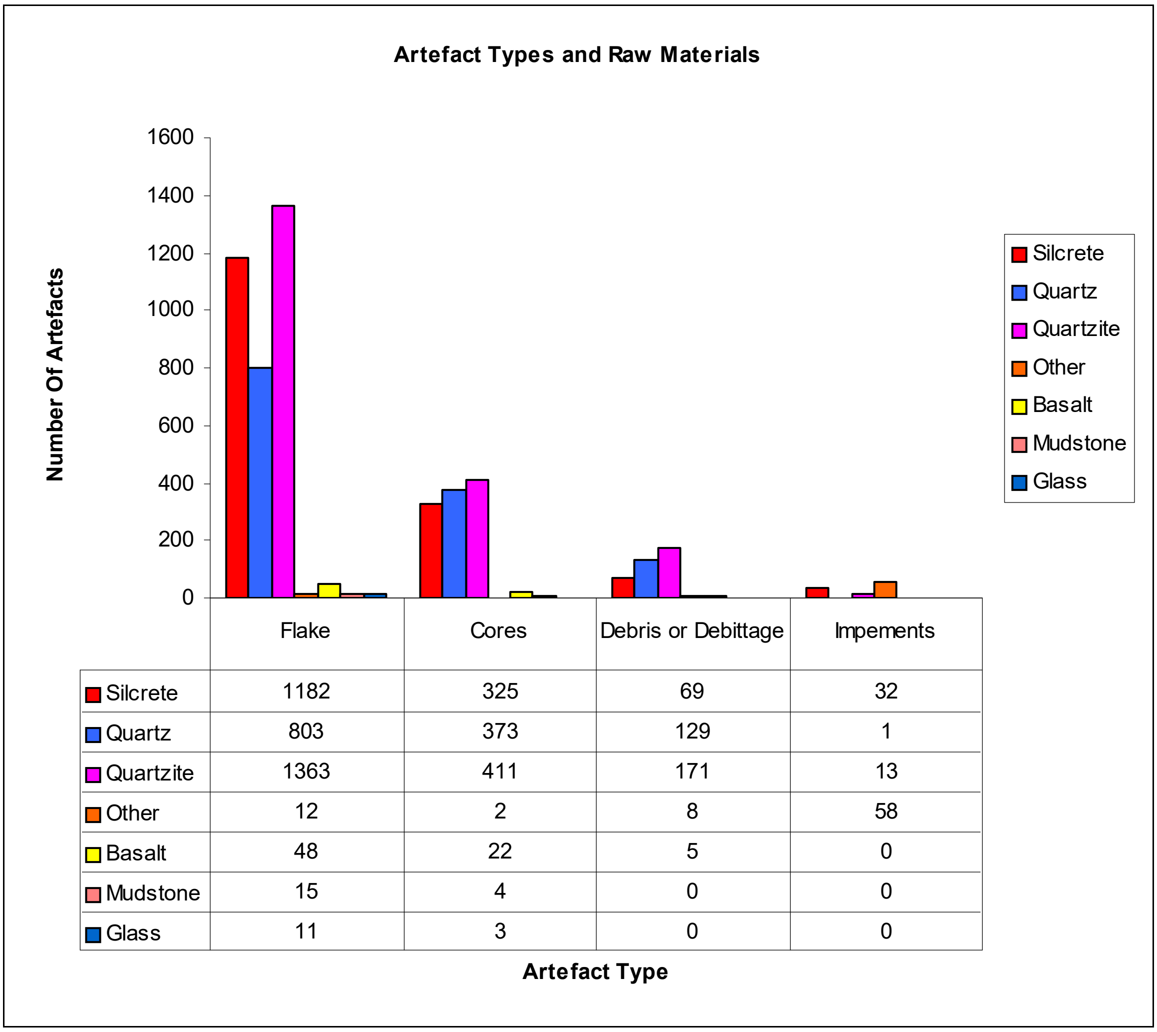
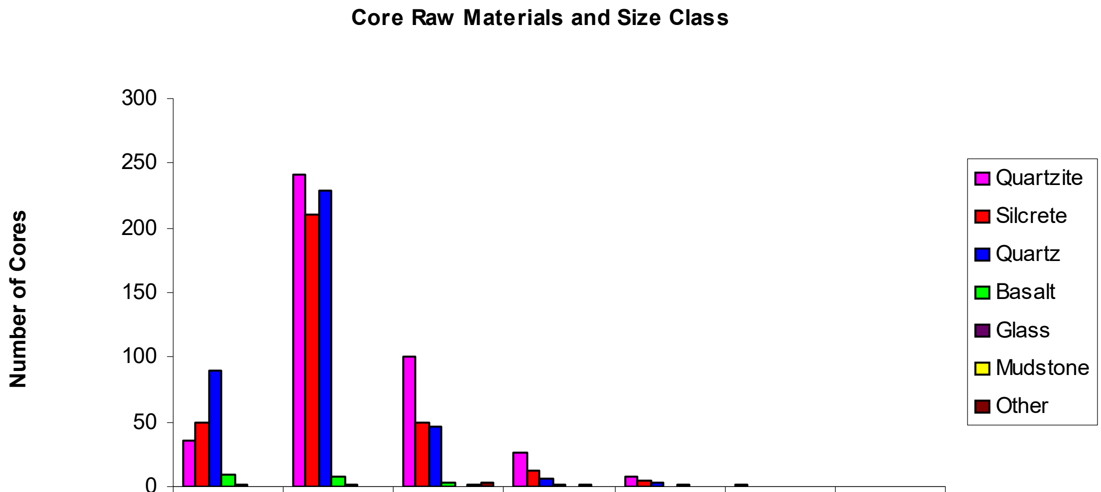


Figure 9-9: Artefact types and Raw Materials - OPNP.

Artefact Type	N	Silcrete	Quartz	Quartzite	Basalt	Glass	Mudstone	Other	Total %
Flake	3,434	1,182	803	1,363	48	11	15	12	67.9
Cores	1,140	325	373	411	22	3	4	2	22.5
Debris or débitage	382	69	129	171	5	0	0	8	7.5
Implements	104	32	1	13	0	0	0	58	2.1
Totals	5,060	1,608	1,306	1,958	75	14	19	80	
(% of Total)	(100)	(31.8)	(25.8)	(38.7)	(1.5)	(0.3)	(0.4)	(1.6)	100

Table 9-24: Percentage of each artefact class and raw material - OPNP.

At OPNP 1,140 cores were recorded.



	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Quartzite	35	241	101	26	7	1	0
Silcrete	49	210	49	12	5	0	0
Quartz	89	229	46	6	3	0	0
Basalt	10	8	3	1	0	0	0
Glass	1	1	0	0	1	0	0
Mudstone	0	0	2	2	0	0	0
Other	0	0	3	0	0	0	0

Size Class of Cores

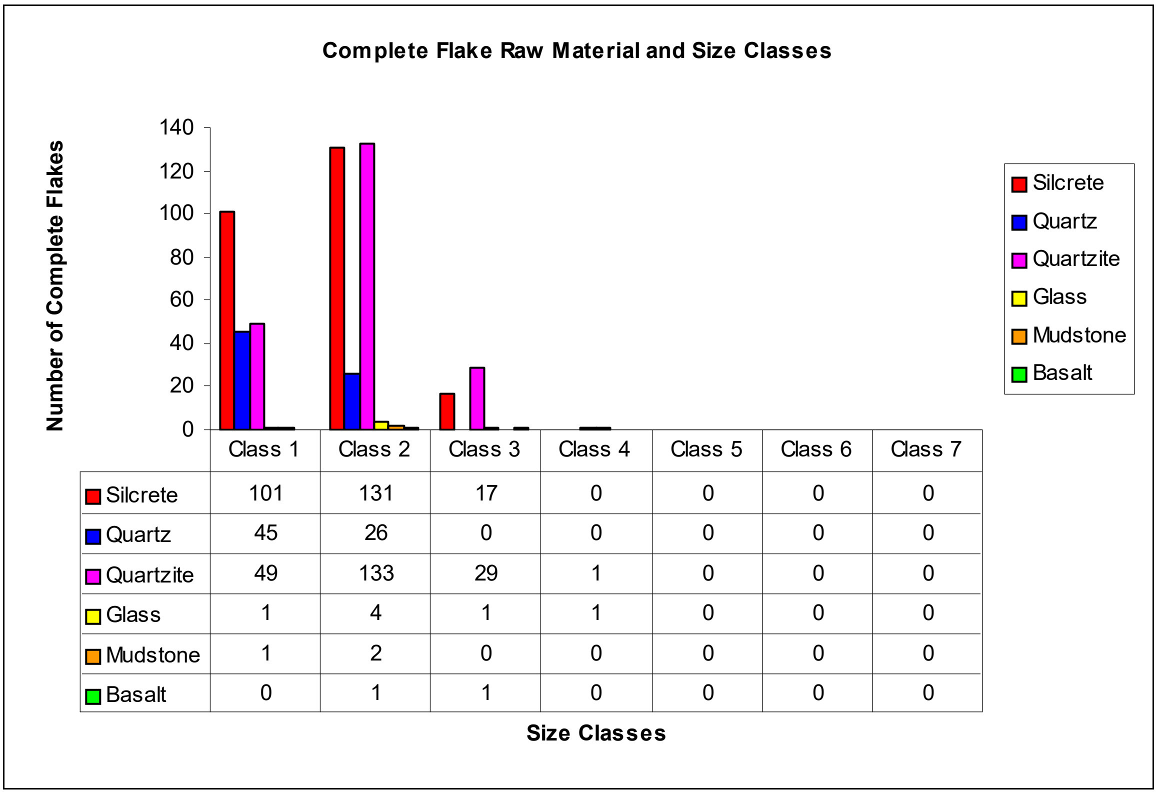
Figure 9-10: Core raw materials and number of cores per size class - OPNP.

Quartzite was the most common material in the OPNP assemblage. Quartzite cores accounted for 36.1% of the total number of cores recorded. Quartz (32.7%) and silcrete (28.5%) were the next most common raw materials. All other materials recorded account for only 2.7% of the total cores recorded. The majority of all cores fall in size class 2 (60.4%), while significant numbers of cores are size class 1 (16.1%) or size class 3 (17.9%). There was 64 cores larger than size class 3, accounting for 5.6% of the total assemblage. The majority (66.5%) of cores recorded did not display cortex.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=1,140	758	21	58	4	49	16	49	1	65	2	64	0	21	1	10	4	10	0	3	3	1

Table 9-25: Core Percentage of Cortex - OPNP.

3,434 flaked pieces were recorded at OPNP – 545 complete flakes, and 2,889 broken flakes.



	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
Silcrete	101	131	17	0	0	0	0
Quartz	45	26	0	0	0	0	0
Quartzite	49	133	29	1	0	0	0
Glass	1	4	1	1	0	0	0
Mudstone	1	2	0	0	0	0	0
Basalt	0	1	1	0	0	0	0

Figure 9-11: Complete Flake Raw materials and size classes - OPNP.

Silcrete was the dominant raw material used in the manufacture of complete flakes (45.7%), followed by Quartzite (38.9%) and Quartz (13.1%). All other materials account for only 2.4% of the total assemblage. The majority of complete flakes were size class 2 (54.7%), with significant numbers of complete flakes being both size class 1 (36.3%) and size class 3 (8.6%). Only 0.4% of complete flakes were larger than size class 3. 95% of complete flakes displayed no cortex.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=545	516	5	5	0	6	0	2	0	2	0	8	0	1	0	0	0	0	0	0	0	0

Table 9-26: Compete Flake Cortex - OPNP.

2,889 broken flakes were recorded at OPNP.

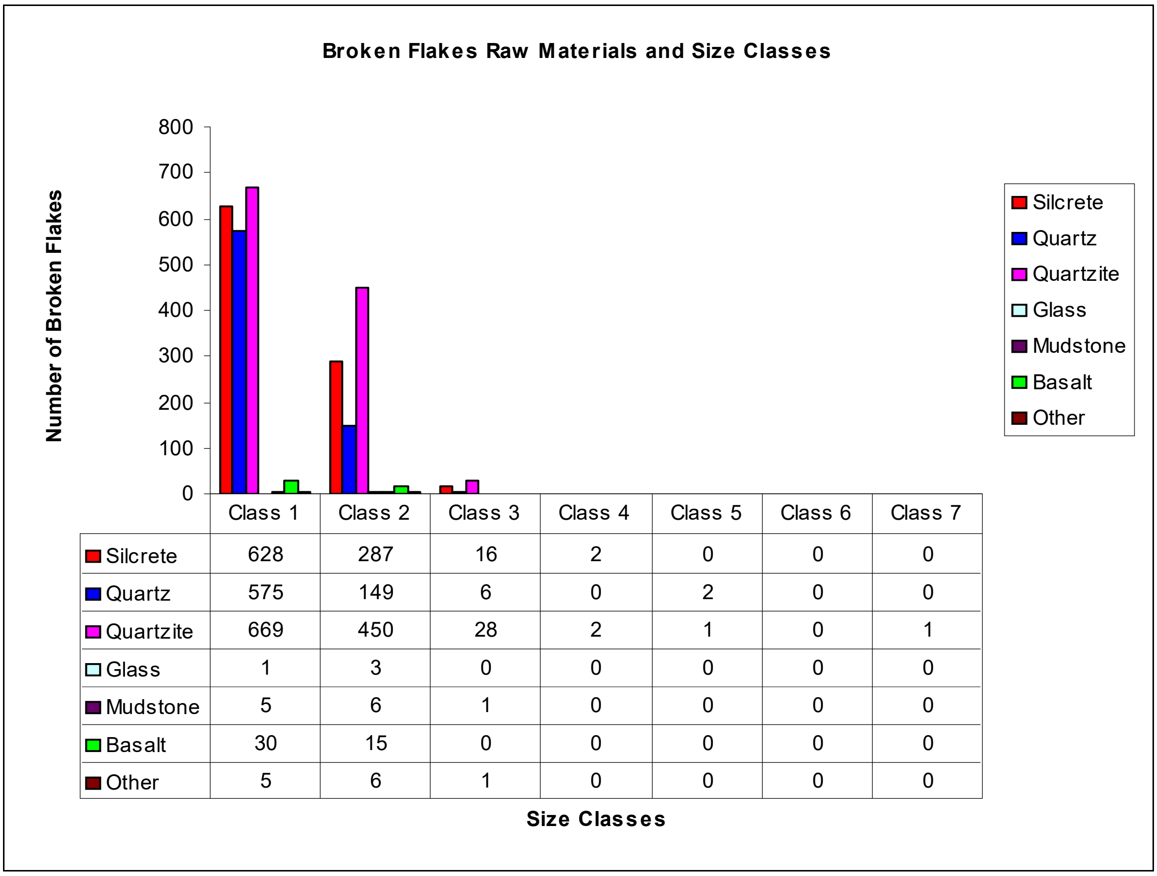


Figure 9-12: Broken flakes raw materials and size classes - OPNP.

Raw Material	N	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Total %
Silcrete	933	628	287	16	2	0	0	0	32.3
Quartz	732	575	149	6	2	0	0	0	25.3
Quartzite	1,151	669	450	28	2	1	0	1	39.8
Glass	4	1	3	0	0	0	0	0	0.1
Mudstone	12	5	6	1	0	0	0	0	0.4
Basalt	45	30	15	0	0	0	0	0	1.6
Other	12	5	6	1	0	0	0	0	0.4
Totals	2,889	1,913	916	52	6	1	0	1	100

Table 9-27: Number and Frequency of broken flake raw material types - OPNP.

Quartzite was the dominant raw material in the broken flake artefact category (39.8%), closely followed by Silcrete (32.4%) and Quartz (25.34%). 66.22% of all broken flakes were size class 1, and 31.71% of broken flakes were size class 2. The remainder of all material types accounts for only 2.1% of all broken flakes. 92% displayed no cortex.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=2,889	2,650	37	46	0	41	4	25	0	25	0	52	0	1	0	2	0	4	1	1	0	0

Table 9-28: Broken Flakes Percentage of cortex - OPNP.

Of the 5,060 artefacts recorded at OPNP, only 104 (2%) were recognisable formal tools. Each category of implement recorded will be addressed separately below.

Implement	N	%
Geometric Microlith	16	15.4
Scraper	22	21.2
Hammer stone	30	28.8
Grindstone	28	26.9
Backed Piece	8	7.7
Total	104	100

Table 9-29: Implements – OPNP.

1. Geometric Microliths

A total of 16 geometric microliths was recorded during the OPNP survey (15.38% of implements).

Raw Material	N	%	Class 1	Class 2
Silcrete	8	50	6	2
Quartz	1	6.2	1	0
Quartzite	7	43.8	4	3
Total	16		11	5
(% of Total)			(68.8)	(31.2)

Table 9-30: Geometric Microliths - OPNP.

Silcrete was most common implement raw material (50%), followed by quartzite (43.8%), while 68.8% of the Geometric Microliths were size class 1. All were either class1 or class 2. None of the 16 Geometric Microliths recorded exhibited cortex.

2. Scrapers

A total of 22 scrapers were recorded at OPNP. Silcrete was the dominant raw material (77.3%), with the remainder being made on quartzite. 13 of the 22 scrapers displayed secondary retouch, while only four displayed cortex.

Raw Material	N	%	Class 1	Class 2	Class 3
Silcrete	17	77.3	6	8	2
Quartzite	5	22.7	1	3	1
Total	22		7	11	3
(% of Total)			(31.8)	(50)	(18.2)

Table 9-31: Scrapers - OPNP.

3. Hammer Stones

A total of 30 hammer stones were recorded at OPNP. All of the hammer stones were made on locally sourced quartzite river cobbles that showed characteristic evidence of the battering associated with stone tool manufacture.

Raw Material	N	%	Class 2	Class 3	Class 4	Class 5	Class 6
Quartzite River Cobbles	30	100	2	11	7	8	2

Table 9-32: Hammer Stones – OPNP.

All of the recorded hammer stones displayed considerable cortex, but none displayed any flaking.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=30	0	0	0	0	0	0	2	0	5	0	10	0	2	1	3	0	1	0	0	3	3

Table 9-33:Hammer stone Cortex – OPNP.

4. Grinding Stones.

A total of 28 grinding stones were located during the OPNP fieldwork. These items displayed characteristic concave or convex polishing on at least one surface, and were often polished on multiple surfaces. Once again, all of the grinding stones were made on locally sourced quartzite river cobbles.

Raw Material	N	%	Class 3	Class 4	Class 5	Class 6	Class 7
Quartzite River Cobbles	28	100	5	14	3	3	3

Table 9-34: Grinding Stones - OPNP.

The majority of grinding stones were size class 4 or larger (82.14%), and cortex was present on all.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=28	0	0	0	0	0	0	1	0	1	0	8	1	1	0	3	4	2	0	3	4	0

Table 9-35: Grinding Stone Cortex – OPNP.

5. Backed Pieces

A total of 8 backed pieces were recorded during the OPNP survey.

Raw Material	N	%	Class 1	Class 2
Silcrete	7	87.5	5	2
Quartzite	1	12.5	0	1
Total	8		5	3
(% of Total)			(62.5)	(37.5)

Table 9-36: Backed Pieces - OPNP.

Most backed pieces were made on silcrete (87.5%), and none displayed any cortex.

A total of 382 pieces classified as debris or débitage was recorded during the OPNP survey (8% of total).

Raw Material	N	%	Class 1	Class 2	Class 3	Class 4
Silcrete	69	18.1	27	36	5	1
Quartzite	171	44.8	25	128	16	2
Quartz	129	33.8	84	45	0	0
Basalt	5	1.3	4	1	0	0
Other	8	2.1	1	1	6	0
Total	382		141	211	21	3
(% of total)		100	(36.9)	(55.2)	(5.5)	(0.8)

Table 9-37: Debris or débitage - OPNP.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=382	327	4	12	0	8	1	4	0	6	0	12	0	7	0	0	0	1	0	0	0	0

Table 9-38: Debris or débitage Cortex - OPNP.

Quartzite accounted for 44.8% of all debris, while 55.2% of all pieces of debris were size class 2. 85.6% of debris displayed no cortex.

Size class one (48.6%) artefacts were the most common at OPNP, while quartzite was the most common raw material (38.7%), and 84.8% of all artefacts displayed no cortex.

Woodlands Historic Park (WHP)

The fourth and final fieldwork sessions at Woodlands Historic Park (WHP) resulted in the recording of 939 archaeological items. Of this total, 921 stone artefacts were recorded. The remaining 18 items consisted of 13 possible quarried stone sources, four scarred trees, and one hearth.

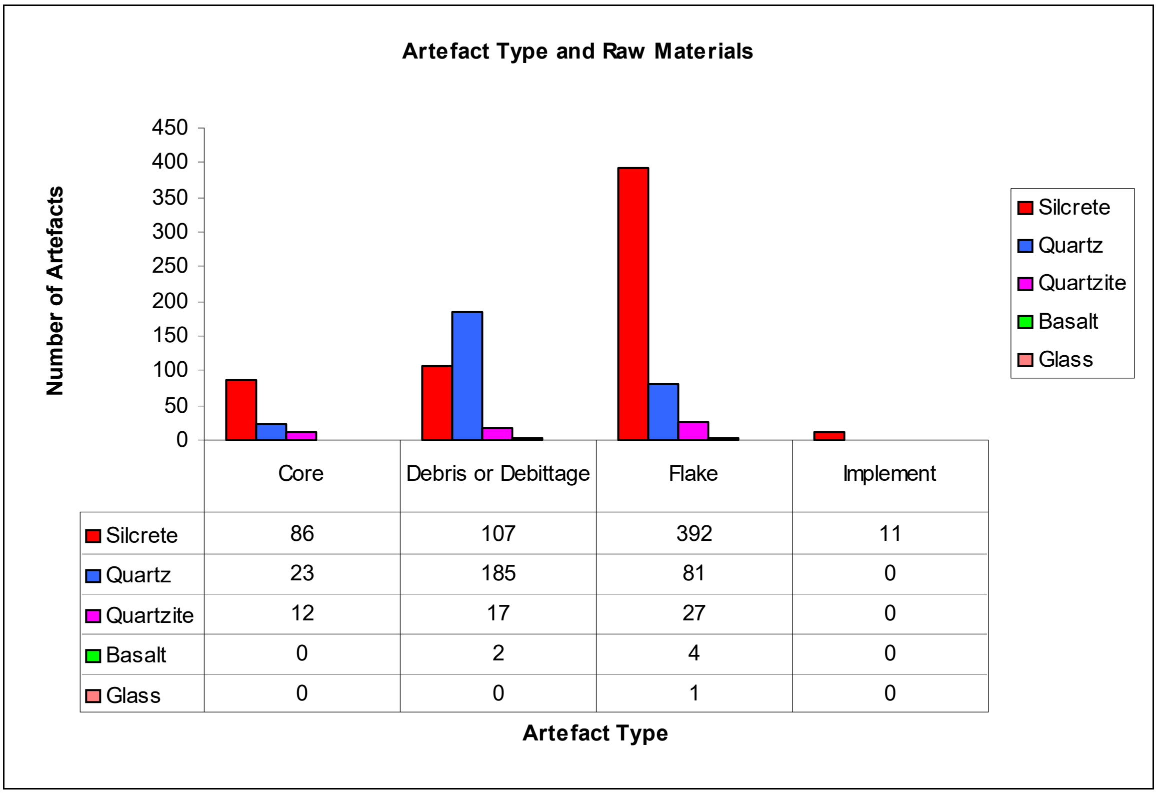


Figure 9-13: Artefact types and raw materials - WHP.

Artefact Type	N	Silcrete	Quartz	Quartzite	Basalt	Glass	Total %
Core	121	86	23	12	0	0	13.1
Debris or débitage	284	107	158	17	2	0	30.8
Flake	505	392	81	27	4	1	54.8
Implement	11	11	0	0	0	0	1.3
Totals	921	596	289	56	6	1	
(% of Totals)	(100)	(64.7	(28.4)	(6.1)	(0.6)	(0.1)	100

Table 9-39: Artefact Types and Raw Materials - WHP.

A total of 121 cores were recorded during the WHP fieldwork session.

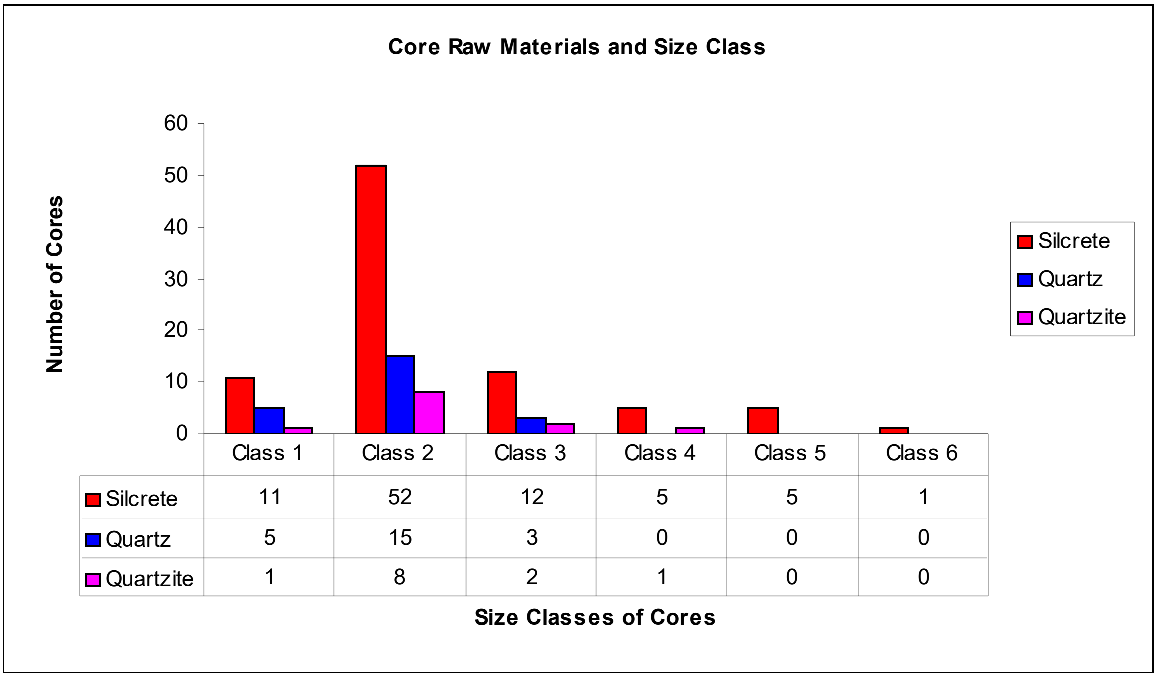


Figure 9-14: Core Raw Materials and Cores Per Size Class - WHP.

	N	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Silcrete	86	11	52	12	5	5	1
Quartz	23	5	15	3	0	0	0
Quartzite	12	1	8	2	1	0	0
Total	121	17	75	17	6	5	1
(% of Total)		(14.1)	(61.9)	(14.1)	(4.9)	(4.1)	(0.8)

Table 9-40: Cores - WHP

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=121	69	6	5	1	6	2	7	0	7	0	10	0	4	0	2	0	1	0	1	0	0

Table 9-41: Core Cortex - WHP.

Silcrete size class 2 are the most numerous cores (42.9%), while size class 2 is the most common core size. 57% of all cores displayed no cortex.

147 complete flakes were recorded at WHP.

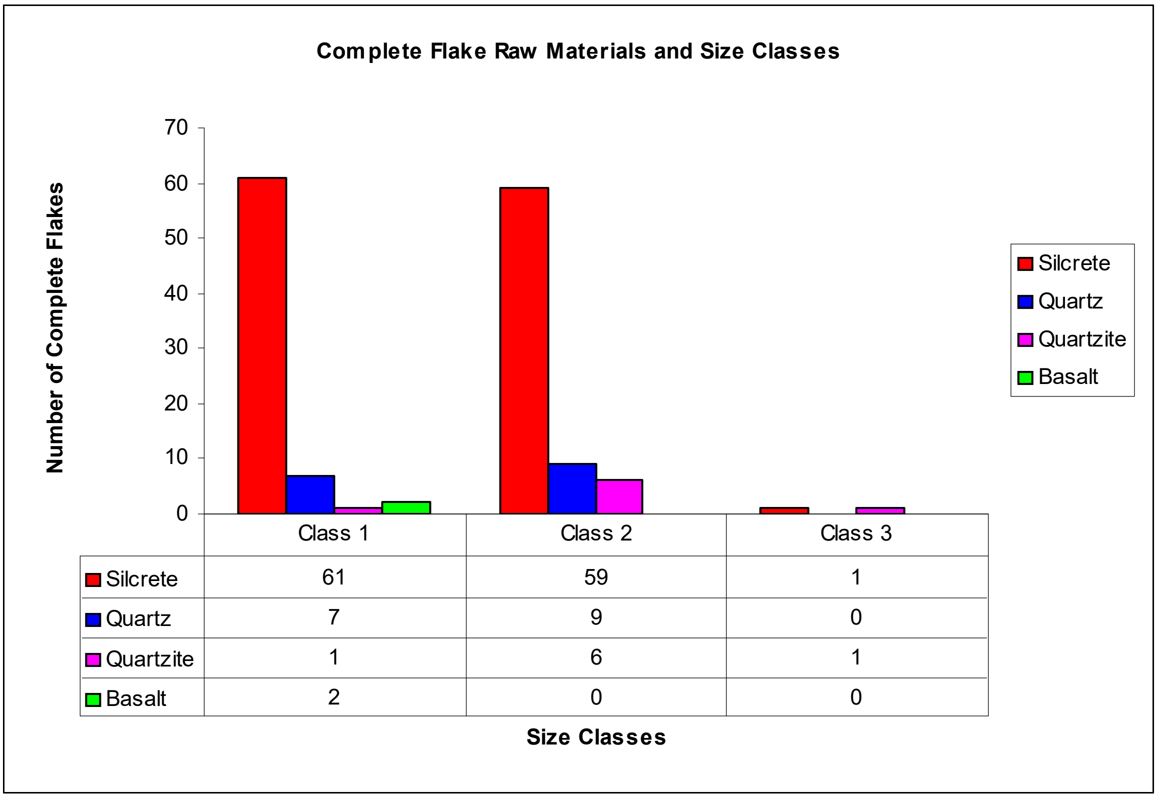


Figure 9-15: Complete Flake Raw Material and Size Class - WHP.

Raw Material	N	Class 1	Class 2	Class 3	Total %
Basalt	2	2	0	0	1.4
Quartz	16	7	9	0	10.8
Silcrete	121	61	59	1	82.3
Quartzite	8	1	6	1	5.5
Total	147	71	74	2	
(% of Total)		(48.3)	(50.3)	(1.4%)	100

Table 9-42: Complete Flake Raw Material Percentages and Size Class – WHP.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=147	127	3	4	0	4	0	2	0	4	0	3	0	0	0	0	0	0	0	0	0	0

Table 9-43: Complete Flake Cortex - WHP.

Silcrete size class 1 (41.5%) and class 2 (40.1%) complete flakes were the most common complete flakes, while 86.4% displayed no cortex.

358 broken flakes were recorded at WHP.

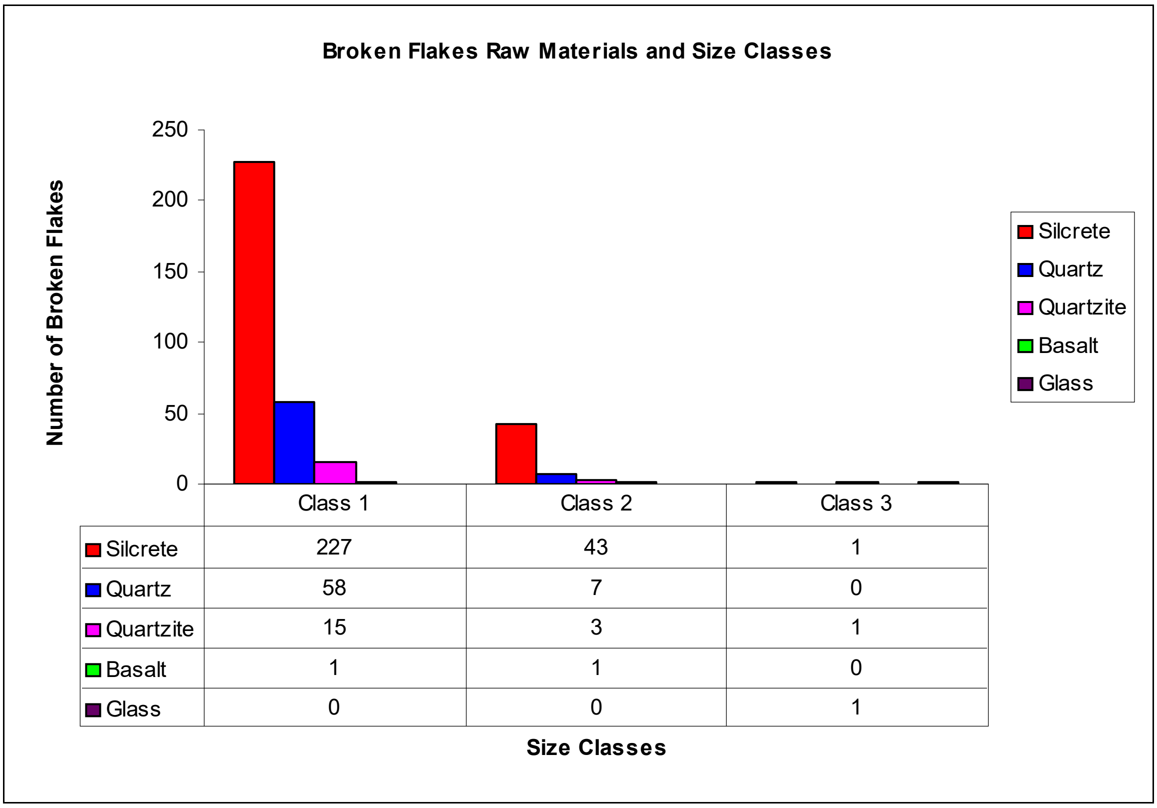


Figure 9-16: Broken Flakes and Size Classes - WHP.

Raw Material	N	Class 1	Class 2	Class 3	Total %
Basalt	2	1	1	0	0.5
Quartz	65	58	7	0	18.2
Silcrete	271	227	43	1	75.7
Quartzite	1	15	3	1	0.3
Glass	19	0	0	1	5.3
Total	358	301	54	3	
(% of Total)		(84.1)	(15.1)	(0.8)	10000

Table 9-44: Broken Flakes Percentage of Raw Materials and Size Class- WHP.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=358	342	0	6	2	0	0	1	0	1	0	6	0	0	0	0	0	0	0	0	0	0

Table 9-45: Broken Flake Cortex - WHP.

Silcrete class 1 (75.7%) broken flakes are the most common broken flakes, while 95.5% of broken flakes displayed no cortex.

There were a very small number of formal tools (n=11) identified during the WHP fieldwork session. These 11 artefacts were all small backed blades made on silcrete. None of these backed blades displayed cortex.

Artefact Type	N	Material	Class 1	Class 2	Class 3
Backed Blades	11	Silcrete (11)	9	0	2
Total	11		9	0	2
(% of Total)			(81.8)	(0)	(18.2)

Table 9-46: Implements - WHP.

There were 284 pieces of debris or débitage recorded in the WHP assemblage.

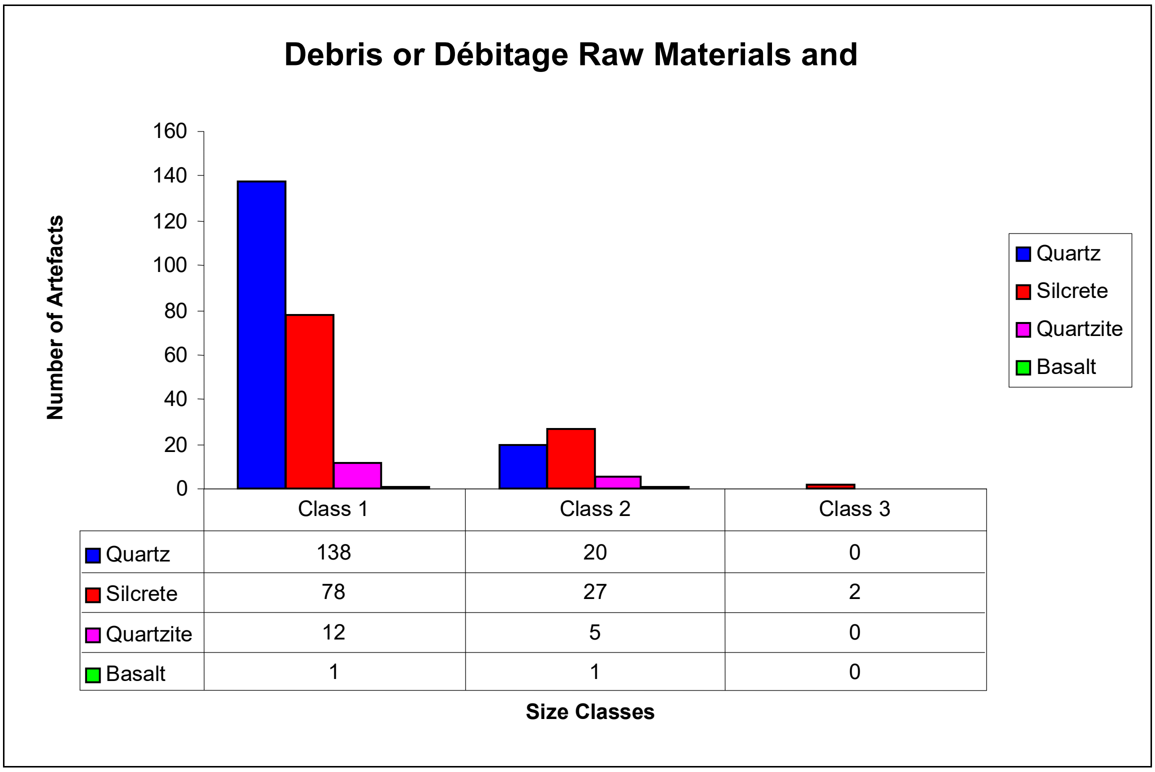


Figure 9-17: Debris or débitage Raw Materials and Size Class - WHP.

Raw Material	N	Class 1	Class 2	Class 3	Total %
Basalt	2	1	1	0	0.7
Silcrete	107	78	27	2	37.7
Quartz	158	138	20	0	55.6
Quartzite	17	12	5	0	6.0
Total	284	229	53	2	
(% of Total)		(80.6)	(18.6)	(0.7)	100

Table 9-47: Percentages of Raw Materials and Size Class - WHP.

Cortex %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
N=284	244	3	8	0	5	2	3	0	4	0	10	1	1	0	1	0	0	0	1	0	0

Table 9-48: Debris or débitage Cortex - WHP.

Quartz size class 1 (55.6%) was the most common type of debris or débitage at WHP, while 85.9% of all waste displayed no cortex.

Eighteen other sites were recorded at WHP during the fieldwork session. None of these eighteen sites correspond to any previously registered AAV sites. Thus, either the sites were previously unknown or the co-ordinates for these sites held by AAV are in error.
Silcrete Outcrops – thirteen small silcrete outcrops were located in WHP. All of the outcrops were a very poor quality large grained silcrete. While the outcrops showed signs of quarrying activity, the silcrete was of a very inferior quality.

Scarred Trees – four scarred trees were recorded in WHP. Three scars were recorded on living Red Gum () specimens, while a fourth scar was recorded on a dead Grey Box (). This latter specimen was the subject of an AAV investigation after it was discovered that the scar had been illegally removed using a chainsaw. The perpetrator(s) were identified.

Isolated Hearth – one isolated hearth was located on the bank of the Moonee Ponds Creek. The hearth consisted of a stratified deposit of charcoal approximately 75 centimetres in diameter, and 20 centimetres in depth. The deposit had become exposed due to erosion on the creek bank. The site most was extremely vulnerable due to it's proximity to the creek, and would most likely not survive. There were no stone tools located in the stratified charcoal deposits.

9.2. Project Brief

The following is a transcript of the project brief, originally designed and written by Richard Cosgrove, David Frankel (La Trobe University) and Nora Van Waarden (Aboriginal Affairs Victoria) (Cosgrove, Frankel and Van Waarden, 1997).

Primary Aims

The primary aim of this project is to establish predictive modelling of the distribution of Aboriginal archaeological sites within the Melbourne metropolitan area. Alongside its value in heritage management, this will also contribute to a better understanding of local prehistory and the viability of using current survey data. It will therefore require the evaluation of existing data collected through archaeological surveys. The project will provide training in all aspects of archaeological survey and analysis, especially in linking academic and applied concerns

Context

The Heritage Services Branch of Aboriginal Affairs (AAV) is the state government agency responsible for Aboriginal heritage and management. It is responsible for recording, assessing and protecting the Aboriginal archaeological resources of Victoria and for conducting research into them. The AAV Site Registry is responsible for the management of data relating to Aboriginal archaeological sites and places, and for providing relevant information to a variety of clients regarding cultural heritage management and planning issues.

The AAV sites database has accumulated over the last 25 years. These records have been built up from a variety of sources, ranging from casual individual reports to substantial long-term co-ordinated research programs. They therefore vary in individual quality of recording expertise and reliability. Equally significantly, survey design, strategy and coverage have also varied. This diversity compromises the extent to the AAV database can be used as a reliable resource for either research or management decisions.

Since 1992 the Heritage Services Branch of AAV has been developing a site linked computer-based Geographic Information System (GIS). This provides a means for determining where registered sites lie in relation to one another and to various features on the landscape. It enables AAV to make efficient use of the data-base to provide information to clients and advice on cultural heritage. E provision of such information and advice frequently requires statements to be made about the likely Aboriginal cultural values of broad areas of land on the basis of limited and site specific data. In some instances, localised site distribution models may also be available from previous reports, although most such models are generalised and largely untested. The ability to frame advice using a theoretically based and rigorously tested regional model would be a significant advantage. This will require an assessment of the reliability of the database.

Significance

Alongside the high level training of the PhD student, the significance of this project can be seen in the two dimensions of academic and applied archaeology.

Applied

1. The development of predictive models of site location, suitable for management and planning in the Melbourne Metropolitan area.
2. A formal assessment of the reliability of the AAV sites database.
3. A refinement of protocols for incorporating site data in the planning process.

Academic

1. The critical evaluation of current data and the development of procedures to assess varied quality and methods to overcome it.
2. The incorporation of vast quantities of evidence from surface surveys into a regional archaeology generally based on a relatively small number of excavations.
3. The construction of models of land-use and site location with implications for a better understanding of Aboriginal behaviour and adaptations to changing environments.

Methods and Approaches

Following a general survey of the relevant literature, the research design for the practical component of the project envisages several stages.

*Stage 1***.** Initial intensive survey of selected areas on the less developed fringe of the Metropolitan area to establish a control on site distribution and locations in relation to varied environments.

Background.

According to Altschul and Nagle (Altschul and Nagle, 1988) there are at least three crucial criteria that must be met before reliable predictive models can be created.

1. An understanding of the variability in the site type and their location in relation to environmental structure.
2. The identification of large or ‘influential’ sites. These are known to affect site distribution on a regional scale. Their ‘pull’ can influence the pattern of surrounding sites, limiting the usefulness of models based solely on

environmental data. This factor has been explored by Rhoads (Rhoads, 1992) who argued that scarred trees found in western Victoria had an influence on the distribution of surrounding sites not directly related to environmental variables.

3. Depositional and post-depositional processes must be identified and understood in context of long-term fluctuations in settlement patterns. An understanding of the sample areas geology and geomorphology is critical for models to be effective tools in cultural resource management. The fieldwork for this project will include both pedestrian survey strategies and shovel testing of different geomorphological units. These techniques have been successful in Tasmania (Cosgrove, 1990; Smith, 1995b). In assessing the AAV database, sampling areas and sampling units within zones will be chosen on the basis of potential future development impacts, where this will not unduly bias the sample.

The model development will be carried out in three phases. It will focus on the zones where urban expansion is planned; particularly the undeveloped lands surrounding Melbourne. The actual selection will be made in consultation with AAV and representatives of the local Aboriginal communities.

The First Phase will stratify the sample areas in terms of environmental attributes. Stratifying allows the sampling units to be broken down into their ecological and geomorphological components. This will be an office-based study, utilising existing physical data from AAV and land management authorities.

The Second Phase will be ground inspection carried out on foot using transects within each selected stratified sample. The methodology applied will permit a relatively quick appreciation of the site types, is relatively easy to lay out in the field and provides a first order assessment of site distribution.

The Third Phase will use quadrats laid out within each environmental zone in much the same way as applied by Rhoads (1992). The number and distribution of both transects and grids will be determined based on final choice of sampling areas. Geographic Positions Systems (GPS) will record all locations.

Stage 2 Analysis and correlation between newly documented sites from control samples and those drawn from the AAV Register. This will allow an assessment of the reliability and utility of the database. This stage will involve the comparison between the models generated in Stage 1 with information in the existing AAV site linked GIS database. This information will be important in the development of predictive models and will be of great value in comparing different data sets. Based on the predictive model generated in Stage 1, simulation models and sensitivity maps will be constructed and compared with those generated from the AAV database. How far they depart from each other will, to a large degree, be indicative of the reliability and utility of the present AAV site register to predict site location.

Stage 3 will allow the development of a general model of prehistoric land use and settlement in the Melbourne region. This is one of the major academic outcomes, and will serve as an important basis for developing further predictive modelling useful in providing advice to Local Government Authorities on planning in Stage 4.

Stage 4 will formulate methodologies and criteria for predictive models based on AAV's site database to a number of Local Government Authorities in the Melbourne Metropolitan Area. The greatest land development and disturbance lies within the growing metropolitan corridors within and surrounding Melbourne, and this therefore forms an appropriate testing area. In applying the predictive model and working with particular planning and development issues, better protocols will be developed to assist AAV and Local Government Authorities reduce the risk to Aboriginal heritage. It will help provide a justifiable base from which to provide appropriate advice to developers.

Research Training

Need

For many years, archaeologists have been aware of a substantial and widening gulf between academic archaeology and the concerns of management-oriented heritage (applied) archaeology. There is a clear need to develop both general training in this field, as well as to explore the research potential of heritage data generally. This project, which brings academic and applied archaeologists closer together, will materially assist with this.

Scale

The scope of the project, involving substantial fieldwork, the development of new methodologies and their application to a specific management concern, demands a significant program of research, appropriate for a PhD, especially as it will make a contribution to both pure and applied archaeology.

Aboriginal Communities

As with other current projects within AAV and the Department of Archaeology at la Trobe, the involvement of Aboriginal communities is seen as of primary significance. This project will continue this practice. It will provide the opportunity for Aboriginal people to receive training in aspects of archaeological fieldwork and heritage management, and bring them into closer contact with university research.

The Industry Partner

Research Profile

An important component of the work of the Heritage Services Branch of AAV is to devise and monitor archaeological surveys and studies. Although mainly directed toward specific management ends, these constitute the overwhelming majority of all archaeological studies carried out in Victoria. As part of their recent development of GIS and upgrading of the existing database, AAV have become increasingly aware of inadequacies in current practices. This project is seen as an important step towards assessing the quality of current information, and for developing new protocols.

Relevance of this project

This project will provide a substantive contribution to the work of AAV in developing a predictive model for the Melbourne Metropolitan area. AAV has recently started a program of digitising survey coverage and associated information from previous surveys to form a separate layer in their GIS. This will link into the more general contribution of the project in providing a new basis for evaluating and using data for managing heritage sites and places. It is seen as filling a critical gap in current industry practice , and will have long term implications for the practice of heritage studies and management in Victoria. In the longer term, the approach and results will be valuable tools for equivalent management authorities in other parts of Australia.

Links between Industry and University

General

There is a critical need in academic archaeology to develop better working relationships with industry, and to make use of the large quantities of data collected by heritage agencies in writing general prehistory's of Australia.

Specific

The Department of Archaeology at La Trobe is in the process of establishing a Cultural Resource Management course (in conjunction with other areas of study). Plans for the cultural resource management program will provide formal training in linking academic and applied approaches. The lecturer in charge of this course will need to establish close links with both AAV and other heritage agencies in Victoria. This fellowship will form a logical step in this development.

9.3. ^{14}C Dates for the Study Area

The following table presents a compilation of all ^{14}C dates for the study area of this thesis. The data was compiled from Godfrey *et al 1996*. The majority of dated materials in the study area are from either the Green Gully or Keilor excavations.

Several ^{14}C Dates have been obtained subsequent to Godfrey et al (1996) paper. These have been through the work of John Tunn at Brimbank Park. Tunn (1998) originally obtained dates of 8,926 ± 60 BP (NZA 8538) and 9,024±63 BP (NZA 8537) for cultural features during honours research at La Trobe University. Since then, Tunn (Pers Comms) has obtained a date of 12,879 ±59 BP (AHU-152) for another excavated cultural feature at Brimbank Park.

Site Name	AAV No	Type	Location	Environment	Context	Lab No	Age	±	Material
Maribyrnong - Geological Unit		Soil Horizons	Braybrook	Soil Quarry	24' below top of Maribyrnong Terrace	GX-148	1,020	80	Wood
Maribyrnong River		Open Site	Braybrook	Soil Quarry	Hearth	W-169	8,500	250	Charcoal
G-DR 8	7822-0488	Open Site	Gisborne	Kororoit Creek	Hearth	Beta-45593	1,460	50	Charcoal
G-DR 8		Open Site	Gisborne	Kororoit Creek	Hearth, Layer 2, Spit 5, Feature 1	Beta-61795	2,160	70	Charcoal
Green Gully	7822-0005	Burial	Keilor	Quarry in River Terrace	From Human Bone	NZ-675	1,742	128	Bone
Green Gully		Burial	Keilor	Quarry in River Terrace	From Human Bone	NZ-676	6,429	193	Bone
Green Gully		Open Site	Keilor	Quarry in River Terrace	Trench F, Square 8, Spit 4	V-81	8,535	180	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	Carbonate Nodules, Keilor Terrace	ANU-126	2,015	65	Carbonate
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	8ft below top of Maribyrnong terrace	V-78	3,145	95	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	22 ft below top of Maribyrnong Terrace	V-77	4,440	100	Wood
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	2m below surface, East river bank	ANU-694	5,570	90	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	Quarry in River Terrace	Intermed. zone below Green Gully J	V-75	5,990	105	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	5m below surface, East river bank	ANU-695	6,660	110	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	Burnt earth in pit, 5m below surface	ANU-652	6,810	460	Charcoal
Green Gully - Geological Unit	7822-0005	Burial	Keilor	Quarry in River Terrace	41'above grave top and 21' west	V-63	8,155	130	Charcoal
Green Gully - Geological Unit		Burial	Keilor	Quarry in River Terrace	Roots, 51' below grave top, 24' east	V-65	8,155	130	Charcoal
Green Gully - Geological Unit		Burial	Keilor	Quarry in River Terrace	48' below grave top and 24' west	V-64	8,990	150	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	Quarry in River Terrace	Intermed. zone over Keilor terrace	V-74	11,030	140	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	Section thru. Keilor terrace at weir	V-79	14,940	500	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	Quarry in River Terrace	Lower level of Keilor Terrace	V-73	17,300	300	Charcoal
Green Gully - Geological Unit		Soil Horizons	Keilor	River Terrace	Arundel clay in Keilor terrace	V-76	30,700	1850	Charcoal

Site Name	AAV No	Type	Location	Environment	Context	Lab No	Age	±	Material
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KAA Excavation, Base of level 3	ANU-735a	17,400	1300	Charcoal
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KAA Excavation, Lowest level	ANU-734b	22,860	1300	Charcoal
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KAA Excavation, Base of level 3	ANU-735c	22,860	1300	Charcoal
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KA excavation, 2’ below Level 2	ANU-81	24,000	+1300-5700	Charcoal
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KAA Excavation, Highest Occupation	ANU-697	25,540	+1390-1180	Charcoal
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KAA Excavation, Lowest level	ANU-734a	27,450	+1760-1450	Charcoal
Keilor - Dry Creek	7822-0010	Open Site	Keilor	River Terrace	KA excavation, Level 2	ANU-65	31,600	+1100-1300	Charcoal
Keilor - Dry Creek		Open Site	Keilor	River Terrace	KAA Excavation, W2 clay	ANU-696	38,750	+1390-1180	Charcoal
Keilor - Geological Unit		Open Site	Keilor	River Terrace	About same level as Keilor Cranium	NZ-366	15,353	1052	Charcoal
Keilor - Geological Unit		Open Site	Keilor	River Terrace	Near base of Doutta Galla silt	Gak-2516	17,800	600	Charcoal
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-1320	5,196	208	Carbonate
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-1222	6,186	171	Carbonate
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-1321	6,759	102	Carbonate
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-1326	6,772	51	Bone
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-2516	7,328	111	Carbonate
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-1221	7,716	72	Carbonate
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Human Skeletal Remains	NZ-1327	11,979	98	Bone
Keilor Archaeological Site		Open Site	Keilor	River Terrace	Hearth, Pit B, Spit 14	SUA-2216	13,300	+1000-900	Charcoal
Keilor Archaeological Site		Open Site	Keilor	River Terrace	6.75' Below diastem, Doutta Galla silt	NZ-207	18,236	194	Charcoal
Lancefield Swamp		Open Site	Lancefield	Paddock	Black Clay, Unit 2	SUA-425b	1,735	120	Organics
Lancefield Swamp		Open Site	Lancefield	Paddock	Black Clay, Unit 2	SUA-425a	1,915	110	Organics
Lancefield Swamp		Open Site	Lancefield	Paddock	Bone Bed, Unit IV a	GX-4118c	3,100	210	Bone
Lancefield Swamp		Open Site	Lancefield	Paddock	Bone Bed, Unit IV a	GX-4118r	8,775	260	Bone
Lancefield Swamp		Open Site	Lancefield	Paddock	Bone Bed, Unit IV a	SUA-407r	12,550	650	Bone
Lancefield Swamp		Open Site	Lancefield	Paddock	Bone Bed, Unit IV a	SUA-407a	16,070	315	Bone
Lancefield Swamp	7823-0021	Open Site	Lancefield	Paddock	Bone Bed, Unit IV a	GX-4118a	19,800	450	Bone
Lancefield Swamp		Open Site	Lancefield	Paddock	Channel Fill, Unit IV b	SUA-685	25,200	800	Charcoal
Lancefield Swamp		Open Site	Lancefield	Paddock	Channel Fill, Unit IV b	SUA-538	26,600	650	Charcoal

Site Name	AAV No	Type	Location	Environment	Context	Lab No	Age	±	Material
Lancefield Swamp		Open Site	Lancefield	Paddock	Green Clay, Unit V	SUA-453	Plant	Modern	Plant
Maribyrnong River		Open Site	Near Green Gully	River Bank	Possible Fireplace, 21' below diastem	Gak-966	7,700	140	Charcoal
Maribyrnong River		Open Site	Near Green Gully	River Bank	Possible Fireplace	Gak-985	7,710	150	Charcoal
Springfield Gorge	7823-0013	Burial	Near Lancefield	Lava Cave	Woven bag associated with burial	SUA-1495	330	70	Fibre

Table 9-49: Radiocarbon dates for the study area. Compiled from Godfrey et al. (1996).

9.4. Artefact Size Class Target

This is the ‘artefact target’ used to ascertain the size classes of artefacts recorded in the field. Please note, this is not too scale.

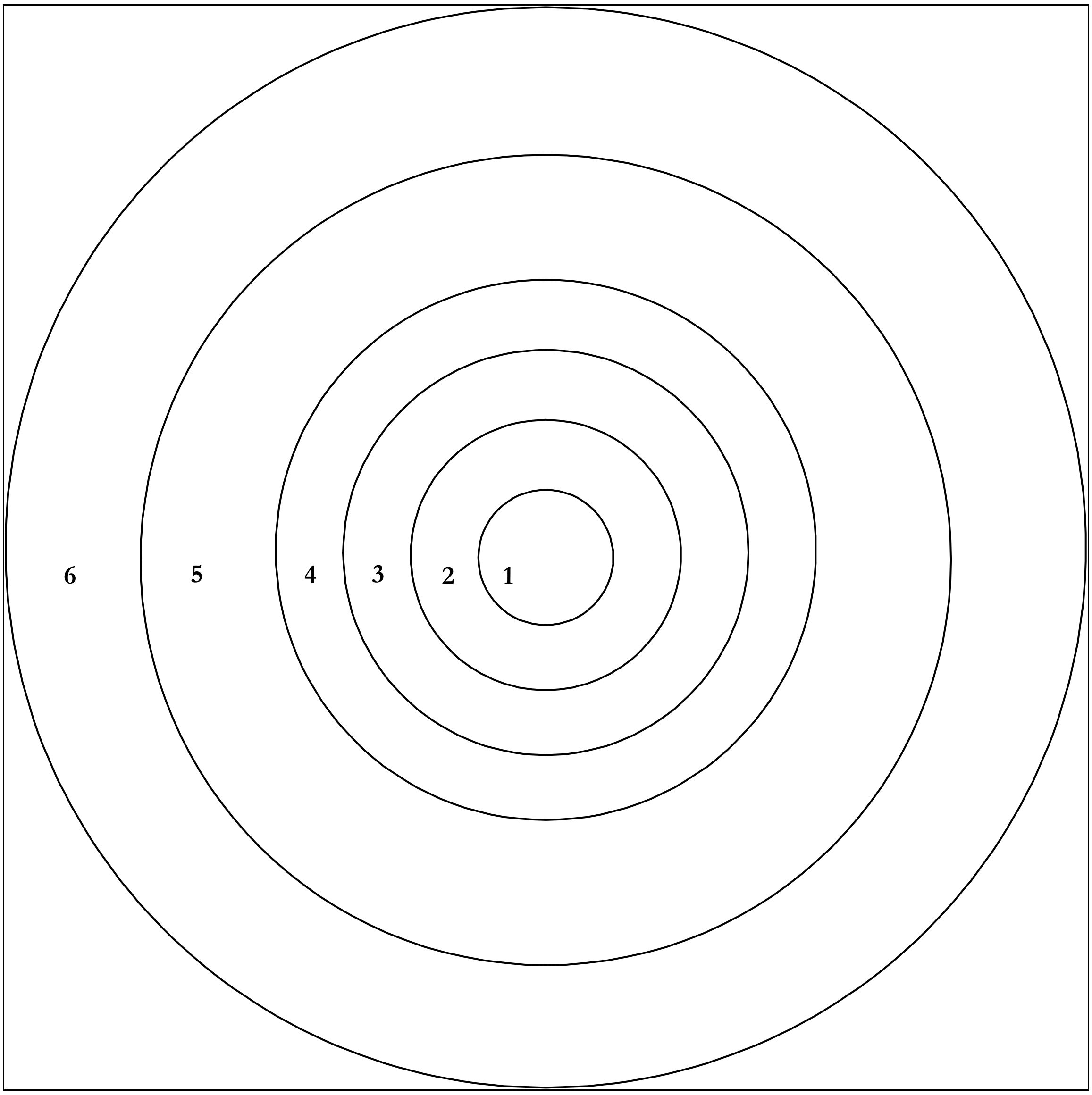


Figure 9-18: The artefact target used to measure the size of material recorded.

Size classes are as follows:

- Size Class 1= 1-25mm,
- Size Class 2=26-50mm,
- Size Class 3=51-75mm,
- Size Class 4=76-100mm,
- Size Class 5=100-150mm,
- Size Class 6=151-200mm,
- Size Class 7= >200mm).