An assessment of climate and decomposition and their effects on techniques used to locate graves

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Abstract

Climate is directly linked to the decomposition of biological remains and both climate and decomposition have a bearing on the methods used to locate graves. The aim of this thesis is to investigate the effects of climatic variables and decomposition processes on grave location techniques. Using information collated from extant literature and responses from a questionnaire sent to archaeologists and other professionals, the ways in which climate and decomposition effect location methods are evaluated. This research is of interest both to forensic archaeologists but also to the wider archaeological community because archaeologists from various fields all gain some evidence about past lifeways from biological remains.

The results of the research suggest that an approach to locating graves which employs a range of techniques (that is, a multidisciplinary approach) is the most successful way to accommodate the effects of climate and decompositions on grave location methods. The use of a multidisciplinary approach not only accommodates the limitation caused by climate and decomposition on the techniques but also takes advantage of positive effects of the variables. Techniques such as thermal imagery and visually recognising ground changes are assisted by decomposition and climate. Multidisciplinary approaches can take advantage of these effects. By employing archaeologists with skills in many methods of grave location search operations can be tailored more specifically to individual site conditions. Thus, more accurate information can be obtained more productively.

One of the key points to emerge from this thesis is the issue of the lack of published material, particularly in relation to professional experiences concerning the effect of climate and decomposition on the techniques that have been used in the field. While many archaeologists and forensic practitioners involved with locating graves accept that climate and decomposition affect the methods used, few have published on the details of the relationship between climate, decomposition and location techniques. This thesis bridges this gap in published research by demonstrating the effect that both these variables have on the grave location techniques.
Declaration

‘I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain material previously published or written by another person except where due reference is made in the text’

Signed:

(Natasha Paling)

Date: 23rd May 2005
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1. Introduction

1.1. Significance and use to archaeology

One of the areas of information that archaeologists use comes directly from the skeletal remains of those that lived in the past. As a result of this, archaeology has developed many sub-disciplines that deal directly with the issue of human remains. Bioarchaeology, or biological archaeology, explores the lives and lifestyles of human beings in the past from information gained from skeletal remains (Larsen 2000, p. 3). Information can also be gained about the health and diet of individuals or populations through the examination of bones and teeth (Peuch 1979, p. 592) and chemical analysis (Chamberlain 1994, pp. 22 - 23). In order to retrieve this information the practitioner needs well preserved skeletal remains. Thus, a better understanding of the methods utilized to locate graves will be invaluable to archaeologists.

Archaeologists can infer much from burials, such as information concerning status, gender and religious beliefs (from factors such as grave orientation, body arrangement, grave goods and body adornment) (Parker Pearson 1999, pp. 5 – 11). All of this information is important in constructing an accurate description of past lifeways.

Another sub-discipline which commonly works with graves is that of forensic archaeology. The location and excavation of graves is one of the main contributions made by the forensic archaeologist (Blau 2004, p. 12). Archaeologists working in a range of areas are interested in the grave as a site, a burial place or a place of potential information. However, the study of graves is
reliant on being able to locate the site. This involves the use of various methods, such as documentary evidence and geophysical techniques, to name but a few. These methods in turn can be affected by variables which may significantly affect their usefulness.

One of these factors is climate. There has been little in-depth research addressing the link between climate and decomposition and the detection of graves. This thesis will examine the decomposition processes that affect the human body, the effects climates have on these processes and how both of these factors, particularly climate, affect the techniques that archaeologists use to locate graves.

1.2. Aims and predicted outcomes

The aims of this thesis are to investigate the effects of climate on the decomposition of human remains in varying situations, examine the techniques used to locate graves and identify whether climate and decomposition affect the techniques used to locate graves.

After addressing the above aims the predicted outcomes will be as follows:

1. Provide an overview of the various methods that professionals use to locate graves. This information will afford a better understanding of the limitations of the techniques, the best places to use them and their success rates.

2. Focus on the key limitations of techniques employed to locate buried human remains. Case studies will be employed to provide a better understanding of the conditions under which these techniques have resulted in poor results.
Achieve a better understanding of the decomposition processes that affect a body after death, both surface and sub-surface. The goal is to explore the effect this, when combined with climatic variables, has on the techniques used to locate graves and produce a set of criteria relating to the preservation of bodies in varying conditions. This can be used to predict the success of locating methods in the field.

Demonstrate the extent to which climate and decomposition are limiting factors in grave location, identify which body location techniques, if any, are affected by climate and address the impact of any limitations on the results of field surveys and location attempts.

1.3. Why climate and decomposition?

After reviewing the literature and discussing case studies with a colleague, climate was selected as a key variable affecting body decomposition and possibly grave location methods. In the course of these discussions it was realized that, although significant work has been carried out in colder climates, little had been published concerning warmer climates, where work on clandestine burials and mass graves is now being conducted (e.g. East Timor). Another reason for this focus was Australia’s close geographical proximity to South East Asia. However, while the initial focus of research was going to be warmer climates, through the course of the researching process it was found that many authors did not directly mention climate in relation to their work. This led to the investigation of all climates regardless of the initial question design.
One of the main reasons for selecting climate as the variable to be researched was the vast number of climatic zones throughout the world. This fact is well known and archaeological work is carried out in all climates. An improved understanding of the affects of various climatic variables on grave location methods will be valuable to archaeologists worldwide.

1.4. Climate

One of the key areas of importance to this thesis is climate. This concept needs clarification before proceeding further as there are many factors involved with the term. Weather and climate are directly linked to a combination of solar radiation and the rotation of the Earth (Graedel & Crutzen 1995, p. 33). These factors join together to give us the combination of temperature, precipitation, wind flow and humidity that makes up the climates of different countries around the world (Graedel & Crutzen 1995, p. 28). It is important to bear each of these climatic variables in mind when reviewing this thesis.

One commonly used system for classifying the world’s climates is the Köppen Climate Classification system. This system was introduced in 1900 by Russian-German climatologist Wladimir Köppen. The system divides the Earth’s surface into climatic regions generally coinciding with world vegetation and soil patterns. The world is divided into five climatic types with a further four subgroups and then six secondary subgroups associated with some climatic types (Strahler, A. N. & Strahler, A. H. 13th May 2005, (online) URL: http://www.blueplanetbiomes.org/climate.htm). These climatic zones have different characteristics which the researcher must bear in mind when reviewing information (Appendix 1).
2. Background

All places mentioned in the following pages can be located according to climate type on the map in Appendix 2.

2.1. Decomposition

2.1.1. The processes of decomposition

2.1.1.1. Introduction

The processes of human decomposition have been well studied, with particular reference being made to above ground remains. However, although there is a great body of published work in this field, it is worth noting that decomposition is in no way an exact science. Local environmental conditions, as well as climate and seasonality, need to be taken into account in any studies addressing decomposition rates. Some of the variables involved are briefly discussed in the following sections of this chapter.

2.1.1.2. Decomposition studies

Although numerous scholars have been involved in the study of the decomposition of human remains there are a few notable individuals. The earliest work in the field of human decomposition was carried out by Arthur Mant. Mant carried out a study of
approximately 150 exhumations in Germany post-World War II (Mant 1953, p. 84, Mant 1987, p. 65). In this research the main requirements for decomposition were identified as warmth, moisture, air and bacteria (Mant 1953, p. 91). Mant also published the recognised changes of mummification, occurring through post-mortem dehydration of the body and adipocere\(^1\) formation (Mant 1960, p. 25, Mant 1984, p. 154).

William Bass, University of Tennessee, USA, has conducted some of the more recent decomposition work. He has done multiple experiments with both above and below ground cases in both summer and winter conditions (Bass 1997). Bass’ main project in the above area of research has been the Anthropological Research Facility, dubbed the ‘Body Farm’, at the aforementioned university. This project was initially set up in order to better understand the processes of decomposition so that he could apply them to forensic cases (Bass and Jefferson 2003, pp. 88 - 89). An overview of research which has contributed to our understanding of human decomposition is provided below.

2.1.1.3. Sequences of decomposition

Through his research at the Body Farm, Bass found that there is a rough sequence of decomposition that takes place in bodies located above ground. This consists of maggot activity, skin around the face being eaten away, skin and hair slippage, decomposition odours and body fluids excreting from the nose, mouth and anus occurring within the first week (1997, p. 183). Within the first month maggot activity will be diminished and the body will be in the decay stage with some

\(^1\) A greasy substance associated with moist burials (Mellen et al. 1993, p. 91)
skeletonisation (p. 184). Within the first year the bones will be dry and bone breakdown generally occurs from the first decade onwards (p.184). All of these events occur as above in warm, outdoors environments. In the case of burial, everything is delayed, maggot and beetle activity will be decreased and the odour of decay may be undetectable to humans. In many above ground cases the initial stages mentioned above can occur in as little as 96 hours, leading to bloating and discolouration within the first month (Clark et al. 1997, p. 161). However, it has been noted that the decomposition of buried remains occurs eight times slower than in bodies left above ground (Rodriguez 1997, p. 459).

2.1.1.4. Variables

2.1.1.4.1. Introduction

There are many variables involved in decomposition studies. These include clothing, bedding and injuries (Galloway 1997, p. 147), body size and composition (Galloway et al. 1989, p. 615), seasonal and latitudinal differences (Galloway et al. 1989, pp. 612 – 3), soil type and drainage patterns (Rodriguez & Bass 1985, p. 849) as well as animal and insect activity (Mant 1960, p. 29). They also include climatic conditions, depth and human interference, all discussed below.

2.1.1.4.2. Climate

Galloway has conducted multiple studies on decomposition rates in Arizona, USA. Galloway has found that protected burials show some adipocere formation and in
some cases dark flaking tissue is attached to the bones. In addition there is a lack of pupae casings as found in surface remains. Galloway also indicates that some clothing alters decomposition and may, depending on fibres, change decomposition patterns (1997, p. 147). Finally, Galloway points out that the issue of recent buried remains in Arizona is often irrelevant as modern burials do not often occur due to soil conditions.

Working in the colder conditions of Alberta, Canada, Micozzi writes that in cases where bodies have been repeatedly frozen and thawed the decomposition process is, in effect, reversed and bodies decay from the outside in (1997, p. 174). Limited preservation occurs when the temperature is 5 to 15°C. If the temperature is under 5°C no desiccation needs to take place for the body to be preserved as the bacteria responsible for decomposition are not active (1997, p. 172). Cases have been documented where a body can be reduced to partial mummification and skeletonisation within four days (1997, p. 176).

At the other end of the climatic scale, Spennemann and Franke have carried out work on the small atolls in the tropical Pacific. The area has improved conditions for bacterial growth and, with high humidity and rainfall, often has fast decomposition rates. They state that when bones are found they are often completely skeletonised and slightly eroded (1995a, p. 357). After 14 to 96 months full skeletonisation has usually occurred. Bones that have been interred for more than 20 months normally have some level of bone erosion (Spennemann & Franke 1995b, p. 70).
2.1.1.4.3. **Depth**

Rodriguez points out that burial depth is an important factor in the decay rate of bodies. Rodriguez notes that soil is a barrier for solar radiation and as such temperature and temperature variation decreases with depth. In burials of only 1.2 metres the temperature is almost constant, decomposition is slowed and predator depredation is halted (1997, p. 459).

2.1.1.4.4. **Human interference - embalming**

Not all bodies are buried immediately and this needs to be taken into account in decomposition studies. Throughout time bodies have been embalmed using chemicals which alter the decomposition process and can, for a time, halt it altogether. Nineteenth century embalmers used aluminium sulphate, potassium carbonate, copper sulphate, arsenic, zinc chloride and bichloride of mercury to preserve bodies (Berryman *et al.* 1991, p. 230). These elements, as well as those used by more modern morticians, could be found naturally in surrounding soils. If these chemicals can be found in the environment surrounding a body it could be possible that the body will be naturally embalmed leaving more remains to be detected using archaeological methods. There needs to be work carried out to see whether natural embalming from ground chemicals is indeed possible.
2.1.1.5. **Summary of decomposition variables**

There have been multiple decomposition studies conducted throughout North America and some in other countries. However, there needs to be more work done in other climates, such as those of Southeast Asia. One of the main problems with the study of decomposition and the publishing of this information is the amount of information that would relate to sensitive cases, particularly in the former Yugoslavia. In instances where trials are pending, much information would need to be suppressed. As such we are limited in the information available for research. Hopefully, this will change as cases are brought to an end and research results can be published in academic settings.

2.1.2. **Entomology studies**

Insect succession is directly linked to the process of decomposition. Due to this, entomological studies must be considered in any thorough examination of this issue, and the question surrounding the effects of climate and decomposition on grave locating techniques. Climate particularly effects insect succession with seasonality playing a major role. Introna *et al.* state that researchers must acknowledge that carrion fly assemblages are determined by many factors including geographic distribution and the microclimatic conditions of the study area (1991, p. 238).

Little work has been published on insect succession onto buried human remains. However, one study did look at the insect succession rates onto buried pig (*Sus scrofa*) carcasses. Payne *et al.* found that ants were present at the body within three to six hours of burial (1968, p. 1180). Also present were numerous flies and
maggots. Within 10 to 35 days the weight of the body had dropped to 40 percent of the original. This then dropped to 20 percent over the next six to eight weeks. In total there were 48 arthropod species found during these experiments, 26 of which were not found during above ground experiments (1968, p. 1181). However, it is worth noting that significant work has been carried out on above ground body placement.

Bharti and Singh carried out experiments to observe the insect succession rates onto rabbit carcasses in the Punjab region of India, an area with warm to hot maximum temperatures, warm minimum temperatures and some rain. This was done in each of the seasons in the region (2003, p. 1133). In total they found that 38 species of insect were present at the carcass, comprising of four orders and 13 families. Bharti and Singh also identified eight beetles, eight ants and a few species of spider (during the rainy season and autumn) (2003, p. 1143). The succession rate at higher temperatures was accompanied with rapid resource use, which meant that the faunal diversity was reduced. Similarly, the faunal diversity was reduced during winter because fewer insects are active during this time (2003, p. 1142).

Avila and Goff carried out a study to identify whether the succession rate onto burnt carrion was any different to that onto unburnt. They identified that the bloating stage occurred sooner in burnt carcasses leading to a faster succession in the rest of the stages. One possible explanation to this could be that metabolic gases were released through cracks in the skin, formed during the burning process (1998, p. 584). This is an important point as it could alter the timing of early decomposition stages which is vital if relying on arthropod succession for time of death.
Another study, in Southeastern Brazil, noted that a total of 14,113 insect species were present over the course of the study. This was largely made up of two specific types (Diptera (85%) and Coleoptera (12%)) (Lopes de Carvalho and Linhares 2001, p. 605). It was noted that these insects favoured natural body openings and hairy, moist areas of the body (2001, p. 606). This is important information to identify the stage of decomposition of the body. Certain species only arrive at certain stages. Insects play an important role in decomposition, as mentioned previously, so more work is needed in this area. This is particularly the case in below ground burials where little has been published for the benefit of other researchers in the field.

2.2. Location methods

2.2.1. Introduction

Throughout the history of archaeology there have been numerous methods used to locate both single and, more recently, mass burials. Some of the more prominent of these techniques are outlined in the sections below. The aim of this thesis is to establish how climate and decomposition impact on these methods. These concepts will be introduced in this chapter and then discussed further in chapter 5.

2.2.2. Historical documentation and eyewitness accounts

Having long been used in archaeological work, the consultation of historical documentation and eyewitness accounts is frequently used in the search for graves, whether they are clandestine graves or cemetery plots of the historical period. This is
supported by Brock et al. (1991), Owsley (1995), Nobes (1999, 2000), Davis et al. (2000), Jarvis (2002) and Mihajlovic et al. (2000). All of these authors mention the use of historical documentation and eyewitness reports prior to survey work being carried out. Not only do these documents help to narrow down the search area but, if accurate, can speed up the mapping of sites and so enable more areas to be searched.

One such study is that of Jarvis. Carried out in conjunction with the Cambodian Genocide Programme (CGP) and the Documentation Centre of Cambodia, the study is using historical records and eyewitness statements to map the areas of clandestine graves or places of torture (2002, p. 95). The results of the study hinge solely on the reliability of historical documentation, both of regions and periods in time.

This reliance on historical documents alone is the main disadvantage of this project, as with any other research project involving the use of these types of resources. Time can distort the memories of eyewitnesses causing important information to be forgotten. In these instances documents lose context and become less significant.

### 2.2.3. Visual recognition of ground changes

In studies of graves, vegetation changes are particularly relevant. Buried bodies may provide a better growth medium for surrounding plants which would mean that the area directly above and around the grave would have greater plant growth. Added to this, the disturbance of soil with digging equipment loosens the soil leading to easier root penetration. Alternatively, if the body is covered in stones or wrapped in plastic, the presence of the body could inhibit the growth of vegetation (Hunter 1996, p. 87).
When a body is buried there tends to be some soil that does not fit back inside the grave pit. This can be sighted if not scattered throughout the area (Hunter 1996, p. 88). Archaeologists and law enforcement officials need to be aware of this issue when conducting any search for a grave. Excess soil, unless taken away or hidden, can be found with careful investigation. Also, some signs of soil sinkage due to the decomposition of the body can be detected by the trained observer.

2.2.4. Photography

Photography is one of the hallmarks of most archaeological research and this is no different in the detection of graves or burials. Regardless of the form, all methods involve using film to take various images of sections of the earth and each can offer different advantages to the investigator. Aerial photography for archaeological purposes was first pioneered after World War I by O. G. S. Crawford (Riley 1982, p. 5). Over time various methods have been developed. These different methods, black and white, colour infrared, multispectral and thermal imagery, are briefly discussed below.

2.2.4.1. Black and White photography

This type of film is particularly sensitive to the red portion of the spectrum. This means that a faster shutter speed can be used, even through haze cutting filters (Mathien 1981, p. 70). The advantage of this is that more photographs can be taken. Hence, this type of photography is ideal for creating stereo pairs. Stereo pairs involve the taking of two photographs within seconds of each other in slightly
different locations. Through the use of a viewing device a three dimensional image can be viewed. In the Chalmette National Historic Park project, Mathien was able to use this technique to find depressions unidentifiable to the naked eye (1981, p. 79). Theoretically, this could be useful in the detection of unmarked graves.

2.2.4.2. Colour Infrared

This method is highly useful in locating bodies of water or areas that were at one stage boggy. Water absorbs infrared light and this registers as darker patches on the images (Mathien 1981, p. 70). Although not strictly for use as a grave detection device, this method could be useful in locating burials, as these sites may retain moisture longer than the surrounding areas.

2.2.4.3. Multispectral photography

One of the most flexible of all types of photography, this method takes multiple shots over different colour bands at the same time. This means that multiple shots can be taken in the same light and weather conditions, reducing the variables in the survey (Mathien 1981, p. 72). The disadvantage with this method is that there is no programme that allows the surveyor to view all photographs at the same time (Mathien 1981, p. 75).
2.2.4.4. Thermal Imagery

Thermal imagery measures the soil temperature changes with an infrared camera. It is best executed in the hours post dawn, as this is when soil cooling takes place. All information is recorded and is displayed in one of 256 shades of grey. The cooler the soil, the darker the image and the hotter the soil, the whiter the image (Davenport 2001, p. 89).

Although this method could be ideally suited to the location of graves, particularly clandestine mass graves, it is only of use while decomposition processes are taking place. Once the body/bodies have decomposed the method is of limited use (Davenport 1981, p. 90).

The following are some limitations placed on using photographic images (Davenport 2001, p. 88):

- Difficulties can be experienced in resolution (in differentiating between objects that are close together).
- The strength of the signal must be more than the strength of the background noise, such as wind and rainfall.
- Particularly occurring in the case of graves is the problem of distinguishing between disturbed soil and the surrounding undisturbed soil.
- If the target is too small it will not be easily detected.
2.2.5. Probes

Little work has been published on the use of probes to locate buried human remains. However, as probes themselves are inexpensive and non-intrusive, when compared to archaeological excavation (Owsley 1995, p. 736), they are ideal for use over smaller areas (p. 737).

Probing works by detecting differences in soil density felt by the operator. If a probe penetrates with little resistance it is often an indication of disturbed soil which may be linked with a burial (p. 738). While this technique has many possible applications in the field, Owsley mentions several disadvantages. The ground cannot be frozen, weather must be favourable, and the operator must be trained and experienced as well as being physically fit (p. 737). Despite all of these limiting factors, probing is one of the most useful tools in urban areas where GPR and electrical resistivity are often not suitable due to the high levels of metallic rubbish, leading to loud background noise (p. 738).

Owsley writes of specific cases where probes have been used with great success. In one case, where the body was located in only 20 minutes of probing (p. 738), and another, where a mass burial of four individuals was located in the corner of a basement firing range. In this latter case both informants and cadaver dogs had been used with no success (pp. 738 – 9).
2.2.6. The use of cadaver dogs

The use of dogs for searches has been increasingly common since 1974 (Sorg et al. 1998, p. 120). They are widely used for many types of searches including those for buried or hidden human remains (Lasseter et al. 2003, p. 1). Air scent dogs (commonly known as cadaver dogs) are the main type used in these searches and are trained to recognise the generic scent of human decomposition and then track this scent to its source (Sorg et al. 1998, Komar 1999, Lasseter et al. 2003,). The principle behind this is that of the scent cone. Molecules from the decomposing body escape through the soil and are distributed by the wind. The dog then picks up on this scent and is able to locate its origin (Lasseter et al. 2003, p. 1).

Harvey and Harvey carried out tests to establish whether bloodhounds can differentiate between two individuals. These trials were carried out in average humidity (ranging from 11 to 25%) and in temperatures ranging from 18 to 26°C (p. 812). It was found that if properly trained and experienced in detection work this is possible in almost one hundred percent of cases. In addition, bloodhounds could differentiate between the scent of two people over trails that are 48 hours old (p. 814). This is significant as it could help locate the clandestine grave of one individual.

The results from Komar’s study varied greatly compared to those of Harvey and Harvey. This study tested the ability of various dog breeds to detect scattered and scavenged human remains that were not visible to the naked eye. The overall recovery rate in these tests was 81% (1999, p. 406) with this increasing to 90 to 100% in tests with larger drifts of snow and cooler temperatures (1999, p. 407).
Komar demonstrated that dogs can be used to great effect in colder climates to locate human remains. However, Komar also established that it was necessary to train dog and handler teams in a variety of terrain and with a variety of human body elements (1999, p. 407).

Lasseter et al. carried out a similar study to Komar. This study was carried out in Tuscaloosa (Alabama), an area where climate is representative of a large proportion of the southeast region of the United States (2003, p. 2). Carried out in summer, temperatures ranged from 27.5 to 34°C during the study (2003, p. 3). The study tested the dog and handler team’s capability to detect buried remains at various stages of decomposition (p. 2) in varying localities ranging from grassy areas to dense woodland (p. 3). The results of these trials varied depending on the team and the time of day that the trial was held. In tests later in the day, teams had to work in the hottest part of the day. This meant that both the dog and the handler were hot and tired, reducing accuracy (p. 5). This is a severe limitation on this method of grave detection. If temperature or humidity is too high, the dogs encounter difficulty in finding the scent.

The overriding issue in cadaver dog searches is the ability of the dog to find the scent cone and follow it to its source. Also a factor is the handlers’ ability to recognise the alerts that the dog subsequently gives. As such, dispersal of the scent is vital. This can be affected by a number of variables. These include air temperature, humidity, wind, terrain, water and hydrology and soil type. Similarly, frozen ground can inhibit the scent, heat from the ground will release scent, extreme temperature will make the scent rise too quickly and dense, moist air will limit dispersal (Sorg et al. 1998, p. 122).
Cadaver dogs can be a useful method of locating human remains whether scattered out of sight or buried in clandestine graves. There needs to be more study in this area, particularly addressing varying climates and varying stages of decomposition. The literature has also highlighted the need for standardised training methods for the dogs used (Lasseter et al. 2003, p. 5).

2.2.7. **Ground Penetrating Radar (GPR)**

Ground Penetrating Radar (GPR) sends a nanosecond long pulse of electromagnetic energy into the ground, through one of two antennae. This pulse is then reflected off objects and this reflection is detected through another antenna. The time taken for this to occur is recorded and then converted to a depth measurement (Smith and Jol 1995, Buck 2003, Davis et al. 2000). This process is directly linked to soil water content. This determines signal velocity (Davis et al. 2000, p. 69). GPR can detect changes in water content of three percent occurring less than 15 centimetres in depth (Theimer et al. 1994, p. 179).

In order for accurate measurements to be taken the operator must first find out the signal velocity of the local area (Miller 1996, p. 649). This is done through locating an object of known depth and recording the time that the signal takes to reach the object and return. These figures are then put into an equation that gives the operator the signal velocity (Davis et al. 2000, p. 69). Without these figures the GPR survey cannot take place.

However, there are cases where GPR technology is particularly useful. This is the case in sandy dunes (not coastal marine) and hills, gravel, peat, some volcanic
material and coastal plains. The technique is of some use in urban areas to locate objects under cement (Miller 1996, p. 652). GPR is also of use on snow covered or frozen ground, where archaeological excavation is nearly impossible (Vaughn 1986, p. 595).

There are limitations in this technology, as with any other scientific method. As mentioned previously, the operator must know the local signal velocity but, perhaps GPR’s principle weakness is that it cannot penetrate clay. It can detect where there are gaps in the clay horizon though and, as such, the method is most commonly used for this (Wynn 1986, p. 251).

Sternberg and McGill carried out tests in the warm climate of southern Arizona on the usefulness of GPR in varying locations and varying types of archaeological site. In the Arizona basins the conditions are perfect for the use of GPR. There are high concentrations of sand (56 to 79%) and significant levels of water content (1995, p. 216). The mountain ranges in the area are also favourable for GPR with the area being largely made up of volcanic material (1995, p. 217). Throughout their study, Sternberg and McGill located several roasting pit sites and the GPR was easily able to detect the difference between plastered and non-plastered surfaces (1995, p. 219). It was also able to locate previously undiscovered anomalies (1995, p. 222).

Work on a Basque whaling station in Red Bay (Labrador) suggested that the GPR detected buried human remains in one area of the site. Probing of this section later revealed that the GPR findings were accurate (Vaughn 1986, p. 597). Later, further surveying of the area found that there were a number of anomalous zones throughout the area that could be burials. This was not substantiated because of time constraints.
so, while the researchers could not be sure that the anomalies were burials, the soil disturbances were of archaeological significance (Vaughn 1986, p. 597).

Davis et al. carried out experiments in Longyearbyen (Svalbard, Norway), an area with an arctic climate. In 1918 many people from Longyearbyen succumbed to ‘Spanish Flu’ (2000, p. 68). The aim of these surveys was to identify the graves specific to these victims, exhume the bones and take samples for virologic and bacteriologic investigations (2000, p. 68). The GPR was used to identify the depth of the burials. This was in some ways successful as the GPR showed that the ground was disturbed to a depth of two metres. Eventually, however, it was revealed that the graves themselves were only 1.2 metres deep (2000, p. 73). The GPR correctly identified the graves that researchers were looking for and also some other anomalies that could be unmarked graves (2000, p. 73). In this situation GPR proved to be a useful and fast tool for locating and identifying graves.

There are great possibilities for GPR in the locating of human remains in a wide range of environmental and climatic conditions. Although GPR is commonly applied in archaeological situations it is not always successful in finding evidence. However, the lack of evidence is still evidence, as GPR often shows us where there is nothing of archaeological value.

2.2.8. Electrical Resistivity

Resistivity surveys have been in use since the 1950s (Wynn 1986, p. 249). The process involves passing a small electrical current through the earth and measuring
the subtle sub-surface variations that arise. Resistivity is linked to moisture content and porosity (Gaffney et al. 1991, p. 2, Imai et al. 1987, p. 138).

Clay filled ditches and pits are detected as they give a low response (Gaffney et al. 1991, p. 2), making this method potentially good for locating burial shafts. Electrical resistivity needs to be subjected to further practical testing to establish the accuracy of the method to detect burial locations.

2.2.9. Electromagnetism and Magnetometry

2.2.9.1. Electromagnetism

Electromagnetic (EM) technology involves a current flowing into the ground from an electric loop and inducing a secondary EM field. This field is then collected by a second loop at the other end of the boom. This field needs only to pass near to an object for it to register a response (Nobes 2000, p. 717). EM work has been routinely used for mapping work for many years and has been highly successful in locating shaft tombs in Jordan and other parts of the Middle East (Wynn 1986, pp. 249 – 50). The Middle East as a region is dry with a warm mean temperature. In instances where graves are located in these areas the typical response appears as an anomalous positive response, occasionally with negative sidelobes (outer edge), or vice versa (Nobes 1999, p. 363).

Nobes suggests that one of the best uses for EM technology is to locate areas that are of potential interest for further searching (2000, p. 715). In his study he was working with law enforcement officials to locate a missing female victim. The body
was located in a grave approximately 1.2 metres deep in well drained sandy soil with a low water content (2000, p. 716). The initial search area was surveyed using the EM technology in conjunction with GPR. This survey area was organised using eyewitness testimony and no positive disturbances were found (2000, p. 718). This highlights the limitations of the use of eyewitness accounts, as mentioned in section 2.2.2., above. When the survey area was expanded the body was eventually located, using this method combined with GPR.

### 2.2.9.2. Magnetometry

Buck explains that magnetometers measure the earth’s magnetic field and highlight disturbances in this field. These disturbances are then investigated and identified (2003, p. 1). The magnetic anomaly detected can be from either the grave itself or from the edges of the grave and the way that this exhibits itself is dependant on whether the grave and its contents are more or less magnetic that the surrounding soil (Nobes 1999, p. 363). It is important to note that this method works best in areas with little or no vegetation. Also, any ferrous material will cause the results to be inaccurate (Gaffney et al. 1991, p. 8).

In Buck’s study the magnetometer was used in three different environments to attempt to locate graves and a clandestine burial. These environments were the hot, damp conditions of Hawaii, the cooler conditions of Texas and another unknown location with volcanic properties (2003, p. 5). In all three cases it was found that no distinct graves could be located due to the high levels of background noise from metallic rubbish at the locations and the presence of metal flower holders in one of the sites (2003, p. 5).
The use of a proton-magnetometer (working on the same concept as the aforementioned magnetometer) to locate graves in a historic period cemetery was successful and provided information concerning the general characteristics of the cemetery including the orientation of the graves (Brock & Schwartz 1991, p. 86).

### 2.2.10. Atomic Dielectric Resonance

One of the newest technologies on the market is Atomic Dielectric Resonance (ADR). Very limited work has been published in this field and information about its function is sparse. Radar World, a sales company in the United States, lists ADR as a radar controlled sensor and software system, capable of scanning down up to five kilometres and able to distinguish between different types of material in an archaeological setting (Radar World online, accessed 30/06/04). While this technology seems to be the technology that archaeologists have been waiting for, there is little published evidence that the method will be of use in locating graves. Because of this, results need to be questioned and work carried out and published before this technology is considered further. As a result this method will not be discussed in chapter 5.

### 2.2.11. Multidisciplinary approaches

Regardless of their field of expertise, many specialists will acknowledge that in order to successfully locate sites using any of the aforementioned techniques, there needs to be cooperation and interaction between experts (King et al. 1993, Mihajlovic et al. 2000, Nobes 1999, 2000).
One multidisciplinary approach to the problem of locating graves is that of ‘Project PIG’ carried out in Colorado in the United States (France et al. 1992, p. 1445). Colorado has a mild climate with the average monthly temperature reaching 17.9 °C and the mean minimum monthly temperature of 2.3 °C. It has a relatively high mean monthly rainfall and snowfall.

France et al. mention that there are a number of specialists involved with this study including botanists, entomologists, geologists, pedologists, aerial photographers, geophysicists, thermal imagery and soil gas specialists, taphonomists and animal specialists as well as cadaver dogs (1992, p. 1447). Designed to give law enforcement officials useful guidelines for locating clandestine graves, Project PIG utilised the above disciplines to create experimental situations of clandestine grave creation. Numerous pig bodies were buried in the survey area and information was recorded concerning the variables of the graves (1992). This NecroSearch project (France et al. 1997, p. 497) has been in operation since 1986 and is just one example of how different experts need to work together to locate these sites.

2.3. Summary

Although there have been numerous projects to locate graves throughout the history of archaeological research, there has been limited research addressing the effects of climate and decomposition processes across a range of environmental settings. The effects of various climatic conditions on the decomposition of human remains and their subsequent effect on location methods will be explored further in chapter 5.
3. Methods

3.1. Introduction

This thesis is a literature-based research project and throughout the course of the research process relevant journals, books and databases were consulted. In order to augment the findings from the literature a questionnaire was also sent to practitioners.

3.2. The use of questionnaires in archaeological studies

Increasingly, questionnaires and interview-surveys are being carried out as a part of archaeological research. This is particularly the case in modern material culture studies where projects have employed both interviews and archaeological analysis to formulate their results.

The Garbage Project (in Tucson, Arizona) is one of the best examples of the use of questionnaires in archaeological research. The project was started in 1973 and is still running to this day. It has surveyed over 7000 households thus far and compares both interviews and garbage analysis. This project has found that ‘front door’ responses are very different to ‘back door’ responses. For example there was a higher proportion of both cigarette packets and alcohol cans and bottles than would be expected from ‘front door’ responses (Rathje & Schiffer 1980, p. 34). This project exposes one of the problems with questionnaire based studies. The
information that people provide and the material remains that are actually present are often contradictions (Rathje 1984, p. 14).

The Garbage Project also encountered some limiting factors. Questionnaires were administered one on one which led to problems involving transport and, as very few of the undergraduate volunteers involved were bilingual, Mexican-American households had to be left out of the sample group (Schiffer et al. 1981, p. 72). Due to these limitations the project is not representative of a whole population, simply a proportion of it.

In the case of the questionnaire research in this thesis sensitive information is not requested and participants have the option not to answer a question if they so wish. Also, there are no limitations concerning where the questionnaire can be sent, as the questionnaire will be administered electronically.

3.3. Questionnaire design

While there is much research on decomposition and the specifics of location methods, there is little combining the two. In an effort to bridge this gap in my thesis research a questionnaire was designed to obtain information from practitioners using grave location methods (Appendix 3).

Questions aim to investigate where respondents have worked, how they have located burials, how successful these methods are and how many graves have been found using these methods. Also, have these graves been excavated, how many bodies have been recovered, how deep have these graves been, what level of preservation has been found and who has done the exhumation work (for full explanation of
questions refer to section 3.4. below). In order to most effectively use the information gained, respondents were asked to identify methods and other information according to country and region, so as to link the information to a known, or easily established, climatic pattern.

The questionnaire took the form of a descriptive survey, i.e. a survey which gauges people’s opinions (Oppenheim 1992, p. 38). This was considered the best way to determine individual’s opinions concerning the link between the thesis’ main variables (climate and decomposition) and the grave location methods that are commonly used. After further research into questionnaire design it was decided that questionnaires would be distributed via Email. Oppenheim (1992) indicates that the most effective form of questionnaire is an interview based questionnaire (p.81). The average postal questionnaires usually receive a 40 percent success rate (Oppenheim 1992, p. 81, Warwick & Liniger 1975, p. 129). Email delivery enabled the “one-on-one” aspect that an interview would contain, allowed individuals to respond with little effort and also enabled a world-wide sample. Email also allowed for a faster response rate when compared to other forms of questionnaire (Frazer & Lawley 2000, p. 3).

Questionnaires were sent to individuals who have been involved in the location of graves (Table 3.1). These contacts were made with the assistance of Dr. Soren Blau. In order to increase sample size additional responses were sought through the placement of the questionnaire on the British Association of Human Identification (BAHID) website.
Table 3.1 – Names and affiliations of questionnaire recipients

<table>
<thead>
<tr>
<th>Recipient name</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Timothy Anson</td>
<td>Adelaide University, Dept. Anatomical Sciences</td>
</tr>
<tr>
<td>Judy Birmingham</td>
<td>Sydney University, Dept. Archaeology</td>
</tr>
<tr>
<td>Professor Sue Black</td>
<td>University of Dundee, Dept. Anatomy and Forensic Anthropology/BAHID</td>
</tr>
<tr>
<td>Associate Professor Chris Briggs</td>
<td>University of Melbourne, Dept. Anatomy and Cell Biology/VIFM</td>
</tr>
<tr>
<td>Mr. Paul Chetham</td>
<td>INFORCE</td>
</tr>
<tr>
<td>Mr. Derek Congram</td>
<td>Unknown</td>
</tr>
<tr>
<td>Dr. Melissa Connor</td>
<td>PHR</td>
</tr>
<tr>
<td>Professor Margaret Cox</td>
<td>INFORCE</td>
</tr>
<tr>
<td>Dr. Corinne Duhig</td>
<td>Cambridge University/BAHID</td>
</tr>
<tr>
<td>Mr. Mirko Fernandez</td>
<td>United Nations (UN)</td>
</tr>
<tr>
<td>Dr. Rob Fitzpatrick</td>
<td>CSIRO Land and Water</td>
</tr>
<tr>
<td>Ms. Ambika Flavel</td>
<td>INFORCE</td>
</tr>
<tr>
<td>Dr. William Haglund</td>
<td>PHR</td>
</tr>
<tr>
<td>Mr. Ian Hanson</td>
<td>INFORCE</td>
</tr>
<tr>
<td>Mr. Phillip Mill</td>
<td>Ecophyte</td>
</tr>
<tr>
<td>Ms. Kate Oakley</td>
<td>AFP</td>
</tr>
<tr>
<td>Ms. Kathryn Powell</td>
<td>Adelaide University, Dept. Anatomical Sciences</td>
</tr>
<tr>
<td>Professor Mark Skinner</td>
<td>ICMP/Simon Fraser University, Dept. Archaeology</td>
</tr>
<tr>
<td>Mr. Jon Sterenberg</td>
<td>ICMP/INFORCE</td>
</tr>
<tr>
<td>Michael Travers</td>
<td>AFP</td>
</tr>
<tr>
<td>Emeritus Professor Richard Wright</td>
<td>Consultant</td>
</tr>
</tbody>
</table>

* For explanation of acronyms see Appendix 4.

3.4. The questionnaire

Questions 1 to 6 aimed to establish background information concerning the respondent, their training as well as the countries/regions in which they have worked. Of these six questions, question 3 established the countries/regions where respondents had worked. This was done so that connections could be made to the climates of those locations and then be applied to the decomposition rates of human remains. From these variables, assumptions will be made about the wider thesis question. Question 5, which asks the timeframe in which work was undertaken
(calendar years), could lead to insights concerning the possible application of newer techniques to cases. Also, question 6 aims to establish how successful the techniques that were employed actually were.

The next series of questions aimed to establish how grave age and depth and local climatic and vegetation conditions could have affected the results of searches for graves. Question 7 assessed the ages of the graves found. Time since burial is significant as it would establish the likely preservation of the body and therefore, how much of the body there was still left to find. As a by-product of question 7, the question will help to establish how much soil settling there would have been prior to detection work being carried out.

In order to understand local conditions for the areas where work was carried out question 8 established the local vegetation conditions. Vegetation conditions are useful in understanding ground conditions and their relation to location methods. This may lead to insights into how well techniques may have worked and might also lead to comments on other possible techniques that could have been utilized. Similarly, question 9 established the climate and weather conditions during location work. This question was designed to gain an understanding of the limitations and pressures placed on both the equipment and the operators. This question, when combined with question 10 (establishing the methods that were used), enabled an assessment of how other techniques may have been useful. Question 11 was designed to establish who carried out the location work. Through this it was discovered whether trained personnel were used. This question was also designed to lead to a hypothesis concerning the accuracy of results. Question 12 asks the respondent to assess the success rate of the techniques and questions 13, 14 and 15 all attempted to
discover if there were other techniques that could have been used to get different or better results. These questions were all designed so that the respondent could look at their work with hindsight and suggest ways that better results could have been achieved.

The aim of question 16 was to discover whether excavations were carried out. This was useful as it gave information concerning the preservation of the body which could then be used to make correlations to the technique/s used. Question 17 was included for much the same reasons as question 11, to establish who carried out the actual work. The next series of questions also related to the grave conditions.

Question 18 gave an approximation of grave depth which could then be used to make further assumptions as to the effectiveness of techniques. Similarly, question 19 aimed to establish the number of bodies per grave in an effort to better understand preservation and the possible effect of these factors on the techniques used.

Question 20 was designed to identify different levels of preservation to establish whether this had any affect on the techniques used. In order to get the widest variety of responses many different possibilities were given to respondents. Question 21 continued from question 20 to gain the respondents opinion on whether body preservation actually affected the results of the techniques used.

Questions 22, 23 and 25 were designed to obtain information concerning what information had been published on the topic of grave detection. Question 24 was designed to establish whether copies of unpublished information could be accessed.
3.5. Analysis of results

Results were reviewed using a spreadsheet programme. Information from the questionnaire responses was converted to frequency information and was then displayed visually. Other information was put into tabular form. No statistical analysis of the results was carried out in this thesis.

Information was grouped into the categories of results of background research, the results of the questionnaire, including response rates, respondents professions, techniques used, graves numbers and body numbers, country specific information and, finally, the results pertaining to the thesis question from the respondents point of view. This information was all then discussed in chapter 5.
4. Results

4.1. Results of questionnaire

The different aspects of the questionnaire results are outlined in the following sections.

4.1.1. Response rates

Of the 21 people to whom questionnaires were emailed, 9 (43%) did not respond. In total 12 people (57%) did respond, however only 6 (29%) of these completed and returned the questionnaire. The remaining people either promised to complete the questionnaire or replied to tell me that they would be unable to do so (Figure 4.1).

Figure 4.1 – Responses to the questionnaire
4.1.2. Respondents

In total there were 6 people that completed and returned the questionnaire. Half of these people were forensic anthropologists (50%). The remaining professionals included a biological anthropologist, a forensic archaeologist and an archaeologist/surveyor (16.67% each) (Figure 4.2).

![Figure 4.2 – Questionnaire respondents professions](image)

4.1.3. Climate and vegetation

The responses relating to climatic and vegetation conditions where graves have been located and bodies recovered are detailed in Table 4.1. In the cases of Australia and the former Yugoslavia (the name used by participants who did not name specific countries in the region) there are multiple entries. This indicates either different locations, in the case of Australia, or work carried out by different people, in the case of the former Yugoslavia.
Table 4.1 – The weather/climate and vegetation conditions and grave depths of each country where a questionnaire participant has worked

<table>
<thead>
<tr>
<th>Country</th>
<th>Grave depth</th>
<th>Weather/Climate during work</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>&lt;1m</td>
<td>Dry</td>
<td>Desert like</td>
</tr>
<tr>
<td>Australia</td>
<td>1.83m</td>
<td>Fine, cold</td>
<td>Clover, grass</td>
</tr>
<tr>
<td>Australia, Adelaide</td>
<td>0.9m – 2.26m</td>
<td>Clear, dry, hot</td>
<td>Cemetery</td>
</tr>
<tr>
<td>Australia, Torrens Island</td>
<td>N/A</td>
<td>Clear, dry</td>
<td>Low vegetation</td>
</tr>
<tr>
<td>Bosnia</td>
<td>0.5m – 3m</td>
<td>24 – 32°C</td>
<td>Dense, high growth</td>
</tr>
<tr>
<td>Canada</td>
<td>Surface</td>
<td>Seasonal</td>
<td>Dense vegetation</td>
</tr>
<tr>
<td>Croatia</td>
<td>0.5m – 2m</td>
<td>Snowfall</td>
<td>Dense, high growth</td>
</tr>
<tr>
<td>East Timor</td>
<td>0.5m – 1m</td>
<td>Dry, hot</td>
<td>Monsoonal, scrub</td>
</tr>
<tr>
<td>Former Yugoslavia</td>
<td>&lt;3.66m</td>
<td>Extremes of cold and hot</td>
<td>Varied</td>
</tr>
<tr>
<td>Former Yugoslavia</td>
<td>1.5m – 2.5m *</td>
<td>Dry, sometimes rain</td>
<td>Glades, meadows</td>
</tr>
<tr>
<td>Former Yugoslavia</td>
<td>2m – 3m</td>
<td>Varied</td>
<td>Varied</td>
</tr>
<tr>
<td>Former Yugoslavia</td>
<td>2m – 3m</td>
<td>Varied</td>
<td>Varied</td>
</tr>
<tr>
<td>Grenada</td>
<td>1.83m</td>
<td>Dry, 25°C+</td>
<td>Grass</td>
</tr>
<tr>
<td>Iraq</td>
<td>1.83m</td>
<td>Dry, hot</td>
<td>Naked sand</td>
</tr>
<tr>
<td>Italy</td>
<td>&lt;3.66m</td>
<td>25°C+</td>
<td>Farmland</td>
</tr>
<tr>
<td>Kosovo</td>
<td>1m – 2m</td>
<td>?</td>
<td>Dense, high growth</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>1m</td>
<td>90% humidity, extreme heat</td>
<td>Jungle, dense, high grasses</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>1.83m</td>
<td>Dry, 40°C+</td>
<td>Naked soil</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Varied</td>
<td>UK range</td>
<td>Varied</td>
</tr>
<tr>
<td>United States of America</td>
<td>1.83m</td>
<td>Humid, 30°C+</td>
<td>Garden</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>0.5m – 2m</td>
<td>Clear, dry, hot</td>
<td>Low open scrub</td>
</tr>
</tbody>
</table>

N/A = not applicable, no excavation work carried out
? = no information provided
* can be 3m, 4m, 5m

4.1.4. Techniques

The techniques used for detection work were tabulated using the frequency that each technique was mentioned in the responses to the questionnaire. Figure 4.3
demonstrates the frequency that different techniques were mentioned as used in work by the respondents. The results of this section of the questionnaire showed that the most widely used methods of grave location were both the use of documentary evidence and eyewitness reports (29%) and the use of the surface scrape method as well as digging test pits (23%). The use of the probe was also reported as frequently used (10%) and visual recognition of vegetation changes also had a high percentage of usage (17%). Photography was also listed as a method (6%) and geophysical techniques such as resistivity (6%) and GPR (4%) were also used. Cadaver dogs were reported as the least frequently used by questionnaire respondents (2%).

**Figure 4.3** – The frequency of techniques used by questionnaire respondents

The table below demonstrates the range of techniques used in each country by the questionnaire respondents.
Table 4.2 – Techniques employed to locate graves according to country

<table>
<thead>
<tr>
<th>Country</th>
<th>Techniques used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Eyewitness reports, visual recognition of ground changes.</td>
</tr>
<tr>
<td>Australia</td>
<td>Electrical resistivity, GPR, historical documents, surface scrape, probe</td>
</tr>
<tr>
<td>Bosnia</td>
<td>Satellite photography, eyewitness reports, visual recognition of ground changes, surface scrape and test pits, intelligence</td>
</tr>
<tr>
<td>Canada</td>
<td>Eyewitness reports, visual recognition of ground changes.</td>
</tr>
<tr>
<td>Croatia</td>
<td>Satellite photography, eyewitness reports, visual recognition of ground changes, surface scrape and test pits, intelligence, probe</td>
</tr>
<tr>
<td>East Timor</td>
<td>Eyewitness reports, visual recognition of ground changes.</td>
</tr>
<tr>
<td>Former Yugoslavia</td>
<td>Eyewitness reports, visual recognition of ground changes, cadaver dogs, probe, surface scrape</td>
</tr>
<tr>
<td>Grenada</td>
<td>Located in a cemetery</td>
</tr>
<tr>
<td>Iraq</td>
<td>Intelligence</td>
</tr>
<tr>
<td>Italy</td>
<td>Digging</td>
</tr>
<tr>
<td>Kosovo</td>
<td>Satellite photography, eyewitness reports, visual recognition of ground changes, surface scrape and test pits, intelligence</td>
</tr>
<tr>
<td>Serbia</td>
<td>Probe, surface scrape, resistivity, GPR</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>Intelligence, probe, surface scrape, visual recognition from the air</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Varied</td>
</tr>
<tr>
<td>United States of America</td>
<td>Intelligence</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>Surface scrape</td>
</tr>
</tbody>
</table>

4.1.5. Graves and body numbers

It is important to note in this section that more work has been carried out in some countries than others. For example, more exhumations have been undertaken in the former Yugoslavia than Afghanistan. The reader needs to bear this in mind when reviewing these results, because a greater number of case histories could lead to more accurate results. Throughout the next section of this chapter mass will be used
when the number of bodies per grave reaches over 10, *multiple* when the number of bodies is four plus, *double* meaning two bodies and *single* meaning one body. The values of each term have been assigned for this thesis alone and have no basis in other sources of information. Also, the information contained in this section relates to excavation work.

Each country that the participants of the questionnaire have worked in has different grave conditions and these are displayed in two different figures below. Figure 4.4 shows information for single, double and multiple graves whereas Figure 4.5 only illustrates information concerning mass graves.

Whereas participant work in East Timor has been mainly on single graves, work carried out in Croatia has encompassed both single and mass graves, the latter incorporating an average of 40 bodies per grave. Participants responding to the questionnaire who have worked in Bosnia and Afghanistan indicated that the work was mainly on mass graves each of 100 plus bodies. However, in Afghanistan there was also some work carried out on single graves. Participants have also carried out work on mass graves in Serbia and Grenada.

On the opposite end of the spectrum all the work carried out by participants in Australia and Canada has been on single graves, in the case of Australia all in cemetery situations. This is also the case in Uzbekistan, the United States of America, the United Kingdom, Italy and Iraq. In Kosovo and Sierra Leone participants in the questionnaire all wrote that they had carried out work on multiple graves. This was also the case with those respondents that had worked in the former Yugoslavia, only on a much larger scale. Respondents wrote that they have carried
out work on hundreds of multiple graves in that region, averaging at ten bodies per grave.

**Figure 4.4** – The number of graves and the average number of bodies per grave per country (does not include mass graves)

![Graph showing the number of graves and the average number of bodies per grave per country.](image)

* Where the figure is 100, this means hundreds

**Figure 4.5** – The number of graves and the average number of bodies per grave per country (only mass graves)

![Graph showing the number of graves and the average number of bodies per grave per country.](image)

* Where the figure is 100, this means hundreds
4.1.6. Respondents opinions

As part of the questionnaire respondents were asked to assess whether they thought that climate and decomposition affected the techniques that they used to locate graves. The majority of participants were of the opinion that climate and decomposition did not affect grave location methods (Figure 4.6). One of the participants that responded positively gave the reason that the more flesh that is present the less archaeological recovery will be made. The other said that both the smell of decomposing bodies and the carrion birds overhead suggested the presence of a grave.

Figure 4.6 – Respondents opinions on whether climate and decomposition affected grave location techniques

*Note n = 7 because one respondent had differing opinions due to different cases indicating different responses.
4.2. Summary of results

Of the 21 questionnaires sent out, 29% (6) were returned. The questionnaire received responses from four different professional groups working in a variety of different countries.

Just as the questionnaire gave information concerning the climatic conditions of each country, it also secured information concerning the average grave conditions for each country that the participants have worked in. While participants that carried out work in Serbia and Grenada said that they worked extensively on mass graves, those who worked in Australia said that all work was carried out on single graves in cemetery situations.

The questionnaire information identified that the most widely used methods of grave location were the use of documentary evidence and eyewitness reports (29%), surface scraping and the digging of test pits (23%) as well as identifying vegetation changes (17%).

Finally, the results of the questionnaire in relation to the thesis question itself revealed that most respondents felt that climate and decomposition did not have any affect on the techniques that were used to locate graves (71%). These findings will be discussed in chapter 5.
5. Discussion

5.1. Introduction

While it is acknowledged that climate has a significant effect on decomposition, the issue of whether climate and decomposition have an effect on grave location methods has been minimally addressed in the literature. Considering each location technique separately, this chapter compares and contrasts the existing literature with responses from the questionnaire and examines the relationship between climate, decomposition and grave location techniques. The limitations of the techniques are tabularised in Appendix 5.

5.2. Historical documentation and eyewitness accounts

The use of eyewitness reports and historical documentation is recognized as possibly the most useful method of grave location employed today, both by published research and the respondents to the questionnaire. Professionals from different fields all utilise these resources and have had significant results with them. Climate and decomposition are not limiting factors for eyewitness reports and historical documentation because these forms of evidence are generally recorded at the time of the grave being created. Climate may have a detrimental effect in cases where witnesses have been viewing events in poor weather. Alternatively, if events were recorded or viewed in good weather the description of locations may be of better quality. As such, the climatic conditions of the present have little effect on them.
Climate may effect the interpretation of reports, such as if there is increased vegetation or if key landscape attributes, such as large trees, are removed it may be more difficult to locate a site. Similarly, in cases where snow covers the ground, features may be unidentifiable.

Respondents to the questionnaire who employed eyewitness reports or intelligence to locate graves noted that in only a few cases did the information offered by eyewitnesses not lead to correct location of a grave. In these cases the reason for this was not climatic influence but the eyewitnesses not accurately remembering events.

5.3. Visual recognition of ground changes

Decomposition, while not having an effect of the use of eyewitness reports or historical documentation, has a significant effect on the visual recognition of ground changes. Settling of dirt into the grave as the body decomposes and decreases in size is a common indicator that a grave is present. As a body decomposes it first fills with gasses which cause it to bloat and so push up the soil above it. When these gasses disperse the resulting shrink in size causes that soil to then sink back into the grave leaving a sometimes obvious depression. This depression is one of the key signs that archaeologists look for when surveying land. While body decomposition is the cause of ground sinkage, climate is also directly linked. Climate has a pronounced effect on the decomposition of human remains and as such effects the visual recognition of changes to the ground.

Vegetation growth is also greatly affected by climate and decomposition. The changes in vegetation growth patterns can be seen by surveyors and can indicate the
presence of a grave or graves. While the specifics of vegetation growth (i.e. whether increased or decreased) are dependent on the depth of the grave and also the body composition, they are also dependent on the stage of decomposition and the length of time that the body has been buried. If the grave is recent, vegetation growth may be significantly reduced when compared to the surrounding area. Although climate may not have a direct effect on this method of grave location it does effect decomposition.

5.4. Photography

Photographic methods are also employed by archaeologists and other professionals to visually identify ground changes and therefore locate sites. While much is written in the literature about the employment of this technique, photography only accounted for 6% of the techniques utilised by questionnaire respondents.

All methods of photography utilised for the detection of ground features (black and white photography, colour infrared, multispectral photography and thermal imagery) utilise aerial photography to record images so high wind speeds can cause camera equipment to shake and so ruin photographic images. However, although this may occur, modern equipment goes a long way in reducing this problem.

Vegetation can often obscure the view of important features, such as depressions in the ground or areas of high moisture, but this issue cannot be corrected. The colour infrared technique detects moisture content and as recent graves retain moisture for longer than the surrounding soil the ability to see the ground is particularly important. If the grave is located in dense vegetation it might not be located using colour infrared. Thermal imagery, on the other hand, detects changes in soil
temperature. In this case vegetation cover may not have as much of an effect on results. During the decomposition period of a body the processes at work produce a lot of heat which could be detected using thermal imagery. Climate has a significant effect on decomposition, which in turn, has a considerable effect on the results of thermal imagery.

5.5. Probes

According to the literature, probing is one of the techniques that is not greatly effected by climate or decomposition. Climatic variables such as weather affect the ground conditions so, in some cases, such as frozen ground, the probe may not be able to penetrate the ground. Despite this, published information only rarely mentions its use, whereas the probe was one of the methods most frequently used by practitioners (10% of techniques used). It is interesting to note that, although not commonly mentioned in published reports, the probe is one of the quickest and cheapest methods of grave detection and delineation. One questionnaire respondent pointed out that the technique is quick and requires no specific training other than being able to recognise soil density changes.

Probing is relatively non-intrusive when compared to archaeological excavation so would be ideal for large or small scale projects to locate graves, particularly when working with a small budget. Why this method is not often mentioned in published papers is not known. One reason for the lack of published information concerning the use of the probe could be that the method is not viewed well by the academic community because it is an invasive method. It is possible to cause damage to remains through the use of the probe. Questionnaire respondents commonly use the
probe but mention that they do not publish much of their project information. Consequently there is little published evidence for use of this method.

5.6. The use of cadaver dogs

Perhaps the most climate sensitive method of grave or body location is the use of cadaver, or air scent, dogs. Although dogs can work in regions with low humidity levels, as soon as the humidity gets too high the dog starts to experience difficulties in locating the scent. In high humidity areas the dog pants too much to properly smell any scent. Climate has a significant negative effect in the case of cadaver dogs, rendering them useless in certain climatic zones. Alternatively, success has been gained in tests where dogs have had to locate bodies deposited under large drifts of snow. Again, though, this reduces the areas where dogs can be of use detecting graves.

The dispersal of the scent of the decomposing body is vital in the employment of dogs for searches. Frozen ground or air that is too moist will limit dispersal of the scent. Alternatively, if the ground is too hot the scent will rise too quickly and the dog will not be able to detect it. Here, the climate of the search area plays an important role in the utilising of this method of detection and conditions on the ground need to be assessed before work commences.

While the literature suggests that cadaver dogs are widely used, the questionnaire respondents replied that in only 2% of cases they employed them in searches. One reason for this discrepancy could be the type of professional that the literature concerns. In many cases the literature was discussing the use of dogs in relation to
Cadaver dogs may not have been employed as readily for archaeological work. There needs to be further research to identify whether cadaver dogs can be of significant use in archaeological cases.

5.7. Ground Penetrating Radar (GPR) and geophysical techniques

GPR is one technique that has shown good results in varying climates around the world. Although the technique relies on soil water content to attain results it has successfully located graves in Arizona (an area of high sand content with significant moisture content), Red Bay in Labrador (with a cool climate and situated on the coast) and has had significant success in Longyearbyen (Norway) operating in frozen ground. The results would seem to suggest that climate is not a limiting factor for GPR. Although it has had success in varying climates, GPR is still affected by soil water content which in turn is affected by climate. In this way climate could have an effect on GPR, although practical results would seem to refute this.

The effect that climate has on electrical resistivity is similar to that on GPR. Although climate does not directly affect the method, resistivity is linked to water content and porosity, which are also linked to climatic variables. Because of this link there are some limitations placed on the technique but, as with GPR, climate is not one of them.

Most of the methods used by the questionnaire respondents were done so with success. However, in some cases the techniques used had no success, such as GPR and electrical resistivity at St. Mary’s Cemetery in Adelaide, South Australia where both methods had negative results due to extensive ground disturbance from olive
tree roots as well as background noise. The problem of extensive ground disturbance needs to be taken into account when planning search operations.

Climate has little effect on electromagnetism either, with successful searches being carried out in Jordan for many years. Similarly, successful searches have been undertaken in areas in the United States. Published information suggests that the technique is of use in areas with low water content. However, there is no information to suggest that the technique does not work just as successfully in areas of high water content. While background literature mentions electromagnetism quite frequently, the questionnaire respondents did not record this method as one that they had used. Electromagnetism is only indirectly affected by climate and is not affected by decomposition so would be a good method for detecting graves.

Magnetometry is most greatly affected by the presence of ferrous materials, a variable not affected by climate. Indirectly climate does affect magnetometry though. Vegetation conditions have a considerable effect on the technique. To efficiently scan the area there needs to be little or no vegetation present. As climate is directly linked to vegetation there is an indirect effect on the technique.

Whereas background research highlighted electromagnetism and magnetometry as methods of grave detection, the questionnaire respondents did not list these methods as being ones that they use to detect graves. Reasoning for this could be the expense of the technology. The most commonly used techniques, according to the results of the questionnaire, are amongst the cheapest methods available. These techniques (reports and documentation, digging and surface scrape, visual recognition of ground changes and the use of the probe) are all methods that require little financial assistance and are able to be carried out using only a few people. Magnetometry and
electromagnetism on the other hand require specialists to operate equipment as well as the hiring or purchasing of machinery. These could be financially straining to a research and/or operational budget.

Table 5.1 – Techniques and whether they are affected by climate and decomposition

<table>
<thead>
<tr>
<th>Technique</th>
<th>Affected by climate</th>
<th>Affected by decomposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyewitness reports and historical documentation</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Visual recognition of ground changes</td>
<td>Y, I</td>
<td>Y, D</td>
</tr>
<tr>
<td>Black and white photography</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Colour infrared</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Multispectral photography</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Thermal imagery</td>
<td>Y, I</td>
<td>Y, D</td>
</tr>
<tr>
<td>Probes</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>The use of cadaver dogs</td>
<td>Y, D</td>
<td>Y, D</td>
</tr>
<tr>
<td>GPR</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Electrical resistivity</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Electromagnetism</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Magnetometry</td>
<td>Y, I</td>
<td>N</td>
</tr>
<tr>
<td>Multidisciplinary approaches</td>
<td>N</td>
<td>Y, D</td>
</tr>
</tbody>
</table>

Y = yes, N = no, I = indirectly, D = directly

5.8. Multidisciplinary Approaches

The results of the questionnaire suggested that many of the techniques of grave location are either directly or indirectly affected by climate and decomposition (Table 5.1). In order to combat the effects of climate and decomposition on grave location methods, a multidisciplinary approach can be adopted. Through the use of a multidisciplinary approach specialists from many different fields of research can be brought together to better utilise the methods available.
However, there were discrepancies between the background research and the results from the questionnaire relating to the multidisciplinary approach to grave location. While some respondents mentioned that they used multiple techniques in their work they did not detail the work that had been carried out by members of a different professional group. Most mentioned that others had carried out some of the searching work but did not provide details. In contrast, many authors (King et al. 1993, Mihajlovic et al. 2000, Nobes 1999, 2000) identify cooperation between professionals as one of the best ways to achieve positive results. It would have been more valuable to have a section of the questionnaire dedicated to understanding what other professionals have done to contribute to respondents work.

Whenever a project is planned or a technique utilised in the field, variables need to be assessed and their effects minimised wherever possible. Because of this a multidisciplinary approach tailored to individual site conditions is the most constructive method of grave location.

5.9. The effects of climate and decomposition on location techniques

The literature indicates that climate effects decomposition which in turn has an effect on the usefulness of some location techniques. In both thermal imagery and the visual recognition of ground changes, decomposition plays an important role. However, while thermal imagery requires the heat of decomposition processes to detect the grave, other methods do not. Decomposition of human remains has no effect on most of the techniques that are used by practitioners today.
It is interesting to note that while decomposition only affects a couple of grave location methods (i.e. thermal imagery and the visual recognition of ground changes) this effect is often a positive one. In these cases decomposition leads directly to the location of the site and because of this decomposition is required. However, climate is nearly always a negative effect either limiting the effectiveness of the technique or causing problems for the use of the technique. Because of these positive and negative effects, multidisciplinary approaches should be favoured for grave location projects as the effects of climate can be reduced while the positive effects of decomposition can still be achieved.

Questionnaire recipients were asked whether they thought that climate and decomposition affected the techniques that they had used to locate graves. There were seven responses to this question, from the six respondents, as one answered differently for two cases. In total 71% (5) said that they did not think that these variables affected the techniques utilised. However, two people (29%) said that, in their opinions, the variables of climate and decomposition made a significant difference to grave location methods.

The first of these participants said that, in a case in Sierra Leone, searchers were alerted to the presence of bodies because of an overpowering scent of decay and the sight of carrion birds overhead. The first of these factors is linked to the climatic conditions of the time (90% humidity and extremely hot) which enabled decomposition processes to advance faster than in cooler conditions. This then led to the presence of carrion birds and hence, detection of the bodies.

It is believed that the second of the positive answers was a misinterpretation of the question. The answer that was given was that the more flesh that is present the less
archaeological recovery will be made. This answer could indicate that the respondent felt that archaeological techniques were of less use in detecting graves with bodies that still had a large proportion of soft tissue. The answer tends to lend itself to the conclusion that it was a misunderstanding of the question, though.

In light of the questionnaire respondents answers, it is easy to suggest that there is no connection between the variables mentioned above and grave location methods. However, as has been seen, there are some methods that rely on decomposition for their results and others that are directly affected by some environmental conditions. The results of this section of the questionnaire are broad and are in no way technique specific. This could account for the negative response. These issues will be discussed in more detail later in this chapter.

5.10. Countries, graves and body numbers

The results of this section of the questionnaire were mixed, indicating the diverse range of fieldwork carried out by the respondents. Whereas background research revealed little about some countries, the results from the questionnaire demonstrated a wide range of work carried out in diverse countries. While background research gave much information on countries such as the United States, it gave little on countries such as Grenada and Sierra Leone. The results of the questionnaire clearly illustrate the wide variety of countries where forensic archaeological work has been carried out.

Respondents to the questionnaire had collectively worked on every type of grave (single, double, multiple and mass). In total there were 16 countries where
respondents had worked and of these there were eight countries where single graves were examined, with mass graves also being uncovered in one of these countries (Croatia). Double graves were only worked on in one country, the United Kingdom, while multiple graves were looked at in four cases. Mass graves were the second most commonly recorded grave type, being worked on in Afghanistan, Bosnia, Croatia, Grenada and Serbia. This wide variety of countries gives a good cross-section of work carried out in the area of grave location and makes it easier to apply the effects of climate and decomposition to the techniques that have been used.

Decomposition is important when reviewing information concerning grave type. There are differences between the decomposition of a body in a single or double grave when compared to those in a mass grave. The bodies in a mass grave decompose at very different rates to those in single graves. It is not uncommon to find bodies in the early stages of decomposition close to those that have almost completely decomposed (Mant 1987, p. 66). This fact has ramifications for some of the aforementioned location methods. For example, thermal imagery is only of use when decomposition is taking place. Whereas a single grave is only in this stage for a short amount of time, the decomposition processes are extended in mass graves. This could mean that there is a wider window of opportunity to detect the grave using thermal imagery.

Another technique that may be of greater use in the detection of mass graves is visually recognising ground changes. Mass graves disturb a larger area of ground and so have a bigger effect on the surrounding area. Also, more left over soil would remain after backfilling the grave. If this soil has not been taken away it will be
easily identified. All of these factors need to be assessed when work is being carried out in the field.

5.11. Other grave types and methods used

Perhaps not surprisingly, some of the information gained through the questionnaire concerned graves that were located in a cemetery. Frequently, location work is carried out to locate unmarked graves within the grounds of a cemetery, in cases where headstones are no longer present and maps of grave sites are not available. This use of techniques is supported by the literature and is a key element of some streams of archaeology.

One respondent reported that the techniques used were too varied to list. This answer was given as a response concerning the techniques used in one country. Obviously, during the course of a career in grave location the number of techniques used would be significant. However, information concerning the methods used would have been of use for this thesis.

5.12. Limitations

5.12.1. Questionnaire layout and question formation

The question formation process for the survey section of this thesis was the integral part of the research. Initially it was thought that the questionnaire was easy for potential respondents to understand. However, upon discussing the questionnaire with one respondent it was realised that this was not the case. One respondent also
said that the questionnaire layout was difficult to understand. Warwick and Liniger point out that, in mail questionnaires, if a question is not understood the tendency is to skip over it completely (1975, p. 129). This problem could have been combated by having a more thorough introduction to the questionnaire explaining the recording structure and the country number system that the questionnaire employed. This may have reduced the amount of confusion that this system brought about.

Two of the questions included in the questionnaire should have been re-worded or expanded upon before being included in the final questionnaire. Question 20 gives multiple options concerning the condition of bodies after excavation work had revealed them. This question allows for all but one possibility, that being the presence of skeletal remains and keratinous tissue (hair and nails). This was given as a response and, because there was no category listed for it, the answer was difficult to place in the analysis process.

Question 21 asks the respondent whether they thought that climate and decomposition affected the techniques that they used. There should have been another question after this asking for an explanation for their answer to question 21. This would have been of more use to the project.

Question 24 asked if the respondent was willing to provide me with unpublished information. Details of the information required should have been stated more clearly. This made it difficult to request information. An additional question asking the respondent to list unpublished information they were willing to share would have been advantageous.
5.12.2. Responses and respondents

The response rate for the questionnaire was very varied with a large negative response rate. In total 43% (9) of potential respondents did not reply to my initial email. In one case one recipient sent a negative response to me and sent a copy of this response to colleagues, resulting in three negative responses.

Partial blame for the low response rate could be the mode of distribution of the questionnaire. The mail questionnaire is well known for its low cost of distribution but also for the low response rate (Warwick and Liniger 1975, p. 131). Studies of questionnaire creation and distribution have made observations pertaining to response rate. In cases where there is a large amount of work required to complete the questionnaire there is a low response rate. In questionnaires with a personal touch, such as a personalised letter, there is a higher response rate. Similarly, if the questionnaire recipient has an interest in the research topic the response rate will be higher (Warwick and Liniger 1975, p. 132). Theoretically then, the questionnaire should have received a higher response rate than was experienced.

Future research involving questionnaires would contact a larger pool of professionals in order to gauge who would be willing to participate in the questionnaire. These people would be asked how they would wish to complete the questionnaire, either through post or email. Those that wished to carry out the questionnaire via post would be forwarded a copy with complete return postage and the questionnaire would be emailed to those that inclined to complete it that way. Finally, more follow up emails should be sent out to ensure that people did not forget about the
questionnaire. This method would have achieved a higher positive response rate and would have led to better results.

Amongst the six respondents that did complete and return the questionnaire there were four different fields of expertise. In total there were three forensic archaeologists (50%), one biological anthropologist, one forensic anthropologist and one archaeologist/surveyor (each 17%). This gives a useful cross-section of different professional groups.

Each of the aforementioned specialists would have a slightly different understanding of the complex variables involved in the thesis topic. Whereas the forensic anthropologist might be present at the exhumation they play no part in the on site work. They are responsible for identification and time since death analysis in the laboratory. The forensic archaeologist focuses on the application of archaeological methods to locate and retrieve human remains (Byers 2002, p. 9). The biological anthropologist studies humans as a biological species and the archaeologist studies human cultural past and is involved in the reconstruction of past cultures (Park 2002, p. 447). Because of these different fields of expertise it is likely that people who are forensic anthropologists would have different experiences to those people from the field of archaeology. Different job descriptions could be attributed to educations from different countries and educational institutions.

5.13. Summary

Although the questionnaire has provided some useful information concerning the unpublished work that is taking place to locate graves today, questions concerning
the location methods used were not specific enough and, consequently, the
information available to work with was broad. Background research and
questionnaire responses illustrated a wide variety of techniques used for the detection
of graves. However, there were some discrepancies between the two sources of
information. While the questionnaire respondents acknowledge the effect of climate
on decomposition they do not think that these variables have a significant effect on
the techniques used to locate graves.

The idea that decomposition is not an exact science is one of the concepts that has
surfaced from this and other research. Climate has a significant effect on the time
and sequence of decomposition processes. In most burial situations the stages of
decomposition are delayed, due in part to the reduced oxygen levels and also the
physical restriction of the body from flies and other insects. Also, because the
temperature below ground remains largely constant decomposition is slowed.

It is interesting to note that, in some cases, the results from the background research
and those of the questionnaire do not correspond. Whereas background research
indicated that both electromagnetism and magnetometry were used to locate graves,
the respondents of the questionnaire have never used these techniques, despite
considerable experience searching for graves. The failure of respondents to mention
some techniques could indicate a financial restriction on work carried out or simply a
personal desire not to use these methods.

In some cases (e.g. GPR) the practical results seem to refute some of the ways that
climate may affect the techniques. GPR seems to be unaffected by climate or
decomposition despite it being affected by moisture levels, which are indirectly
affected by climate. In light of the widespread use of this technique this is an important point.

The success rate of techniques is difficult to gauge from the literature review as the current trend is for researchers to refrain from publishing poor results. Consequently, methods may result in less positive identifications than assumed from published outcomes. In order for this trend to change, results need to be published regardless of whether a site is located or not.

The techniques used by practitioners around the world do have some limitations linked with both climate and decomposition. These need to be taken into account when planning a search operation. Future grave location projects should employ a multidisciplinary approach wherever feasible to limit the effects of these and other variables. The importance of eyewitness accounts and intelligence reports should not be underplayed and should be incorporated into any searches, when possible.
6. Conclusion

6.1. Improvements to research

The main area for improvement of this thesis is the organisation and distribution of the questionnaire. The questionnaire itself needs to be refined to gather more specific information as well as more detailed information. Additional questions are needed to better gauge respondents opinions and to fully understand each answer. It would also have been valuable to contact more potential respondents in the initial stages of the questionnaire. Professionals from areas such as geology, various fields of archaeology and anthropology, forensic sciences, law enforcement officials as well as scene of crime officials could have been contacted to discover whether they had used the techniques, under what circumstances the methods were used and limitations that they experienced. The questionnaire could have also identified the results gained through the use of grave location techniques.

If the questionnaire was distributed again a wider range of countries would have been sought and potential respondents contacted through email mailing lists such as the Flinders University Archaeology Society, the AUSARCH mailing list and the World Archaeological Congress (WAC) mailing list. This would have enabled a wider group of people to access and complete the questionnaire.

The thesis may also have benefited by choosing only one of the variables discussed. If only climate was chosen as the variable to be studied the information gained may have been more useful. While decomposition could have been studied as a variable
within climate, the emphasis would have been on climate alone. By limiting the
variables being studied the thesis may have been able to contribute more to wider
knowledge.

6.2. Future research considerations

To further explore the effects of climate and decomposition on the techniques used to
locate graves it would be interesting to carry out practical experiments. One such
experiment could involve the burying of a body (either human or pig, due to the pigs
similar composition and decomposition processes to humans) with as many variables
controlled as possible. Once ethical approval is provided, each burial should take
place in different climatic conditions but should be the same body weight, burial
depth and preferably in similar soil types. The researcher could then use each grave
location method at each of these sites in order to ascertain which gives the best
results under varying conditions.

This project brings with it a number of problems though, mainly involving funding.
Not only would bodies have to be procured but they would have to be transported to
various locations with different climates. The bodies would have to be kept cold
while this was happening to avoid large scale decomposition. When the bodies were
in place there would be the expense of hiring or purchasing equipment. Also, as
some of the techniques require specialists to operate them there would be the extra
expense of payment for these people.

Another major problem with the above project would be obtaining ethics approval
for the use of human remains. To my knowledge there have been no research
projects using human remains carried out in Australia. Similarly, the use of pigs has been limited. The ethics approval process would need to be carried out months in advance of the actual field work. However, there is an additional problem with ethics approval. As the project would be carried out in multiple climates it is highly likely that approval would need to be sought from people other than the home university.

As can be seen, any research of this type is fraught with problems. Perhaps a better way of gaining more knowledge concerning the effects of climate and decomposition on grave location techniques is the wider publication of locating projects and research. Many cases are not published due to the sensitivity of the information or the information pending trial. In these cases it may be possible to publish the information relating to the methods used without giving specifics concerning exact location. The wider publication of information would allow all professionals using the techniques to better judge their accuracy.

6.3. Final conclusions

While background research demonstrated that the variables did have some effect on the techniques used to locate graves, the respondents felt that they did not. These conflicting opinions seem to suggest that the effect of climate and decomposition is dependent on individual site conditions and methods used.

Some of the results from the background research and those of the questionnaire do not correspond. Questionnaire respondents did not mention some of the techniques that were identified in the background research. This discrepancy could indicate a
financial restriction on the work carried out or simply a personal desire not to use these methods.

This thesis recognises the advantages of employing a multidisciplinary approach to grave location. While individual techniques may be adversely affected by climate and decomposition the use of multiple techniques reduces the likelihood of these effects impacting negatively on results. Techniques have been used individually with positive results. However these results may be compromised by the effects of both climate and decomposition. Multidisciplinary approaches offer the best solution to minimising the negative effects of climate and decomposition while still employing the positive effects needed for techniques such as thermal imagery and the visual recognition of surface/ground changes.

The negative effects of climate and decomposition can be successfully reduced or eliminated through the careful planning of search operations. While both variables have some effect on the methods used to locate graves careful choice of techniques can minimise the negative effects while still employing the positive effects as mentioned above.

The overriding point that this thesis demonstrates is the need for researchers and professionals to publish their results. While it is acknowledged that some of the more sensitive information is classified and pending trial, it could be possible to publish without giving specific information relating to perpetrators of the crime, specific locations or sensitive names. By publishing some information other people in the field would be able to identify what work is being carried out and what needs to be done. This would help to identify research that needs to be carried out in the future.
Appendix 1 – Köppen Climate Classification system


There are five major climatic types (based on annual and monthly mean temperatures and rainfall):
A: moist tropical climates, high temperatures all year round, large amount of rain per year.
B: dry climates, little rain, huge daily temperature range. Two subgroups S – semiarid or steppe, W – arid or desert.
C: humid middle Latitude climates, warm, dry summers and cool, wet winters.
D: continental climates found in interior regions of large land masses, low total precipitation, seasonal temperatures vary widely.
E: cold climates where permanent ice and tundra are present, approximately four months of the year have above freezing temperatures.

There are further subgroups associated with some of the climatic types (based on seasonal characteristics of temperature and rainfall):
f: moist with adequate precipitation in all months, no dry season.
m: rainforest climate with short dry season in monsoon type cycle.
s: dry season in the summer (high-sun season).
w: wet season in the winter (low-sun season).

Further variations in climate have another subgroup:
a: hot summers, warmest month is over 22°C.
b: warm summer, warmest month is below 22°C.
c: cool, short summers with less than four months over 10°C.
d: very cold winters, coldest month below -38°C.
h: dry/hot, mean annual temperature over 18°C.
k: dry/cold, mean annual temperature under 18°C.

Table 7.1 – Climatic regions and subgroups

<table>
<thead>
<tr>
<th>Climatic region</th>
<th>First subgroup</th>
<th>Second subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>f</td>
<td></td>
</tr>
<tr>
<td></td>
<td>m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>w</td>
<td></td>
</tr>
<tr>
<td>B (subgroups S and W)</td>
<td>s</td>
<td>h</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>k</td>
</tr>
<tr>
<td>C</td>
<td>f</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>s</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>c</td>
</tr>
<tr>
<td>D</td>
<td>f</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>s</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>w</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d</td>
</tr>
<tr>
<td>E</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>w</td>
<td></td>
</tr>
</tbody>
</table>

*Second subgroup applies to initial climatic region not first subgroup.*
Three basic climate groups:

**Group 1:** Low-latitude climates: controlled by equatorial tropical air masses.

- Wet-Dry Tropical Climates (Aw): average temperature: 16°C, annual precipitation: 0.25 cm (all months less than 0.25 cm), latitude range: 15° - 25°N and S, global range: India, Indochina, West Africa, southern Africa, South America and the north coast of Australia.
- Dry Tropical Climate (BW): average temperature: 16°C, annual precipitation: 0.25 cm (all months less than 0.25 cm), latitude range: 15° - 25°N and S, global range: southwestern United States and northern Mexico; Argentina; north Africa; south Africa; central part of Australia.

**Group 2:** Mid-latitude climates: affected by two air-masses. Tropical air-masses move towards the poles and Polar air-masses move towards the equator.

- Dry Midlatitude Climates (BS): annual temperature: 24°C, annual precipitation: less than 10 cm in the driest regions to 50 cm in the moister steppes, latitude range: 35° - 55°N, global range: Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China.
- Mediterranean Climate (Cs): annual temperature: 7°C, annual precipitation: 42 cm, latitude range: 30° - 50°N and S, global position: central and southern California; coastal zones bordering the Mediterranean Sea; coastal Western Australia and South Australia; Chilean coast; Cape Town region of South Africa.
- Dry Midlatitude Climates (Bs): annual temperature: 31°C, annual precipitation: 81 cm, latitude range: 30° - 55°N and S, global position: western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior.
- Moist Continental Climate (Cf): annual temperature: 31°C, annual precipitation: 81 cm, latitude range: 30° - 55°N and S (Europe: 45° - 60°N), global position: eastern parts of the United States and southern Canada; northern China; Korea; Japan; central and eastern Europe.

**Group 3:** High-latitude climates: polar and arctic air-masses, these air-masses meet along the 60th and 70th parallels.

- Boreal forest Climate (Dfc): annual temperature: 41°C, lows; -25°C, highs; 16°C, annual precipitation: 31 cm, latitude range: 50° - 70°N and S, global position: central and western Alaska; Canada, from the Yukon Territory to Labrador; Eurasia, from northern Europe across all of Siberia to the Pacific Ocean.
- Tundra Climate (E): annual temperature: -22°C to 6°C, annual precipitation: 20 cm, latitude range: 60° - 75°N, global position: arctic zone of North America; Hudson Bay region; Greenland coast; northern Siberia bordering the Arctic Ocean.
- Highland Climate (H): annual temperature: -18°C to 10°C, annual precipitation: 23 cm, latitude range: found all over the world, global position: Rocky Mountain Range in North America, the Andean mountain range in
South America, the Alps in Europe, Mt. Kilimanjaro in Africa, the Himalayans in Tibet, Mt. Fuji in Japan.
Appendix 2 – Locations of places mentioned in chapter 2
<table>
<thead>
<tr>
<th>Number</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Germany</td>
</tr>
<tr>
<td>2</td>
<td>Cambodia</td>
</tr>
<tr>
<td>3</td>
<td>Tropical Pacific region</td>
</tr>
<tr>
<td>4</td>
<td>Jordan</td>
</tr>
<tr>
<td>5</td>
<td>Longyearbyen (Svalbard, Norway)</td>
</tr>
<tr>
<td>6</td>
<td>Hawaii (USA)</td>
</tr>
<tr>
<td>7</td>
<td>Texas (USA)</td>
</tr>
<tr>
<td>8</td>
<td>Colorado (USA)</td>
</tr>
<tr>
<td>9</td>
<td>Tennessee (USA)</td>
</tr>
<tr>
<td>10</td>
<td>Arizona (USA)</td>
</tr>
<tr>
<td>11</td>
<td>Alberta (Canada)</td>
</tr>
<tr>
<td>12</td>
<td>Tuscaloosa (Alabama, USA)</td>
</tr>
<tr>
<td>13</td>
<td>SE Brazil</td>
</tr>
<tr>
<td>14</td>
<td>Chalmette National Historic Park (just E of New Orleans, USA)</td>
</tr>
<tr>
<td>15</td>
<td>Red Bay (Labrador, Canada)</td>
</tr>
<tr>
<td>16</td>
<td>India</td>
</tr>
</tbody>
</table>
Appendix 3 – Questionnaire sent out to specialists

VARIABLES AFFECTING GRAVE LOCATION METHODS

1. NAME:____________________________________________________________________

2. PROFESSION: __________________________________________________________________

3. COUNTRIES WHERE YOU HAVE WORKED WHEN INVESTIGATING SINGLE/MASS GRAVES (Please tick):
   1. ARGENTINA ☐
   2. AUSTRALIA ☐
   3. BOLIVIA ☐
   4. BRAZIL ☐
   5. CAMBODIA ☐
   6. COLUMBIA ☐
   7. CONGO ☐
   8. CYPRUS ☐
   9. EAST TIMOR ☐
  10. EL SALVADOR ☐
  11. ETHIOPIA ☐
  12. FORMER YUGOSLAVIA ☐
  13. GUATEMALA ☐
  14. HAITI ☐
  15. IRAQ ☐
  16. PERU ☐
  17. PHILIPPINES ☐
  18. RWANDA ☐
  19. SOLOMON ISLANDS ☐
  20. SOUTH AFRICA ☐
  21. SRI LANKA ☐
  22. UNITED KINGDOM ☐
  23. UNITED STATES OF AMERICA ☐
  24. ZIMBABWE ☐
  OTHER  25. ___________________________
         26. ___________________________
         27. ___________________________
         28. ___________________________
         29. ___________________________
         30. ___________________________

4. AGENCY OR ORGANISATION YOU WORKED FOR/WITH WHEN INVESTIGATING SINGLE/MASS GRAVES (Please list according to country number above):
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________


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5. IN WHICH YEARS WAS WORK WAS UNDERTAKEN? (Please list according to country number above):

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

6. APPROXIMATELY HOW MANY GRAVES WERE LOCATED PER COUNTRY? (Please list according to country number above):

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

7. WHAT WERE THE APPROXIMATE AGES OF THESE GRAVES? (Please list according to country number above):

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

8. WHAT WERE THE LOCAL VEGETATION CONDITIONS? (Please list according to country number above):

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

9. WHAT WERE THE AVERAGE WEATHER/CLIMATIC CONDITIONS DURING LOCATION WORK? (Please list according to country number above):

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
10. WHAT WERE THE MAIN METHODS OF GRAVE DETECTION USED IN EACH COUNTRY? (Please list according to country number above):
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

11. WHO CARRIED OUT THESE SEARCHES? e.g. families, scene of crime officers, trained archaeologists, geophysicists. (Please list according to country number above):
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

12. DID THESE METHODS RESULT IN SUCCESSFUL FINDS? (Please list countries, according to country number above, under the relevant response below):

   YES ☐   NO ☐
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

13. CAN YOU FORSEE ANY OTHER METHODS OF GRAVE LOCATION BEING OF USE IN THESE COUNTRIES IN THE FUTURE?  

   YES ☐   NO ☐
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

14. IF YES, WHICH METHODS CAN YOU FORSEE USING (Please specify which method you would use in different countries, according to the country number above):
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

15. IF NO, WHY CAN’T YOU FORSEE OTHER METHODS BEING OF USE IN THESE COUNTRIES IN THE FUTURE? (Please specify according to the country number above):
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
16. WERE EXCAVATIONS OF SINGLE/MASS GRAVES CARRIED OUT? (Please list countries, according to country number above, under the relevant response below):

     YES ☐
     NO ☐

     ______________________  _______________________
     ______________________  _______________________
     ______________________  _______________________
     ______________________  _______________________
     ______________________  _______________________
     ______________________  _______________________

17. IF YES, WHO UNDERTOOK THE EXCAVATION WORK? e.g. families, scene of crime officers, trained archaeologists. (Please list according to country number above):

     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________

18. WHAT WERE THE APPROXIMATE DEPTHS OF GRAVES? (Please list according to country number above):

     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________

19. WHAT WERE THE APPROXIMATE NUMBERS OF BODIES PER GRAVE? (Please list according to country number above):

     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________

20. WHAT LEVEL OF BODY PRESERVATION WAS FOUND? (Please list according to country number above):

     a) SOFT TISSUE
     b) SKELETAL REMAINS
     c) KERATINOUS (hair and nails)
     d) SOFT TISSUE AND SKELETAL REMAINS
     e) a, b and c

     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________
     ___________________________________________________

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21. IN YOUR OPINION, DID BODY PRESERVATION AFFECT THE LOCATION METHODS USED?:
   YES ☐ NO ☐

22. HAVE YOU PUBLISHED ANY ACADEMICALLY ACCESSIBLE MATERIAL RELATING TO YOUR EXPERIENCES LOCATING GRAVES?:
   YES ☐ NO ☐

23. IF YES, PLEASE LIST:
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________

24. WOULD YOU BE WILLING TO PROVIDE ME WITH COPIES OF UNPUBLISHED MATERIAL/PAPERS?:
   YES ☐ NO ☐

25. IF YOU HAVE NOT PUBLISHED ANY ACADEMICALLY ACCESSIBLE MATERIAL, IS THIS DUE TO THE INFORMATION BEING RESTRICTED?:
   YES ☐ NO ☐

FURTHER COMMENTS:
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________

IF YOU HAVE ANY FURTHER COMMENTS OR QUESTIONS CONCERNING THE RESULTS OR USE OF INFORMATION PLEASE CONTACT ME VIA EMAIL (pali0003@flinders.edu.au) OR POST USING THE COMMENTS SECTION AT THE END OF THIS QUESTIONNAIRE.
THANKYOU FOR YOUR PARTICIPATION.
Appendix 4 – Acronyms for Table 3.1

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAHID</td>
<td>British Association of Human Identification</td>
</tr>
<tr>
<td>VIFM</td>
<td>Victorian Institute of Forensic Medicine</td>
</tr>
<tr>
<td>INFORCE</td>
<td>International Forensic Centre of Excellence for the Investigation of Genocide</td>
</tr>
<tr>
<td>PHR</td>
<td>Physicians for Human Rights</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>AFP</td>
<td>Australian Federal Police</td>
</tr>
<tr>
<td>ICMP</td>
<td>International Commission on Missing Persons</td>
</tr>
</tbody>
</table>
Appendix 5 – Effects of various environmental conditions on techniques used to location graves

<table>
<thead>
<tr>
<th></th>
<th>Historical Records, eyewitness reports</th>
<th>Visual recognition of ground changes</th>
<th>Black and white photography</th>
<th>Colour infrared photography</th>
<th>Multispectral photography</th>
<th>Thermal Imagery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moisture</strong></td>
<td>N/A</td>
<td>Burials may retain moisture ↑ vegetation growth</td>
<td>N/A</td>
<td>Moisture is good</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Porosity</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Detects diff’s in water content</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>Should not affect</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Must be done post dusk or dawn</td>
</tr>
<tr>
<td><strong>Humidity</strong></td>
<td>Should not affect</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>Could affect aircraft used to take photographs</td>
<td>Could affect aircraft used to take photographs</td>
<td>Could affect aircraft used to take photographs</td>
<td>Could affect aircraft used to take photographs</td>
</tr>
<tr>
<td><strong>Snow, frozen ground</strong></td>
<td>Could obscure view of vital features</td>
<td>N/A</td>
<td>Could obscure view of vital features</td>
<td>Could obscure view of vital features</td>
<td>Could obscure view of vital features</td>
<td>Could show body as hotter than surrounding soil if a recent burial</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
<td>Could obscure view of vital features</td>
<td>Could be more or less growth over a grave</td>
<td>Could obscure view of vital features</td>
<td>Could obscure view of vital features</td>
<td>Could obscure view of vital features</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Probes</td>
<td>Cadaver dogs</td>
<td>GPR</td>
<td>Electrical resistivity</td>
<td>EM</td>
<td>Magnetometry</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>------------------------</td>
<td>------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Moisture</td>
<td>Needs a small amount of moisture</td>
<td>Needs a small amount of moisture</td>
<td>Detects water content so moisture is good</td>
<td>Moisture is needed</td>
<td>Has proved useful in both dry and moist conditions</td>
<td>N/A</td>
</tr>
<tr>
<td>Porosity</td>
<td>N/A</td>
<td>N/A</td>
<td>Detects water content so can find less porous areas</td>
<td>Can detect porosity changes</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Temperature</td>
<td>Must be at a workable level for personnel</td>
<td>18 – 26 °C is ideal. High temperatures ↓ effectiveness</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Humidity</td>
<td>Must be at a workable level for personnel</td>
<td>Must be at a workable level for personnel</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Wind</td>
<td>na</td>
<td>Some needed</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Snow, frozen ground</td>
<td>Does not work on frozen ground</td>
<td>Good results have been found on snow covered ground</td>
<td>Works in both conditions</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Too many roots etc may complicate results</td>
<td>N/A</td>
<td>Cannot be too dense</td>
<td>N/A</td>
<td>N/A</td>
<td>Needs little or no vegetation to operate effectively</td>
</tr>
</tbody>
</table>
8. Reference list.


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