Artefact Disturbance in the New England Tablelands: Elucidating the Factors Harming Archaeological Sites

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Vehicle Impact to Site Barley Fields, Uralla, NSW

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I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

[redacted]

Signature

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Abstract

Archaeological experimental studies have been conducted on taphonomic and artefact disturbances worldwide. Studies conducted have addressed various disturbance factors such as wind, water, animal activity, and human impact independently of one another. Generally, these studies were on a small scale with regard to the geographic range and environmental contexts covered. Additionally, no mitigation or site extent analyses have been conducted that would facilitate the management of moving and missing artefacts. The experiment was spread out over five locations in the New England Tablelands in NSW. These locations were at Barley Fields, Uralla, Kirby Farm and the University of New England Deer Park Armidale, Big Llangothlin, Llangothlin and Laura Creek west of Guyra. All locations experienced varying degrees of disturbance due to livestock, kangaroos, deer, rabbits, different slope gradient, soil, vegetation and human activity. Movement, breakage, and disappearance were common artefact disturbances in the New England Tablelands within a short six month period.

Artefacts that were nor moved or moved up to seven metres experienced some breakage in less than a month, some artefacts had disappeared and some of these reappeared because of animal or human activity and environmental changes. One focus of the study was to investigate the effects of slopes on artefact movements over time. The degree of slope gradient was found not to be as significant to artefact movement as previously thought; rather, movement was due mostly to other post-depositional processes, which are discussed in this thesis.

Archaeologists need to consider the potential post-depositional disturbances when determining the extremities of a stone artefact scatter. From a cultural resource management perspective it is more likely that sites recorded without these considerations may be more difficult to locate when the site is revisited for construction.

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1. Introductory Chapter

1.1. Aims of the project

The New England Tablelands are located on the great divide in northwest NSW 188 km west of Coffs Harbour and approximately 111 km north of Tamworth. In the future, the New England tablelands are likely to be further developed by the renewable energy, housing and mining industries. This project will focus on one of the more neglected aspects of archaeology in the New England tablelands; the natural and anthropogenic disturbances which affect the deposition and preservation of stone tools within this region. With little research on this topic having been conducted in the past, a more in depth study is needed to elucidate these effects. Disturbance can change the conditions of a site and in some cases even destroy artefacts. In other areas of Australia and elsewhere in the world, there has been evidence of a number of factors that can affect an archaeological site. These include but are not limited to rabbits, livestock, kangaroos, vehicles wind, and water. This study aims to gain insight into how post depositional processes affect the stone tool distribution in the New England Tablelands.

Stone artefacts are littered across the vast Australian continent. Cultural Resource Management (hereafter CRM) measures are put in place to protect archaeological record from development projects. These measures can include salvage and avoidance. Avoidance of artefacts is one of the most successful ways to ensure their protection. This may include measures such as the establishment of a no go boundary around the extent of a stone artefact site. Arbitrary boundaries can help protect a site from damage by a proponent but how effective are avoidance boundaries? And, what would be considered a feasible site area measurement for a client? CRM professionals must consider a possible minimum boundary buffer for avoidance when there are external factors that can disturb a site. Will an artefact remain in its original context and maintain its integrity when found by an archaeologist? What are current external factors impacting the integrity of stone tools and archaeological sites in the New England Tablelands? The deployment of a six month monitoring program identified the answers to these questions.

1.2. Significance

According to a NSW Strategic Regional Land Use Plan (DPI, 2012: 8), future action such as mining and urban growth could impact known and unknown Aboriginal places, objects and landscapes in the New England region. This signifies the need for a greater understanding of the current impacts on archaeological sites so that future developments can proceed more efficiently whilst offering the maximum protection as part of CRM procedures within NSW, disturbance and landform prediction models are used to understand the integrity of an archaeological site. The data and analysis of this study will benefit future archaeological work undertaken for the purposes of cultural resource management. According to a study in 2011, the New England region will be experiencing future development including renewable energy (Bell, 2011: 1). This study will assist in future management planning through suggested strategies such as boundaries or isolation, and avoidance to prevent the destruction of stone tool sites from development processes.

1.3. Originality

Stone tools are affected by a number of factors including wind, water, earthquakes, rabbits, livestock and human impact. Past studies have neglected to look at taphonomic processes and their effects on stone tools in the New England Tablelands. Studies from locations outside the New England tablelands are reviewed to understand the processes that are most likely to occur in the study area. One study recently attempted to discern artefact distribution in the Genoa Valley in Argentina After the literature review for this Masters thesis was written, an article was published in 2015 entitled: *The memory of the landscape: Surface archaeological distributions in the Genoa Valley (Argentinean Patagonia)* (Leonardt et al., 2015). It was an experimental study analysing stone artefact scatters in the desert of the Genoa Valley. The conclusion stated that there needs to be more experimental studies observing the following aspects in regards to artefact disturbance including:

- Artefact disturbance in different locations and landscapes.
- Artefact size as a variable for artefact distributions
- Experimental design to understand size patterning in the landscape
- Animal trampling

- Full lithic taphonomy analysis to see what is directly having an impact on artefacts

This thesis analyses disturbance, animal trampling, size and weight patterning, and an almost complete lithic taphonomy analysis. The thesis has also raised some concerns about how CRM can benefit from discerning artefact disturbance.

The experiment in this thesis utilised mock artefacts which were made using a magnetic material to allow for identification using a metal detector. Material used included magnetic hematite and broken keys, which were provided as proxies for siliceous stone tools, so that a metal detector could assist in re-locating the mock artefacts more efficiently. This study will gain clarification on artefact disturbance in an environment of increased planning and infrastructure construction within the New England tableland region.

1.4. Terms

The term 'harm' is used in the DECCW Due Diligence Code of Practice 2010 document (DECCW, 2010b, p. 2). It is used to describe instances when a proponent or organisation may "harm" or "destroy" an Aboriginal object (DECCW, 2010: 2). It will be a term used in this thesis as well as destroy, destruction, and impact. Impact and harm refer to the movement, breakage or disappearance of the artefact.

1.5. Physical and Climatic Environment of the New England Tablelands

The New England Tablelands was chosen as a study location due to the likelihood of seasonal or year round historical evidence of Aboriginal occupation. Its abrupt climatic changes and harsh environment makes it unfriendly for human habitation, particularly in the long colder seasons.

The New England Tablelands is situated on the Great Divide in NSW, Australia (Ollier, 1982: 141). This is the third largest divide in the world spanning from southern Victoria to Cape York in the north (Ollier, 1991: 194). Ollier (1991:194) notes that in the Pleistocene era the Great Divide would have also encompassed the Torres Strait islands. The geomorphology of the Great Divide includes several active volcanos throughout the landscape as a result of tectonic movement (Ollier, 1991: 194).

The Great Divide is made up of a combination of plateaus, uplands, escarpments, and mountain ranges (Johnson , 2009: 202). Technically, it is not a mountain range due to the complexity of its geological features. Australia's climate on the east coast has been shaped by the Great Divide in a number of ways, mainly due to the high altitude and constant water flow.

The Great Divide is a landscape comparable to a large dam which captures rainwater during high levels of precipitation. In some cases the water falls into catchment areas that then funnel out to rivers like the Murray Darling Basin (Haworth pers. comm, 2013). In other areas the moisture is collected in lakes or lagoons. In the last 150 years or so Europeans have developed structures such as dams and irrigation channels which have modified the landscape to hold the water permanently, changing the landscape of the Great Divide to benefit post contact populations (M. Bell, 2011).

Prior to European settlement humans would have relied on lagoons, creeks in the uplands and rainfall for drinking water. Precipitation is an important part of geomorphology on a small and sometimes large scale (Dincauze, 2000, p. 158). The average rainfall for the New England Tablelands each year, according to Bureau of Meteorology records over the past 18 years, is 807.0 mm a year (BoM, 2013). Over the last 135 years the average has been 791.2 mm (BoM, 2013). This is higher than Australia's driest locations, where the maximum rainfall would be 200 mm, but lower than tropical locations which can get rainfall of up to 3,200 mm a year (ABS, 2013). Snow does settle occasionally on the New England Tablelands which could affect the landscape slightly (Burr, 2013, p. 1).

There are various types of rock found in the New England Tablelands including granite, basalt, quartz, and metamorphic rocks (Ollier, 1982, p. 141). The variety of rocks present is due to past volcanic activity, which caused high levels of magma underground to flow up and over the landscape 14 million years ago (Ollier, 1982, p. 142).

Lunettes have been identified in close to 60 natural lagoons in the Tablelands (Bell et al, 2008 : 478-480 A lunette is described as:

> *An elongated, gently curved, low ridge built up by wind on the margin of a playa (beach), typically with moderate, wave modified slope towards the playa (beach) and a gentle slope.* (Speight, 2009, p. 40)

At this stage it is difficult to determine how they were formed (Haworth, 2013). It has been argued that they may have been formed by aeolian activity, enabling the sand to travel and be distributed over the granite and basalt bedrock. Llangothlin is a lunette style landform and will be used in this project.

Knowledge of past and current environmental circumstances is critical to interpreting what has occurred in the New England Tablelands both before and after human occupation. These environmental factors will have an impact on artefact visibility and influence the movement and location of artefacts. In the Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (DECCW, 2010a), it is recommended practice to identify geomorphic activity in a subject area (DECCW, 2010: 8). This is to make sense of the erosional processes and help evaluate if there is a need for sub-surface investigations. In some cases, a geomorphologist might be needed to help identify common or uncommon geomorphological processes (DECCW, 2010: 9.) In the New England Tablelands the general understanding of the geomorphology has been very brief and vague. For instance, Ollier's (1982) interpretation of the Armidale region was very general, since it did not look closely at specific landforms. Soil structure and landform analysis provides information about human habitation and drainage, among other archaeological considerations. This study will take into consideration such environmental factors and specific landscape geomorphology in order to better understand the effects that these factors may have on the post depositional disturbance of artefacts.

1.6. Aboriginal occupation in the New England Tablelands 1966-1997

In 1966 the first regional PhD thesis was written in Australia outlining the archaeological evidence in the New England Region. Isabel McBryde was the first to do this and claimed that the New England uplands would have been an ideal "summer camp" for the local Aboriginal people (McBryde, 1966). McBryde also mentioned this in her book in 1974, again noting the colder climate. Evidence from archaeological studies in Tasmania suggests that this may not be the case. The main sites identified in Tasmania include rock shelters and artefact scatters (Cosgrove, 1989, p. 243) . The New England Tablelands was chosen as a study location due to its harsh environment, cold climate and abrupt climatic changes. In following references (Roberts, 2006, p. 98) (Godwin, 1985, p. 41). Godwin (1985) investigated areas where artefact scatters had been identified and also where rock art had been recorded. He determined that McBryde's book on the New England region's prehistory (1974) was the most comprehensive of its time. However, more evidence was needed to confirm McBride's argument that due to the harsh environment and cold climate (1974:338) the Tablelands were used only during the summer months for ceremonial purposes. Godwin surveyed areas most likely to have tangible material culture, like waterways and exposed areas. The outcome changed the interpretation of the New England Tablelands. Godwin also indicated that further archaeological investigation is required in the New England Tablelands, suggesting that it would be good to consolidate his research further and get an accurate date of Aboriginal occupation in the region. Godwin (1997) discussed the habitation of the New England tablelands in *Little Big Men: alliance and schism in north eastern NSW, during the late Holocene.* Here, he discussed the New England region thoroughly and cited evidence found during his 1990 PhD study of year round aboriginal occupation of the Tablelands (Godwin, 1997).

The ground visibility of the Tablelands can make artefact location problematic. Exposure does assist with identifying artefacts during archaeological surveys. To understand why artefacts have been difficult to find, the geomorphological and land use history must be examined. Since the relocation or initial recording of archaeological sites is sometimes effected by visibility or other environmental or anthropological factors, measures of conservation, like avoidance buffers, are sometimes instituted.

1.7. Definition of Avoidance Boundaries and Buffers

The following section describes avoidance buffers in the context of CRM. When an at-risk archaeological site is located, one management strategy is to create a marked boundary around an archaeological site with flagging tape or GPS waypoints. Once this has been marked and uploaded to a computer or electronic device, a buffer is then generated. Buffers can range from 5 m – 100 m, which can be seen as inconsistent from an archaeological and management perspective. The main goal is to stop a proponent from harming the archaeology within the buffer. The explanations for any buffer in consultancy reports do not explain why these are reasonable buffers for sites and they fail to account for other potential problems that could impact the archaeological sites, such as cultural and natural disturbances including but not limited to the general public, animal activity, plant growth, and the weather. Buffers are mainly used to keep a client from harming the site and do not account for other potential disturbances.

Sullivan 2012 describes avoidance in her book *Archaeological Sites: Conservation and Management* as follows:

> *Mitigation strategy may be adopted in which all archaeologically damaging engineering operations are excluded from an area of archaeological sensitivity, i.e. avoidance of ground disturbance and therefore removal of the threat of construction on in situ remains (Sullivan, 2012: 32).*

Avoidance buffers are considered one of the most favoured conservation management strategies in the consultant world, not only in Australia, but overseas as well. Avoidance strategies are described by Sullivan as costly; she states they may not effectively exclude all construction aspects (Sullivan, 2012: 32). She does not mention the continual disturbance from other factors that can impact a site. NSW regulations have not been structured to account for disturbances after a site has been recorded.

1.8. Thesis Structure

Chapters to be included in this thesis include a literature review (chapter 2) of previous studies looking at artefact disturbance, a methodology (chapter 3) indicating how the study was achieved, and a results chapter (chapter 4) outlining the key factors that had an impact upon artefacts in the tablelands, the separate chapter presenting data indicating the amount of movement, breakage, disappearance and total number of factors that were harming the mock sites (chapter 5), and a discussion chapter which explains what was found in the study (chapter 6), and finally a conclusion (chapter 7) summarises the thesis. An appendix was added at the end of the thesis in CD format; this has a collection of graphs, data and photographs of the set up and monitoring periods.

2. Literature Review

2.1. Introduction

This chapter discusses the relevant literature to assist in answering the main question of this study: what impacts are affecting stone tools in the New England Tablelands?

In answering this question the previous literature needs to be explored to determine what studies have been accomplished prior to this research. Categories that will be documented include the importance of monitoring sites over time and the experiments that various archaeologists have conducted. This chapter lists the key results from other studies so that a comparison can be made to this research.

The term taphonomy was first formed by the Russian palaeontologist, Efremov (1940:85), combining *taphos* (burial) and *nomos* (law). Efremov used the term to describe how animal remains changed from the biosphere to the lithosphere. In archaeology the term taphonomy has been used in a number of ways including to describe how bones have been culturally modified by hominids or have experienced non-human modifications (Lyman 2010: 5). Eventually archaeologists used the term taphonomy to interpret the factors that can alter an archaeological site (Lyman 2010: 6). Lyman (2010) states that Efremov did not intend for taphonomy to be used in this way, and that it is not an accurate term to describe non-cultural or cultural formation processes. Lyman states that the archaeologist's use of the term is incorrect in relation to its original use (Lyman, 2010: 13) also. Lyman (2010:13), states that it should be reserved for use in palaeontology as was originally intended. This thesis chapter will explore the potential disturbances affecting stone tools in the New England Tablelands.

Artefact protection for Aboriginal sites has been studied in relation to tourism in Mungo (Midgely, 1998), wind activity in South Australia (Cameron et al, 1989), animal movement and sheet wash in the Hunter Valley and Queensland (Hiscock, 1985), and geomorphological processes in western NSW. It should be noted that not many experimental studies have been accomplished in Australia where a complexity of factors could impact on stone artefacts so some international studies have been included. Overseas studies have observed negative impacts on archaeological sites due to rabbit disturbance (Jones, 2007), ploughing (Ammerman, 1985) and water movement (Brunn et al., 1980); Isaac , 1977). Godwin (1990: 241) observed that broken chert flakes found in the New England Tablelands were the result of cattle and vehicle disturbance but no further investigation was conducted on other potential factors that could have contributed to the breakage.

The New England Tablelands was used for this study due to the increased of development applications in the region as opposed to Sydney or the Hunter Valley. Very little has been accomplished in the New England Tablelands to better understand Aboriginal archaeology. Only the studies by McBryde (1974) and Godwin (1990) have attempted to comprehensively analyse the archaeology of the New England Tablelands. In the Sydney Basin and the Hunter Valley ongoing cultural heritage assessments are being undertaken due to developmental pressures and constant archaeological interest.

In this chapter, the three main types of processes involved in site harm will be reviewed and discussed, including breakage, disappearance, and movement. Land use history in the New England Tablelands will be reviewed to comprehend the changes to the landscape over the last few hundred years. Large industrial change can affect archaeological sites, inevitably altering site integrity. A section outlining the findings of previous studies in the New England Region is also provided. Following this, a section on recent archaeological studies in the New England Tablelands will outline current conditions of sites by looking at taphonomy and disturbance and possible future impacts. Mapping and legislation will be addressed in respect to the study sites under investigation.

2.2. Outline of Processes

There are multiple processes that can affect archaeological sites. For example, a recent study on climate change and tidal movements found that Mesolithic sites were being impacted significantly by high tidal fluctuations and substantial ice melting in Denmark (Milner, 2012). Other studies have shown that animals such as crabs (Specht, 1985), earthworms (Stein, 1983), canines (Jeske, 2001) and feral swine (Engeman, 2013) can influence archaeological sites. Fire and extreme temperatures can also destroy stone artefacts (Hiscock, 1985), thus changing the integrity of a site. The New England Tablelands may have a separate set of processes that may potentially impact the longevity of its archaeological sites.

Archaeological sites may be affected by three types of processes including: geomorphological, animal, and cultural processes. Geomorphological processes are natural, whereas cultural processes are directly anthropogenic. Animal processes refer to the influence of fauna directly affecting the depositional area. These processes are examined below within three sections for each process. The first of these sections introduces the previous studies, the second outlines which studies monitored the disturbance to archaeological sites and the third identifies some of the key what experimental studies analysing artefact impacts.

2.3. Geomorphological Processes

Geomorphological processes are the main agents that can affect stone tool scatters and other archaeological sites in the landscape. Studies that have monitored stone tool disturbance as their main research component are reviewed below. The studies reviewed have analysed the contributing geomorphological factors that can impact a site. For example, Hiscock examined the effects of sheet wash on open and closed sites in 1985 (Hiscock, 1985), Cameron, White, Lampert & Florek analysed wind activity moving stone tools in a sand dune environment in South Australia in 1990 (Cameron, et al 1990). Hewitt and Allen monitored wind deflation and ant activity at a site at Bend Road, Melbourne, and Fanning and Holdaway attempted to research site geomorphological attributes in western NSW (Fanning & Holdaway, 2002-2004). Following the section on monitoring, experimental studies are reviewed. These studies were controlled to allow researchers to further develop an understanding of how stone tools were being impacted by natural occurrences. Non-archaeological experiments include that of Potts, who looked at frost shatter affecting stone in a controlled environment (Potts, 1970).

2.4. Monitoring the Environmental Conditions

In 1985, Hiscock completed two archaeological studies: one of Colless Creek Cave (a closed site) in southwest Queensland; and the other of the Hunter River Valley, NSW (an open site). Colless Creek Cave was found to have dateable charcoal evidence of human occupation and stone tool artefacts (Hiscock, 1985). Hiscock (1985) identified two main processes which affected the closed site: animal movement and sheet wash. Hiscock (1985) also stressed that artefacts move vertically within closed sites. At the open site in the Hunter River Valley near Singleton, Hiscock (Hiscock, 1985, p. 86) observed a combination of surface and subsurface tools. The study found that artefacts underground were more damaged than the ones on the surface which was likely due to a combination of modern trampling, and being heated in prehistoric times (Hiscock, 1985, pp. 86-87).

Hiscock concluded in both studies that trampling can result in stone artefacts appearing to be recently broken (Hiscock, 1985, p. 83). It was stressed that more experimentation was needed in different open sites to further understand this taphonomic processes (Hiscock, 1985, p. 94). There are various taphonomic processes in different locations which could impact on archaeological sites in the New England Tablelands. There is also dissimilarity between closed sites and open sites in that open sites are more likely to be prone to numerous conditions including ploughing, water, heat, and trampling (Hiscock, 1985, p. 84). The taphonomy, as described by Hiscock, can distort an archaeologist's perception of sites due to the amount of different impacts changing the site over time (Hiscock, 1985, p. 94). The New England Tablelands are more likely to have more open and buried sites than closed sites due to a lack of rock shelters (McBryde, 1974). In this study, sheet wash will be observed to see if it is impacting sites in the New England Tablelands.

Research which investigated open site visibility and integrity in a different way is Cameron et al (1990)(Cameron, White, Lampert, & Florek, 1990) . As part of this study the authors carried out an archaeological experiment to test aeolian impacts on stone tools in South Australia to understand the movement of artefacts in high wind areas. The landscapes examined included lagoons and lunettes, similar landforms to the New England study areas chosen for this thesis. The New England Tablelands is considered a more temperate climate with more lush and full vegetation scattering the landscape, whereas the South Australian study area was a hot/dry desert climate. Nevertheless it was noted that geometric microliths, microliths, and flakes moved due to wind funnelling through the valley. Artefacts in this study moved over the three year period and the obtained answered questions about the effects of wind activity.

The research conducted in the experiment sought to monitor the rate at which wind would impact the stone tool distribution in a desert environment. Unfortunately, only one other variable in this experiment was analysed, and that was water. Animal activity was mentioned in the form of sheep and emus, but it was determined that in that three year period it had minimal impact. Water was documented as being the main secondary variable affecting artefact to the movement, but wind was judged the main factor disturbing the site. The crux of the argument was to establish that wind is responsible for both creating and destroying sites (Cameron et al, 1990 : 58).

Insufficient knowledge exists about the multiplicity of factors that can impact a site. Studies of individual factors that cause site disturbance are insufficient. In addition, only one location, Hawker Lagoon, was analysed and although wind was identified as the likely main factor in the disturbance of this site, other factors or the combination of other factors may have contributed as well. For example, animal activity was documented during the experiment but the affect this may have had on site integrity was not addressed. Lagoons in the wet season would most likely attract all kinds of wildlife and they would inadvertently harm the sites. In the three year period of investigation these sites were not visited often enough to enable effective site monitoring.

The impacts of water have also been examined and it has been noted that in Africa most of the earliest human sites were modified by water (Brunn et al. 1980; Isaac 1977). Even though wind deflation is common in an exposed area (Wood & Johnson, 1978, pp. 358-359), a combination of wind and water could affect the site. In the past, there was an issue due to the lack of artefacts found on the Tablelands. However, so far there have been a number of artefacts identified in exposed areas near the wetlands, which demonstrates that ground visibility is crucial when identifying archaeological sites in the New England Tablelands (Beck, Haworth, & Appleton, 2015).

Crow (2004) documented the affects that trees have on archaeological sites. This study found that roots had a tendency to move within a site and eventually large root systems could ultimately damage integrity (Crow, 2004, p. 16).

Downslope movement was analysed in 1973 by Rick (Rick, 1976) on a 20 degree slope near Lima, Peru. A total of six vertical row units were used. Artefacts, including bone, ceramic, and lithic fragments were used for the experiment (Rick, 1976, p. 134). It was found that heavier and denser materials (57.5 g) had a tendency to move further downslope than the lighter objects and least dense objects (3.7 g) (Rick, 1976, p. 143). The main reason that the artefacts moved down slope was fluvial action. Downslope movement will be analysed thoroughly in this thesis to see if fluvial impact is a factor.

One of the more dramatic natural occurrences that can harm an archaeological site is earthquakes. A New Zealand study monitored the affects earthquakes had on archaeological sites in the South Island (McFadgen & Goff, 2003). It was found that artefacts had moved and in all cases quakes degraded the integrity of the sites. In the New England Tablelands earthquakes have been recorded on various occasions, the most recently in 2012, measuring 4.2 on the Richter scale (Nugent, 2012). Earthquakes are quite rare in the Tablelands, however it is still a possibility if an earthquake occurs and if the opportunity arises in this study then it could assist in understanding the environmental processes in the New England Tablelands.

2.5. Experimental

The New England Tablelands experiences some dramatic temperature changes and in winter can go below zero. An experimental study reviewed the impact of frost and other natural processes on stone in cold environments (Potts, 1970). This experiment was undertaken by the University of Sussex in the UK. There are currently no studies in the Tablelands or Australia of frost affecting artefacts or raw material. Frost shatter can occur at 0 degrees or below 0 degrees Celsius (Potts, 1970, p. 122). Studies have shown that this is the operative temperature to shatter rock due to the cold. The process occurs when water seeps through pores in the rock and freezes. Expansion and contraction of ice within the stone causes the rock to explode (Potts, 1970, p. 109). Potts also found that igneous rock did not shatter in extreme cold, but shale and rock materials with larger grain size did shatter (Potts, 1970, p. 122). Frost shatter occurs in the New England Tablelands due to extreme temperature fluctuations. The artefacts that have been identified in the New England Tablelands are mostly various siliceous materials (Godwin, 1985, p. 40). The cold environment, therefore, could be affecting artefacts in the region, especially those of a siliceous nature. Water seeps into the grains and freezes, when the ice expands and contracts due to temperature, the artefact is likely to shatter or break.

2.6. Animal Impacts

To understand what animals will impact the mock stone tools in the New England Tablelands, research was conducted with the various fauna that could impact archaeological sites in the region. The effects of native and non-native animals in the New England Tablelands have been documented by Smith, Ballard and Jones (2011) and also Butze and Helgen (2005) and Roberts (2006). Studies undertaken within and outside the New England Tablelands have attempted to understand the impact animals have on the environment including archaeological sites, with a focus on marsupials (Hiscock, 1985), bird life, ants (Hewitt & Allen, 2010), (Robins, 2011), livestock (Parteger 2011), and rabbits (Smith and

Ballard, and Jones, 2011). Rabbit burrowing has been identified as one of the causes of damage to archaeological sites in New Zealand (Jones, 2007, p. 53). The Uralla Shire Council claim that rabbits cause extensive damage to the New England Tablelands environment (Smith & Ballard, 2011). It is likely that the movement of soil caused by rabbits will influence the chances of locating an archaeological site.

In 1985, Hiscock investigated how animals such as marsupials can impact closed sites. This study found that where a closed site contained artefacts or rock art, there was the potential that animals would have impacted the site at some stage (Hiscock, 1985, p. 88). The evidence that came from Hiscock's investigation concluded a number of animals were rubbing and scratching in the rock shelter (Hiscock, 1985, p. 88). Even though these were the results from a closed site, it was suggested by Hiscock that animals can impact open sites via trampling or burrowing (Hiscock, 1985, p. 87). In the New England Tablelands there are a number of different animals such as livestock, birds, and marsupials that can impact archaeological sites.

Livestock, such as sheep and cattle, have been present in Australia since 1788 (Butzer & Helgren, 2005, p. 80). In the New England Tablelands, livestock have been grazing since the 1880s (Roberts, 2006, p. 119). Stock trampling has been identified throughout Australia and can not only impact the environment, but would also destroy the integrity of an archaeological site. The landscape of Australia was heavily impacted initially by livestock, and these impacts were constant (Butzer & Helgren, 2005, p. 111). These impacts are broad and can include minor destruction of vegetation and soil, due to livestock trampling through an area changing the archaeological integrity of a site (Field, 2006, p. 13).

Field undertook an archaeological investigation of the taphonomy at Cuddie Springs in NSW and noticed a number of factors affecting the site including wind, human impact, and livestock (Field, 2006, p. 13). The site is famous for the supposed megafauna/human overlap in this area, which Field had difficulty in identifying (Field, 2006, p 19). The problem with all aspects is that taphonomic processes like livestock trampling and constant wind deflation have been constantly changing the integrity of the site.

Hewitt and Allen's 2010 investigation of a Pleistocene site at Bend Road in Melbourne measured and observed the effects that ants had on an open site (Hewitt & Allen, 2010). The impact of the ant activity on the stratigraphic integrity was also analysed (Hewitt & Allen, 2010). It was concluded that the ants had a slight impact on archaeological sites over a period of time, however not enough to lower the stratigraphic integrity of the deposit of the site (Hewitt & Allen, 2010). Bioturbation from the ants was limited with the deposit maintaining the definition of the layers.

2.7. Non-Cultural Experimental Studies

Robins undertook a study in 2011 after noticing large numbers of ants impacting on a midden site on the Gold Coast, Queensland (Robins, 2011, p. 149). The experiment was conducted in a controlled environment in a lab with a large glass ant colony. Instead of stone tools, shells, and bone, plastic coated paperclips were used (Robins, 2011, p. 155). The results suggested that ants can have a dramatic impact on sandy midden sites horizontally and vertically due to the burrowing networks they create (Robins, 2011, p. 157). This experiment was only conducted in a glass container where the bioturbation would take place in a very controlled environment and looked at only one ant species. There could have been different environments for the ants or different soil types, also the use of stone or an object that was a stone like shape, rather than paperclips and proper midden material may have yielded more of an accurate understanding of site disturbance from ants.

Pargeter conducted an experiment in Malawi, looking at how cattle and humans can be responsible for macrofracture of stone tools (Pargeter, 2011). Pargeter used milky quartz and pieces of dolerite and a total of 40 cattle in an enclosed location. The results concluded that cattle were the main reason why stone tools can be broken. Humans did have some impacts when walking over the tools, but they led to only small fragments of the tools breaking off. In the study, Pargeter concluded that additional studies were needed to understand other macrofracture affects. These included post depositional processes like detached mobile rocks, dropping, and other trampling agents (Pargeter, 2011: 2887). Since this study is an Australian study, an analysis of how kangaroos impact stone tools will be performed in conjunction with impacts of non-native animals, similar to that of other studies involving rabbits, cattle, deer, and sheep.

2.8. Cultural Processes

Anthropogenic or cultural processes can affect stone tools just as dramatically as natural ones. This section will identify previous monitoring and experimental studies so as to comprehend some of the main disturbances that can affect archaeological sites. The following factors that will be addressed are vehicles, ploughing, tourism, and development. Monitoring projects, including one by Sampson (2007) analysed the disturbance of an archaeological site near a vehicular track in California. Experimentation has been a major part of understanding anthropogenic processes from ploughing to tourism. Odell and Cowan (Odell & Cowan, 1987) and Ammerman (Ammerman, 1985) conducted controlled experiments in America and Europe (Italy) to examine impacts of ploughing on archaeological sites. Midgley undertook controlled experiments to examine the effects of tourism on Lake Mungo in 1998 (Midgley, Spennemann, & Johnston, 1998). Ploughing and tourism are common impacts in the New England Tablelands, with documented cases of tourism in Mt Yarrowyck 1976 and ploughing at East Hill (Sampson, 2007). Also, tourism has a number of aspects that are related to more specific issues that affect archaeological sites including human trampling and the removal of artefacts from their original location.

2.9. Monitoring Modern Cultural Occurrences

One 2007 study, conducted by Sampson in California, observed the conditions of an archaeological site near a road. *Sampson 2007* (Sampson, 2007) monitored the effects vehicles had on the road and what condition the road was in throughout the study. Measurements were made of the length, the height, and the width of the road in relation to the archaeological site (Sampson, 2007). The study identified major impacts to archaeological sites from vehicles travelling on or near the road. The damage included vehicles inadvertently destroying artefacts and features in the Mojave Desert and erosion to the landscape. In addition, the displacement of artefacts was also a major factor. Sampson’s recommendation was to bring in constant monitoring of vehicle recreational activities in off road environments in other locations like national parks and public lands, ultimately to observe and prevent the damage to important environmental and archaeological sites.

2.10. Experimental Human Studies

At Lake Mungo, western NSW, a study on the impact of tourism on artefact movement was undertaken in 1998. Mock sites were placed in areas of high tourist activity and also areas of low tourist activity (Midgley et al., 1998, p. 221). The study concluded that the artefacts had been removed in areas of higher tourist activity (Midgley et al., 1998, p. 230), could not be relocated, or they had moved further away from their original position. It is unfortunate that in this study, tourists visiting the site at different times had been removing the artefacts.

According to Midgley (Midgley et al., 1998), artefacts were taken, damaged or went missing during peak tourism seasons. This had a negative impact on how the site was managed for the purposes of tourism. Mungo National Park is a well signposted area and protected, but it is affected by human activity. This raises questions about sites that are not properly managed or respected by humans. Artefacts pointed out by an expert can be damaged or removed without permission, whereas sites that are not identified correctly or managed accordingly by an archaeologist may also be impacted. The visibility of artefacts on the Tablelands, however, is not a problem due to the thickness of the vegetation. Currently there is an investigation by the University of New England to understand the lunettes and the archaeological sites near wetlands (Beck et al., 2015). Sites can be greatly affected by human activity, changing the integrity and the visibility of artefacts due to trampling or vehicle activity.

Site integrity of an artefact scatter in a plough zone can be complicated. Artefacts might move considerably and even disappear or reappear. This means that archaeological and scientific integrity of the site can be difficult to assess. Odell and Cowan (Odell & Cowan, 1987), an American archaeological team, conducted an experiment by placing 1,000 artefacts varying sizes of in a flat field near a tributary called Silver Creek, which ran into the Illinois River. The stone tools included flakes, bifaces, broken tools and debitage from one of Cowan's knapping episodes (Odell & Cowan, 1987, p. 457). The area was ploughed for 14 instances over a two year period (Odell & Cowan, 1987, p. 480). Tillage changed the site completely by changing the density from a large one to a much smaller one (Odell & Cowan, 1987, p. 481). It also altered the size of the site, essentially doubling it, in comparison to its original extent (Odell & Cowan, 1987, p. 481). Some artefacts were destroyed but could be conjoined. Some artefacts moved five to 15 metres from their original location.

The study found that ploughing can slowly destroy the integrity of a site. However, it did not mention the type of raw material that was used, only the size, shape, and type (Holdaway & Stern, 2004). A plough in Australia could be devastating to a site; churning, moving and potentially breaking artefacts. It could also change the distribution of the scatter, moving one artefact metres away from its original position. Although this was an artificial representation of a potentially real scenario, questions can be raised about the numerous archaeological sites in Australia that have been recorded within plough zones. Undoubtedly there would be many questions which may warrant further investigation. However the main aspect of this analysis is that ploughing can bring artefacts to the surface but also destroy both the artefacts and the site integrity.

Other studies have also observed the effects of ploughing. Before the American study was accomplished, another experiment was conducted in Calabria, Italy (Ammerman, 1985) from 1977-1983. This was similar to the American study, but it related more to surface visibility and the issues of surveying a site in a plough zone. The investigation concluded that for every one artefact on the surface, there were 15 to 20 artefacts under the surface (Ammerman, 1985, p. 39). It also brought to light that surveys need to be more extensive to make sure nothing is missed (Ammerman, 1985, p. 40). Ammerman also found that artefacts did move 15 m from the original location.

2.11. Land use history in the New England Tablelands

In order to understand what changes have affected the region over time this section will look at land use history in the New England Tablelands. Land use history can assist in determining potential disturbances to artefacts. The New England region has been utilised by Europeans since 1831 for the purposes of agriculture (Roberts, 2006: 98). Explorers and agriculturalists began migration to the region to claim territory for the purposes of grazing and settlement. Clashes with local Aboriginal people were common and often brutal (Blomfield, 1981). By 1846 at least 700 stations had been set up for agricultural purposes in NSW, some of which were in the New England Tablelands (Roberts, 2006: 106). Sheep and cattle were the most common livestock present in the New England region at the time (Roberts, 2006: 106). Aboriginal people would take glass and ceramics from Europeans regularly to create tools (Roberts, 2006 107). Aboriginal people soon began to be taken as workers for agricultural purposes, resulting in further changes to the landscape (Roberts, 2006: 114).

Developments following World War One, including industrialisation of the land, changed the landscape with the construction of more permanent buildings and settlements around Australia. Railways, roads, and telegraph poles were built and more farmland was established to develop the New England Tablelands into a resource rich area for European settlers (Roberts, 2006: 114-119). Waterways were manipulated and dams were constructed later in the 20th century (Davidson et al. 2006). Land use changes in the New England area altered the region drastically, which also affected the Aboriginal people, who were becoming more assimilated into white society during this period (Jordan, 2006, p. 122). Previous archaeological studies conducted by McBryde (1974), Bowdler (1981), Godwin (1985) and Davidson (1982) identified that Aboriginal people had multiple areas of interest in the Tablelands. Sites found include bora rings, rock shelters, rock art, artefact scatters, and carved trees. The various types of sites found in the New England Tablelands have most likely been impacted by European influence in the area, ultimately affecting site integrity.

2.12. Previous Studies in New England

Artefacts can be key markers of Aboriginal occupation or presence in Australia (Holdaway and Stern, 2004: xvii), Artefacts are not always on the surface and excavation may be required to determine lithic presence. Geomorphological processes can move artefacts away from their original location. Based on evidence found at Bendemeer, McBryde (1974: 338) argued that the New England area did not appear to have a large Aboriginal presence. McBryde (1974) suggested that archaeological evidence from the New England region suggested the use of the area for "summer camp sites" instead of long occupation sites (Isabel McBryde, 1974, p. 338) (McBryde, 1974: 338). This evidence was interpreted from a small number of excavated archaeological sites in the Tablelands. However, McBryde's study was an overview of the New England region and did not look at the Tablelands fully. Surface sites were not analysed in detail, which meant very little was known about the preservation of the surface sites or how they were interpreted.

Artefacts can be used for different purposes (Holdaway and Stern, 2004: 53). This includes woodworking tools, butchering tools, hunting and gathering tools and ceremonial purposes (Holdaway and Stern, 2004: 53). Sites can often go unnoticed due to tools being reduced significantly, changing the size of the tool to something that is very small and hard to identify in the landscape (Holdaway and Stern, 2004: 71). Holdaway and Stern state that the technology of the tool can be so sophisticated that it can be reused multiple times (Holdaway and Stern, 2004: 71). There is the potential that small stone tools are concealed under the surface. Godwin (1985, 1997) found evidence of stone tools in exposed areas and near waterways, challenging some of McBrydes's theories.

Following McBryde's book on the New England region prehistory, Bowdler (Bowdler, 1981) identified an artefact scatter in Uralla at an altitude of 1,030 metres. This scatter consisted of backed blades that were found during an excavation near a granite rock shelter and a permanent water source (Bowdler, 1981: 107). The granite rock shelter was an ideal location for habitation and contained overhangs which were suitable for occupation (Bowdler, 1981: 107). There was no art on the granite boulders mentioned by Bowdler, which is what McBryde had been looking for (Bowdler, 1981: 107). Bowdler acknowledged this as the only site found as part of McBryde's investigations, but mentioned this was the only granite outcrop of its type in the area. Bowdler also mentioned ceremonial practices were undertaken at locations such as Mt. Yarrowyck, where rock art had been identified (Bowdler, 1981: 106-107). This archaeological evidence was important, but did not take into account the taphonomic processes affecting the archaeological evidence found.

Godwin (1985) identified that a more permanent Aboriginal presence was in fact apparent in the New England region. Godwin discussed the variation of sites on the New England Tablelands, including bora rings, carved trees and stone arrangements (Godwin, 1985, p. 43). Godwin noted in his research that at Llangothlin there were artefact scatters found by Davidson (Davidson, 1982, pp. 51-52). Backed blades have also been identified at Dangars Falls nearby (Godwin, 1985, p. 42). These were all found in areas not previously observed by McBryde. Godwin identified that the artefacts he found were in exposed areas such as "eroding terraces" (Godwin, 1985, p. 40), dry creek beds, or natural clearings. The key here is visibility. McBryde's findings were determined by the initial identification of rock art in Bendemeer as a potential prospect to excavate. Godwin went to areas mentioned by locals or near water bodies such as Llangothlin.

Exposure appeared to be the main contributor in aiding the identification of artefact scatters. It also might have been worth monitoring these sites to see if the artefacts moved regularly, so that the taphonomic processes were better understood. This also may have affected McBryde's study, because large surface scatters were not identified. They may have been subsurface or were constantly moving. As in most archaeological investigations surveying is the main application in finding artefacts or sites. Visibility must be high to be able to see artefacts in the landscape (Catling, 2009, p. 37). According to Mulvaney and Kamminga (1999: 19) artefact scatters are the result of eroded surface deposits.

Godwin's PhD study was printed in 1990. In two sections, Artefact Taphonomy and Rationing, he discussed the importance of the disturbances attributed to some of the artefacts in the New England Tablelands (Godwin, 1990: 241,249-274). Many of the sites that had more than 25% of artefacts transversely broken were deemed to have been disturbed by cattle and vehicles. Godwin admitted it was hard to recognise what had broken the artefacts over time. The difficulty of identifying if it was ancient disturbance, weather or animal activity meant that most of his data on broken artefacts was speculative. Chert was the material most often damaged due to the number of fracture lines through the stone. Godwin was the only archaeologist to look at the taphonomic processes affecting stone tools in the New England Tablelands. Since his regional study it has been necessary to explore the disturbances affecting stone tools directly by conducting several experiments. Although Godwin looked at how artefacts had been broken from certain influences, the study lacked detail about this issue. This study will further assess artefact movement in the Tablelands.

Sutton undertook an archaeological survey of Aboriginal sites in Armidale (Sutton, 1988). He devised a predictive model and a management plan for dealing with unexpected finds in accordance with the *National Parks and Wildlife Act 1974*. The management Plan was necessary at the time; however legislation has adapted and evolved since his study. For instance, in addition to the Australian Museum acting as a depository for artefacts, alternatives are now available such as repatriation to country and Keeping Place storage. Erosion and disturbance was mentioned in Sutton 's report (1988), but only briefly examined. Further investigation is needed to understand disturbance in the New England Tablelands and best management practices for the preservation of artefacts.

There are often various limitations associated with archaeological surveys, and there are no set rules on where a survey should be conducted (Schiffer et al. 1978: 19). This means that the identification of artefact scatters can often be difficult. Generally a survey is conducted in areas where archaeological deposits are likely to be present. Burke and Smith (Burke & Smith, 2004) emphasise that an archaeological survey should be as accurate as possible (Burke and Smith, 2004: 86) also recommending that when doing a survey all parameters are recorded, from landforms to site descriptions. This was an issue with McBryde's (1974) study as it broadly covered the New England region and not specifically the Tablelands. In comparison, Godwin (1990) showed more initiative and surveyed areas close to water bodies and where there were more known archaeological sites. The New England Tablelands comprise a large area of 3,004,202 hectares (OEH, 2011) and according to Beck (2006) more than 7000 sites exist in the New England region, but not every location has been inspected (Beck, 2006). It could take a lifetime to fully understand the archaeological complexity of the New England Tablelands and its Aboriginal occupation.

2.13. Current Studies in the New England Tablelands

Beck et.al. (2015) is currently continuing a project in the Tablelands looking at archaeological and geomorphological attributes near ancient wetlands. The study has involved local Aboriginal communities from Guyra, Tingha, Armidale, and Uralla. Wetland locations include Laura Creek, Barley Fields, Uralla Racecourse, Little Llangothlin, and Lake Llangothlin. The locations with the highest density of surface artefacts have been identified at Barley Fields and Laura Creek. These will be analysed closely and further information in regards to the Lagoon methodology will be discussed in another paper at a later date.

2.14. Legislation

This section will outline the importance of understanding taphonomy and disturbance of an area when dealing with development approval. The NSW *National Parks and Wildlife Act 1974* provides a number of requirements that need to be considered before a development is approved.

Before a mine, road, housing estate, or a renewable energy development is approved in NSW, steps and processes have to be adhered to (DECCW, 2010a). All Aboriginal objects are protected under the *National Parks and Wildlife Act of 1974*, which is controlled and managed by the Office of Environment and Heritage (DECCW, 2010a). Documents such as the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) have been prepared to strengthen laws to prohibiting people from intentionally destroying Aboriginal sites and places. Aboriginal sites and places are defined in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* as being stone tool scatters, scarred trees, rock art sites, rock shelters, bora rings, sedentary stones, burials, quarries, fish traps, and anything that has been identified as being culturally significant (DECCW, 2010a).

Landforms are required to be assessed for their potential to contain Aboriginal objects under the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) to prevent the unlawful damaging of Aboriginal sites. For instance, if a developer wants to build a road near a sandstone outcrop or waterway, part 6 of the consultation process is required to be adhered to and in some cases an Aboriginal Heritage Impact Permit may be required so the development can proceed (DECCW, 2010a). The NSW DECCW 2010 guidelines emphasise the value of water, and suggest that any waterway should be investigated thoroughly (DECCW 2010).Waterways are important as they act as a lifeline for people

Even though the legislation is in place to protect Aboriginal sites, there is a defence for developers to avoid the process of part 6 consultation. This can be achieved through following the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010). The due diligence process usually involves a background assessment and site survey undertaken by the proponent to assess whether a site contains any Aboriginal objects, sensitive landforms or evidence of previous disturbance. A client or cultural heritage professional can argue in a due diligence report that there is no evidence of Aboriginal sites in the study area and that the site has been subjected to disturbances such as ploughing which is seen in NSW as destructive of the integrity of a site (DECCW, 2010b). But, if the visibility of the ground is low and no artefacts are identified on the surface, they could still be present within a subsurface context. In Victoria the legislation (AAV, 2007) does not include ploughing, as a form of disturbance and clients still have to assess the value of a "complex assessment" within a Cultural Heritage Management Plan, which involves survey and excavation alongside the registered aboriginal party/ies (AAV, 2007).

Studies have shown that disturbance such as ploughing can move artefacts around a site (Ammerman, 1985), push them subsurface, and also move them away from their original location, thus diminishing the archaeological integrity of a site. In NSW this means that a Development Approval (DA) could be approved due to the lack of visibility or previous disturbance of an area potentially leading to the destruction of unknown sites by development (DECCW, 2010). By detailed analysis of the taphonomy and disturbances at known archaeological sites in the Tablelands, preventative strategies can be put in place to stop their potential destruction. This could aid in the protection of archaeological objects within the New England region and across NSW.

The artefact scatters already identified in the current study and in previous studies have been found in disturbed and exposed areas. Artefacts found at Barley Fields, Lake Llangothlin, Laura Creek, Dangar Falls, and Saumarez Homestead have been identified on four wheel drive tracks, dried up lagoon beds, and erosional exposures (Godwin, 1990). Artefacts can be disturbed by factors not involving humans such as stock trampling and other environmental processes. The word 'disturbed' applies only to human impact according to the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. Archaeologists in Australia have found artefacts in disturbed contexts (Hiscock, 1985, p. 84) removed from their "archaeological" contexts. Nevertheless, although an artefact might be out of context, this does not mean it has moved prior to human impact since, as evidenced in this chapter, artefacts can move due to changes in the environment. There is always the potential that artefacts may go unnoticed on the surface or subsurface and face destruction without the correct protocols to prevent this.

2.15. New England Tableland Processes

Context may have a lot to do with how a site has been documented and how it has been observed. Processes that can alter a site need to be considered when recording it. There are some processes which will not be encountered in this study. For instance, this research has been undertaken near wetland areas and near proven Aboriginal stone tool sites. An outline of the processes most expected to harm artefacts in the New England Tablelands is provided below. It is necessary to comprehend all these processes on a regional scale so that nothing is missed. As noticed in previous studies, researchers have only attempted to look at small scale impacts. This study may verify Godwin's theories of livestock and vehicles transversely breaking artefacts or it may identify other reasoning as to why some artefacts break, move, go subsurface, or disappear from a site.

This study has not investigated earthquakes because they rarely occur in the New England Tablelands and are not a consistent element to study effectively. On the other hand, animals such as rabbits, cattle, sheep, or kangaroos are expected to be frequent contributors to the disturbance of open sites. Trampling, burrowing, and scratching were monitored throughout the study. Water runoff from rain and snow melting can be frequent occurrences in the New England Tablelands, and these factors were analysed in detail. Frost shatter is likely to occur due to the cold and freezing conditions that occur in the high altitude climate of the Tablelands, but was not monitored due to the chemical structure of the mock artefacts that were used. Magnetic hematite is not a siliceous material and is unlikely to shatter due to frost. In order for frost shatter to occur stone needs to be exposed to rain and dramatic temperature fluctuations and the material must be porous enough to allow water to seep into it. The hematite is more likely to rust and crumble rather than shatter from frost. Ploughing is common in the Tablelands, but is not frequent at the study areas. Future studies may consider further analysis of this. Human impacts such as vehicular movement can be monitored by looking at artefact scatters evident on dirt tracks. Ant disturbance does occur on the Tablelands and is also examined. Fire is an element that has not been fully examined due to its unsafe and unpredictable nature. Burning is a common occurrence in the Australian landscape and could happen in the New England Tablelands. Wind deflation is likely to affect sites in the Tablelands and has been examined as part of this study. These aspects may not affect stone tools; however, as evidenced by this literature review, they could change the integrity of other archaeological site features over time.

2.16. Discussion and Conclusion

This literature review has outlined some of the key research relevant to this study of the combination of anthropogenic and natural impacts that can disturb artefacts and the impacts likely to disturb stone tools. It can be concluded that the best way to comprehend artefactual disturbance is by the method of conducting experiments and monitoring results that involves placing mock artefacts in controlled environments. This method is an important research tool to determine the causes of artefact disturbance and to identify the factors that have been impacting sites in the region. In Godwin's PhD thesis (1990) he noted that some artefacts had been broken from vehicles and cattle, but acknowledged that this was a speculative finding (Godwin, 1990). This study explores how this and other factors impact artefacts. The following questions have arisen from this literature review: How reliable are avoidance buffers in protecting scatters? How far do artefacts move in the New England Tablelands? What factors have caused the movement of artefacts in the region? What factors are responsible for the breakage of stone tools in the Tablelands? How deep do artefacts travel from the surface? How does disturbance effect the interpretation of a site? These questions will be investigated in this study. Finally a better understanding of how artefacts can be managed using the avoidance method will hopefully be realised.

In conclusion, archaeological investigation in the New England region is not as prominent as it should be and more research needs to be conducted. The taphonomic processes and disturbances possibly unique to the New England Tablelands need to be investigated. Other studies have proven that natural and cultural processes can impact archaeological sites over time. With the risk of more development impacting archaeological sites in the future, such as renewable energy projects like wind farms, a deeper understanding of disturbance and taphonomy is required. As discussed, within NSW and across Australia, there are legislative documents which are in place to protect Aboriginal objects. Management strategies are often used to help protect Aboriginal objects and their locations. Essentially, if there is a better grasp of the current elements impacting Aboriginal sites, future impacts to sites can be better managed.

This chapter has indicated various factors that could impact artefacts in the New England Tablelands, including weather, animals, and human activity. These variables need to be investigated to better understand the various external impacts and the consequences it has on stone tool sites. To facilitate this investigation, an appropriate methodology was developed and is discussed in the following chapter.

3. Methods

3.1. Chapter Outline

The objective of this study is to explore the factors affecting artefact movement in the New England landscape. The potential impacts at each site have been predicted below (see Table 1): This chapter outlines the methods used to explore how artefact visibility and artefact movement in the New England Tablelands can be understood.

The aim of the study is to explore what factors affect stone tools and the scale and impact that artefact movement has on Aboriginal archaeological sites in the New England Region. While there were many factors that may be involved in site degradation, e.g. fire, earthquakes, ploughing, soil composition, and artefact density, this study investigates those factors that are most likely to affect sites in the New England Tablelands. Ploughing was excluded because of the lack of properties with current ploughing operations. The table below shows the locations which were chosen and the major impact factors likely to be present at each.

Table 1

Location and Major Impact Table

Impacts	**Hooved/ Animals**	**Non-hooved**	**Native Animals**	**Vehicles Near track and on track**	**Slope**	**Vegetation**	**Weather (Rain, Storm, Wind)**
Location							
Laura Creek	X	X		X	X	X	X
Lake Llangothlin	X	X			X	X	X
Barley Fields				X		X	X

Kirby Farm	X		X		X	X	X
Deer Park	X		X		X	X	X

As previously outlined in the literature review, there has never been research into artefact site integrity with a focus on New England. The closest to New England was Godwin (1990), who explored the transverse breakage of stone artefacts by cattle and vehicles, concluding that it was hard to determine the specific cause of the breakage (Godwin, 1990: 241-242). The methods used in this study will analyse how certain individual factors impact stone tools in the New England Tablelands and what they actually do to stone tools.

Below are methods which were designed to map and understand the movement of artefacts more effectively than in previous studies, and to build on previous research such as that undertaken by Midgley (1998) and Cameron (1990), who found that artefacts are impacted by location specific factors like wind or tourism. They failed to look at other impacts in the area and did not monitor the sites as frequently as they could have.

3.2. Experimental Archaeological Methods

As discussed in the literature review, experimental archaeology can help test various hypotheses and theories (Coles, 1967: 1). When researching how stone tools were used, manufacturing them can help understand how they were most likely utilised (Ascher, 1961: 793). Similarly, by placing stone tools in a landscape and monitoring them over time, a better understanding of their movement and changes can be determined. Observational experimentation was the main method used in this study.

This is a new study and some of the techniques and methods in it are unique. In previous experiments, stone tools were monitored and mapped in the landscape. In this experiment, mock artefacts with magnetic properties were used so they could be found with a metal detector. Previous studies had a tendency to write off or overlook artefacts if they went missing (Midgley, 1998). The concern was mainly with the ones that were visible since it takes time to re-locate the artefacts in the field. Cameron et al. (1990) speculated that the *other artefacts could have been covered by blown sand* (Cameron, et al. 1990: 64). Midgley (1998) did make note of artefacts that went missing during holiday and non-holiday periods and noticed that 94% of artefacts would go missing in the holiday periods and 39% would disappear in the non-holiday periods (Easter and Christmas). In both of these studies it was observed that, after a stringent monitoring period, artefacts would be disturbed by external factors. With regard to my study, stone tools were substituted with metallic and magnetic items in order to minimise the disappearance of material and determine where the mock artefacts would end up.

As part of this study, mock artefacts were placed in the landscape, monitored and detected with a metal detector to better track their movement. Even though this unique experimental process was being undertaken, regular archaeological practice was incorporated into the study including monitoring, survey, and the use of technological devices like a camera, a metal detector, a GPS, and planning frames (Catling, 2009). A detailed outline is listed in a later section of this chapter (see experiment setup).

To better understand artefactual movement and site integrity, this experiment was conducted monthly over the course of six months. Five locations were chosen and controlled with regard to where squares and artefacts were placed. Each location had a combination of different land features and other characteristics such as, slopes, flats, various soil types, varied native and introduced animal species impact, observed human activities, sparse vegetation growth and no growth. Instead of monitoring the potential impacts to actual Aboriginal sites like previous studies, this study observed the kind of changes that were happening to simulated Aboriginal sites in the New England Tablelands by looking at numerous impacts (see table 1). Several locations were selected in an attempt to try and control certain scenarios, and to observe how the artefacts are impacted. Additional monitoring was required over the previous months, instead of monthly there a few cases where fortnightly monitoring was undertaken. The frequency was determined by weather, scheduling and other unforeseen circumstances like public interference and artefact tampering. The experiment also examined whether artefacts move, break, and disappear due to factors such as vehicles. It also measured how this happened and the effects of this on artefact size and placement and, therefore, the interpretive potential of their context. From initial setup to final monitoring stages, this experiment also examined how artefacts can be moved and the distance of this movement. Mock artefacts were used to accomplish this; created in a way to be easily identifiable in the landscape and not of the same material as the genuine artefacts in each location.

Even though this study focuses on the New England tablelands, the findings are applicable to locations with similar environments and industrial developmental patterns. The experiment examines the influences that short term exposure to certain processes can have on stone tools.

Experiments from an archaeological perspective have previously only looked at one location within a region. This study will be at various locations to understand artefact disturbance on a larger scale. The advantage of using a large scale approach is to account for variability in different landscapes and environments observed within a region. For instance, the experiment has taken into account differences in slopes gradients, soil types, vegetation, and faunal activities, which can all contribute to post depositional processes. Accurately mapping and documenting the degree of change is vital to improving heritage practice and to ensuring that artefact scatters are avoided by developers. Previous studies have neglected to examine these processes thoroughly and have only been focused on one or two impacting factors in one location.

3.3. Comparable Methods

The following section outlines previous, experimental archaeological studies and methods similarly to those used in this thesis including Cameron et al. (1990), Midgley (1998), and Partegar (2011). Methods outlined include monitoring, use of mock artefacts, comprehending movement, macrofracture, square setup, and general labelling techniques.

Cameron, et al. (1990), investigated the post depositional effects caused by wind in the Flinders Ranges. Some of their observations and methods are carried over into this study. Similar to that of Cameron et al. (1990), the painting of artefacts was achieved by sourcing a reasonable paint that does not rub or scratch off easily, so that the painted artefact can be readily identified in the field (Cameron, 1990: 62-63).

Midgley (1998) looked at disturbance by tourists at sites within Mungo National Park. The study utilised mock artefacts, but they were not metallic and many were lost. Material used was of the local raw material found in the area and were labelled accordingly. Seasonal monitoring was the main focus of the experiment. They studied how tourists would interact with the artefacts; by touching them, picking them up, and moving them (Midgley 1998: 223). In this study, mock artefacts were used and, rather than seasonal monitoring, monthly monitoring was incorporated, as well as the use of objects with high magnetism to facilitate re-location. Using magnetic objects and a metal detector can help better pinpoint where the artefacts have repositioned in the landscape. This technique limits the loss of artefacts.
Parteger (2011) investigated the effects of human and cattle trampling and macrofracture on artefacts. The methods used in this experiment included the use of a 3 x 2 m rectangular

enclosure where raw material such as dolerite, quartzite, and quartz were knapped and placed in the pen. A total of 150 artefacts, 40 cattle and six humans were used in order determine the impacts of macrofracture (Parteger, 2011: 2884). Even though two impacts were being considered with regard to breakage, there were still other factors impacting the artefacts. Parteger's study only looked at breakage. This thesis also considers aspects like movement, compaction, flipping, and disappearance. Each one of these factors is important in understanding the exact position of the artefact and site monitoring.

Budget: Budgetary requirements included fuel to access field areas, hotel accommodation when gathering materials outside of the New England Region, and expenses incurred for certain materials like washers, fishing crimps, stationery, and curtain weights. Existing equipment was acquired from the University of New England (UNE) where possible.

Logistics: Finally, access to various properties was required so that the experiments could be set up within different locations and environments.

3.4. Discoverability test with metal detector and stone tool comparison

The following section discusses the processes undertaken for finding a substitute material that emits a strong enough magnetic field so that they can be sensed by an E-trac Minelab metal detector (Figure 1). This part of the experiment attempts to understand what can be detected by the metal detector that is a similar shape, size, weight and density to a stone artefact. A list was compiled of the objects (see section 1.4.1) from which ten items were carefully chosen to determine if they were viable options to use in this experiment. All materials and items had a magnetic field and could be picked up by a metal detector. Some items were not tested but are mentioned below.

The items selected to be as similar to a stone artefact as possible. A blind spot test (see section 1.5) was conducted to see if the artefacts could be located by the metal detector without visual cues. The most ideal items for this experiment were decided based on discoverability, size, shape, weight, density and stone tool comparability.

Figure 1: E-Trac Minelab - Metal Detector

3.4.1. Stone with High Iron Content

Researchers in previous studies have accepted that artefacts can go missing after disturbance. A metal detector may be able to detect the metal content within the material making monitoring its movement easier than with regular stone tools. Stone with potentially high iron content was tested in this experiment to see whether it could be detected with a metal detector. Instead of using a material that was local, magnetic objects were sourced outside of the region, apart from basalt, which was sourced locally. Below is a list of materials trialled in this experiment.

Slag was initially chosen because of its potentially high iron content and because it has a similar shape and weight to a normal rock. Slag is a by-product of iron-ore refining. Slag could be used to create stone tools (knapped) and it has some metallic properties giving it the potential to be located in the landscape with a metal detector. Even though there is still a small amount of magnetism present within the slag, testing showed that it is not enough to allow detections by the metal detector. There were two types of slag readily available for acquisition: the Basic Oxygen System, or Steel Furnace Slag, and Electric Arc Furnace slag. These two slag types are the result of different iron smelting processes and are formed differently from one another("What is Slag?," 2006). Both slag types contain iron properties, though at insufficient levels for metal detection. Below are the details of this experiment in relation to what materials I used.

3.4.2. Basic Oxygen System Slag

The Basic Oxygen System (BOS) slag, also known as Steel Furnace Slag (Figure 2), was sourced from a company in Newcastle called South Coast Equipment Group (hereafter SCE) ("What is Slag?," 2006). The company provided approximately 45 litres of varying pieces. Once the material was transported to Armidale, the material was knapped with a hammer stone. A basalt hammer stone was used to attempt to knap the material and thereby remove flakes from the core. If the hammer stone was unable to break the slag, a metal hammer was instead used. Small pieces could be flaked off using the hammer. Following the knapping process, a metal detector was used to scan over the top of the material. Unfortunately, only the larger un-knapped pieces were able to be sensed by the metal detector. Consequently small slag flakes were excluded from the experiment. All the iron properties are taken out of the raw material during the smelting process and the resulting by-product is slag.

Figure 2: Basic Oxygen System Slag

3.4.3. Electric Arc Furnace

Electric Arc Furnace slag was unbreakable using a hammer stone and a metal hammer (Figure 3). Large pieces were ruled out because they could not be knapped. Smaller pieces given by SCE were trialled with the metal detector and were found to be undetectable.

Figure 3: Electric Arc Furnace slag

3.4.4. Glassy Slag

Slag that was glassy was difficult to attain from iron ore companies or equipment groups ("What is Slag?," 2006). Any small amount that was available was smaller than the artefacts found in the New England Tablelands. Glassy slag was excluded from this experiment due to the lack of magnetic properties.

3.4.5. Basalt

Basalt was gathered from the University of New England grounds in attempt to see if it had high magnetic properties that may register on the metal detector. Basalt has more than 10% iron within the material. Four sizes were used varying from 20 mm in maximum cross-sectional up to around 60 mm and; not even the largest piece registered. No further testing was undertaken.

3.4.6. Magnetic hematite

Magnetic hematite has high magnetic properties and forms naturally in iron ore deposits. It also can be knapped or reduced similar to silcrete and chert. The material can crumble under extreme pressure, but once reduced, not only is it detectable with a metal detector; it has the potential to be disturbed in the same ways as other knappable materials. Wollongong was the closest location that was able to provide sufficient quantities of magnetic hematite for the experiment. A magnet was used to test whether magnetic hematite had a high enough iron content to be detected. The magnet was successful in being attracted to the magnetic hematite. A different type of hematite was also tested, which contained a lower level of magnetism than the hematite and failed to attract the magnet. Both materials were transported transported to Armidale where knapping of the material proceeded to alter the shape and sizes to more closely resemble that of an artefact. The resulting pieces were then tested with the metal detector.

At first the metal detector detected all three maximum cross-sectional sizes of the material. These ranged from under 20 mm (small), above 20 mm (medium) and above 30 mm (large). All large, medium, and small pieces were registered on the metal detector. All pieces were painted, numbered, weighed, and then measured (Figure 4 & Figure 5). The yellow paint that was used on the dorsal side was enamel fast dry spray paint and on the ventral side oil based sharpie paint was used for the numbering of each mock artefact. The next stage was to observe conditions at Laura Creek and to check if all sizes of the magnetic hematite could be detected in the landscape. Laura Creek was chosen due to the environment and it was also accessible to the public. All pieces of magnetic hematite were placed within a 1 x 1 m square. Once pieces were placed on a section of the vehicle track, the metal detector was used to see if they could be detected. Large and medium pieces gave off a strong signal, whereas the smaller pieces were unable to be detected. Based on these findings magnetic hematite was used to replicate medium and large artefacts.

Figure 4: Magnetic Hematite Numbered Large and Medium sizes

Figure 5: Magnetic Hematite Painted Large and Medium sizes

3.4.7. Selection of Metals

A list of different metallic items was compiled to determine what alternative materials would be ideal for this experiment. Their characteristics need to be light, jagged and of a similar shape to a flaked artefact. The reason for this is so that close to 100% detection of material from the metal detector can be achieved.

Steel Washers (Figure 6**)** were used because they are small and light, similar to knapped silcrete or chert material. These washers were purchased from the Bunning's Warehouse in Armidale. For more information on the item see section 3.5.

Figure 6: Steel Washers

Fishing crimps (Figure 7) were purchased from the Boating Camping and Fishing store (hereafter BCF). These were used in the blind spot test (see below). These crimps in particular were chosen for their long thin shape, similar to that of regular small stone flakes.

Figure 7: Fishing Crimps

Curtain weights (Figure 8) that were 20 mm in length were acquired from Lincraft. The curtain weights provided a high discoverability quotient due to the metal content.

Figure 8: Curtain Weights

Complete Keys (Figure 9) came in a range of different shapes and sizes and were gathered from Bunning's Warehouse. If the magnetic hematite was hard to detect by the metal detector due to potential low levels of magnetic properties, then the complete keys were a potential substitute. This is due to the size, shape and weight of the keys, and also the fact that a metal detector could be used to find them again if they went missing. Keys also glistened in the sun, attracting the eye much better than a rock can. Since the magnetic hematite was suitable at a certain weight and size, these keys were broken into smaller pieces including proximal and distal segments (medial and distal) (Holdaway and Stern, 2004).

Figure 9: Complete Keys

Proximal Keys (Figure 10) was the name given to the top of the key where the key ring is situated. Bolt cutters were used to reduce the keys to this shape and size. The reduced keys registered a high discoverability from the metal detector, just as much as the complete keys did. However these were not used, because of the possibility that the key rings situated on the top of the keys (Figure 10) might get caught on vegetation or other leaf litter, thereby preventing the movement of the proximal key.

Figure 10: Proximal Keys

Broken Keys (Figure 11) are another alternative metal group that has been used for this experiment. Like the complete and proximal keys, the broken keys are the distal ends of the keys. The broken keys can also be sensed easily with the metal detector.

Figure 11: Broken Keys

3.5. Blind Spot Test

The blind spot test was conducted using two people; one person to place an object within a designated location, in this case the 1 m x 1 m planning frame, whilst the other person is not looking. The first person then covers the object with grass and the second person must find the object with the metal detector. If detected successfully without a visual cue it would then be placed in the potential sampling category for further assessment. If the object was not detected then it would not be considered for additional use. The following objects were incorporated into the blind spot test: washers, sinkers, complete, proximal and broken keys, curtain weights, and the magnetic hematite. In this study, large and medium pieces of magnetic hematite were used in addition to a substitute piece of metal to replicate the shape and weight of a stone tool that is less than 20 mm in cross-sectional size. Alternatives that had been looked at to try and establish the best discoverability are discussed below. It should be noted that magnetic hematite will break under pressure, move, and flip whereas a substitute piece of metal can only be used to understand the movement of smaller artefacts.

The University of New England campus was selected as being a convenient location. However the university grounds were found to be providing false positives when using the metal detector. According to one of the grounds keepers as well as a geomorphologist, Dr Robert Haworth, on campus there are natural iron ore deposits. Smaller pieces (less than 20 mm in size) were not giving the desired reading. A single small piece was hidden in the soil and a metal detector was used to try and locate the object. With no detection signal, the object was lost.

The blind spot test took place at MacDonald Park in Armidale, a public park with some background noise which hindered the experiment. The background noise may have been from unknown dropped metallic items or underground utilities. An area was carefully chosen with minimal background noise. Other metallic materials from Bunnings, BCF, Lincraft, and Woolworths were collected to determine the level of discoverability needed so that items could be detected in the landscape. Other items such as steel washers, keys, slag, curtain weights, magnetic hematite, and fishing crimps were trialled to get a scope of what may have been be useful for this experiment). The following items were only used for the discoverability aspect of the experiment and not the monitoring portion (see Table 1.1 for strength of discoverability). Broken keys were found to be the best option due to the size, shape, weight, and the angular edges on the tips of the keys, which is arguably similar to that of a retouched flake.

Steel Washers were the first to be experimented with in the blind spot test. This was not a problem for the metal detector, but other issues with the washers were that they are round and have a hole in the middle. This could present a problem for the monitoring, because the rounded nature of the washer might get caught on various aspects of the landscape, including roots, sticks, rocks, and leaves. Washers also do not look anything like a stone flake found in the New England tablelands or anywhere else.

Magnetic Hematite is a type of iron ore that is found in South Australia and Western Australia. This was used because it was magnetic and could be knapped in a similar manner to in the way of a stone tool.

Complete Keys were used because of their magnetic properties they have. Also, they are elongated and are of similar shape to stone tool artefacts. These were found very easily with the metal detector due to the size of the key. These could be used in place of the magnetic hematite; however, they are not the same density as a stone so these were not used, and furthermore may have been picked up by the general public if noticed.

Proximal Keys are the topmost ends of the keys. That was used in the blind spot test. Like complete keys, they responded well to the metal detector. The proximal keys were not used because of the shape of the object and the key ring situated at the top of the key. It was believed the key rings could get caught on other objects in the landscape.

Broken Keys were a combination of medial and distal pieces from a complete key. These were small and almost the same shape and size as a small artefact/stone flake. In the blind spot test the broken key gave off a slightly weaker signature than the proximal and the complete keys, however, it was loud enough to determine where they were located.

Fishing crimps of a cylindrical shape were acquired from BCF. They were chosen due to the similarities in size, shape and weight they have to a small stone flake. The detector had no issue picking up they were chosen due to the high iron content within the material. The only issue was that it was thought to be too smooth for this experiment. There was nothing jagged about the sinkers. Also they were expensive in comparison to the broken keys, which were freely acquired.

Curtain weights are disc like in shape and are heavy for their size; however these were quite smooth. It was very easy to locate theses during the blind spot test. Although, since they are nothing like a stone artefact in size, shape or density, they were not used for the monitoring part of the experiment.

Below is a table created for the purposes of understanding the strength of each object used in the experiment (see Table 2).

Table 2

Table of different metals from the discoverability test

Table of Items	Visibility	Discoverability	Similarity to Stone Tools
Complete Key	High	High	Medium
Proximal Key	High	High	Medium
Distal Key	Medium	High	Medium
Spiral Washer	Medium	Low	Low
Curtain Weight	High	Medium	Low
Magnetic Hematite	High	Medium	High
Fishing Crimps	High	High	Low
Slag (BOS)	High	Low	Medium
Slag (EFA)	High	Low	Medium

Key	
High	Highest recorded in test
Medium	Medium range recorded in test
Low	Lowest recorded in test

Discussion

As a result of the blind spot test a combination of magnetic hematite and broken keys were used. Magnetic hematite was used because it can be knapped and shaped into something that looks more like an artefact. It is not a material found in the New England tablelands and can break under extreme pressure. The fact that the metal detector sensed the magnetic hematite at sizes of large and medium (15-20 mm- 20-35mm) made it ideal for the experiment. When the material was reduced to a smaller size (<15 mm), the metal detector struggled to detect it. When the smaller size was detected it was hard to determine if it was background noise or the flake itself. Broken keys replaced the much smaller flakes of magnetic hematite due to its lower frequency. For a full photographic record of the blind spot test and experiment setup please see appendix A.1 in the attached DVD.

3.6. Experiment Setup

Based on the results from the discoverability experiment, large and medium pieces of magnetic hematite were used. The broken keys were each engraved with a unique number for identification (Figure 12).

Figure 12: Broken Keys, engraved and photographed (n= 87)

3.6.1. Determining Site Locations

Five experimental sites were set up within the New England Tablelands (see Figure 13). Between five and nine 1 x 1 m squares were set up at each of these sites. The first of the sites was set up at Laura Creek. An artefact scatter was previously found here in 2013 by the University of New England's Lagoons Heritage Project (Beck et al 2015). The next site was set up at Lake Llangothlin, another location in the Tablelands where archaeological sites have been located, including scar trees and a grindstone. Llangothlin and Laura Creek are the most northern and furthest locations away from the university. The third site was set up to the south of the university close to Uralla at Barley Fields lagoon near another known Aboriginal artefact scatter also discovered by the University of New England Lagoons Heritage Project. The final two mock sites were placed on university land, one within the Deer Park which is inhabited by deer, kangaroos and rabbits. The other site was set up at Kirby Farm where sheep and cattle are held for research purposes.

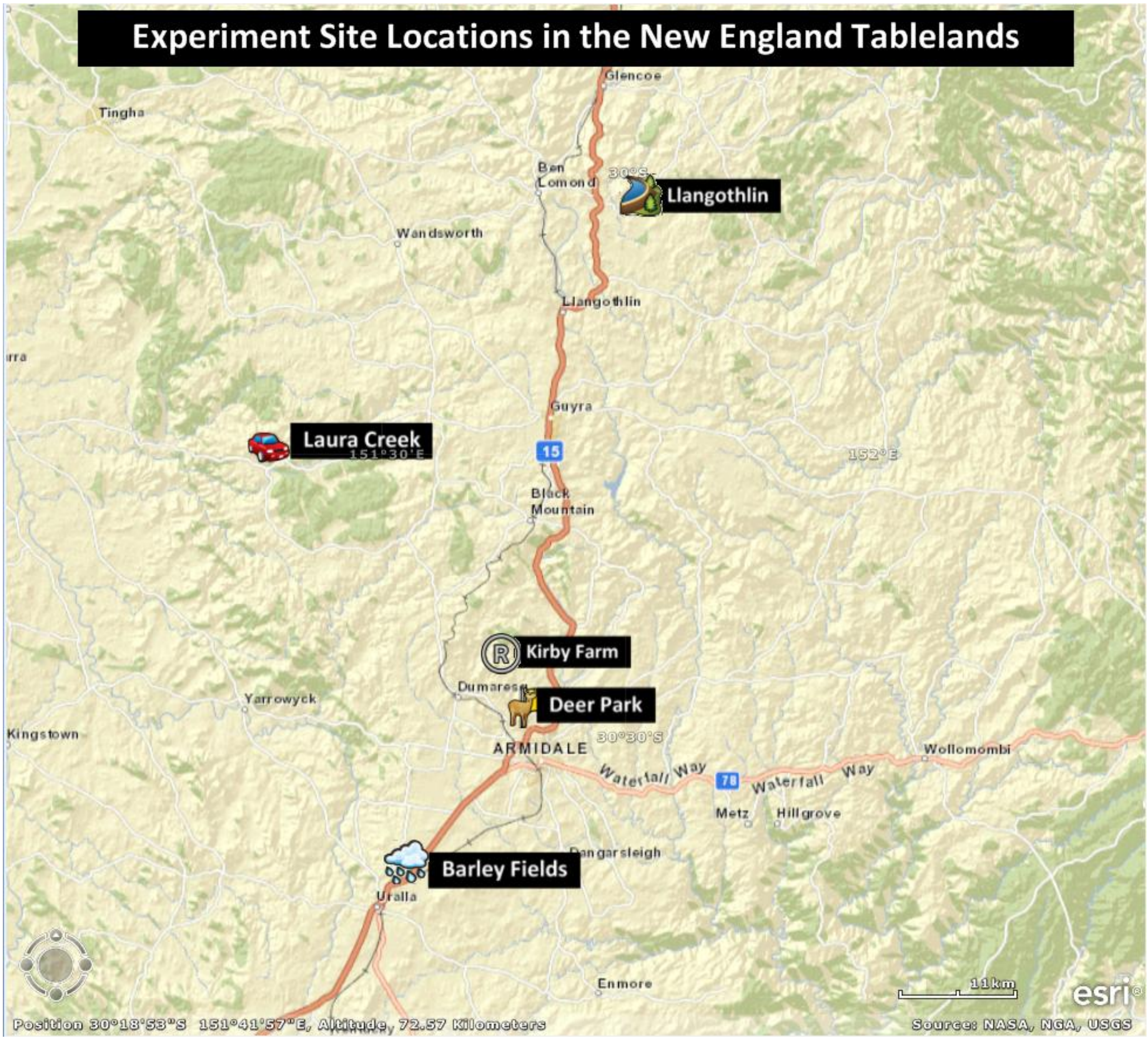


Figure 13: Map of locations

3.6.2. Description of Locations

An Aboriginal artefact scatter is located within Laura Creek on the crest and the slope of the vehicle track near the creek. This was the first location finalised for the experiment since it was close to a known artefact scatter and current public use areas. There are obvious signs of rubbish, modern hearths and even a sprinkler system. The frequent year round use of the vehicle track allows for the examination of continual disturbance to a known artefact scatter. Godwin (1990) noted that artefacts in the New England tablelands were being broken by cattle and vehicles. The effects of slope activity and cattle were also recorded in this area. A total of five squares with 45 mock artefacts were placed in targeted locations to understand these impacts. The first two were placed on flat terrain; one on the vehicle track and one off the track on grass. Two were then placed on the slope with one on the track and one off the track. The final one was placed in an area that appeared to have the most activity: on the track on a slope near the creek.

Llangothlin was chosen due to its sandy soil, steep slope, and the presence of rabbit burrows. One square was placed near a large rabbit burrow, which was measured at a depth of 1.70 m. This appeared to be the largest of the burrows and had a large amount of sand piled up nearby. This sort of disturbance could have moved surface and subsurface artefacts. The second square was placed further away from the burrow to understand how rabbit movement can affect surface artefacts. Sand was not as prominent in this location, but denser vegetation was observed. The third square was placed on the upper slope on the northern terrace of Lake Llangothlin to assess sheet wash and slope activity. The fourth square was placed on the middle slope of the terrace, where a livestock pad was noticed; again slope movement was needed to understand the variables and degrees of disturbance. Finally square five was placed on the lower slope of the lakes terrace, closer to the water line, to understand the degrees of artefact disturbance. It should be noted that there are scar trees surrounding the northern part of the lake and also a grindstone which was found recently on the eastern side of the lake.

Barley Fields is located approximately five kilometres north east of Uralla. It is an old stock route on Crown Land property and a large artefact scatter is present here near an ephemeral lagoon. The land used to contain livestock, but no longer does due to the ecological sensitivity of the lagoon. Barley Fields was chosen because of the high levels of erosion noticed upon first inspection. Vehicles have churned up the soil over a long period of time. The landholder instructed that anyone going onto the property should not drive on it, because of the conservation efforts put in place. A total of nine squares were positioned over the property. Two on a much eroded track and two off, three were placed near a fence line and two were positioned on the flattest part of the property, one on the road and one off. The two squares placed near the fence line were set up to assess the effects of weather events as well as the two squares in the flattest part of the site. These four squares were reset after rainfall, hail, snow, or storm.

Deer Park was chosen because of the high level of animal activity present. This location has two sections; one is solely for kangaroos and the other is for deer. Three squares were placed within the kangaroo section to understand one of the potential hazards affecting artefacts over time in Australia. Two were placed near where kangaroos are most likely to gather, one near a tree and one away from the tree. The other was placed closer to the entrance, where kangaroos were least likely to impact the artefacts. Two squares were placed in with the deer, one near the food trays and the other away from deer activity. The groundskeepers were able to assist in determining these locations. Deer are a common faunal pest in the New England Tablelands and in other locations in Australia.

Kirby Farm was selected because of the high livestock activity. Sheep and cattle are the largest non-native animals to have impacted the Australian landscape, via trampling and grazing. This study will only look at how sheep can impact an artefact scatter. Five squares were placed in one of the sheep paddocks at Kirby Farm, two near the gate approximately five metres apart on the flat in unexposed ground. Another was placed on a highly eroded section of the paddock. The final two were placed on the slope, one on exposed ground and the other on non-exposed ground.

3.7. Square Setup

A total of 25 squares were set up for monthly monitoring, four of which were situated for reset weather monitoring, with a potential for a further four squares if needed. The weather monitoring squares are supposed to be reset after a weather event. For instance, if rain occurs and movement is observed the artefacts will be put back into the original position. Each square was 1 m squared and divided into 100 10 cm squares. Square 1 was in the northwest corner and square 100 was in the southeast corner, numbers have been placed in the top left and bottom right squares for reference (Fig 1.12). Squares were not left in the open at locations and only datum points were permanently present. It was important that each square was set up so as to be easily locatable using two specific datum points. Two galvanised nails were driven into the ground at the North West and North East corners of squares. Each square was setup up in a way to ensure an element of control over the experiment. Where a square was located on a vehicle track, another was sited nearby but off the driving track. This ensured that, if a vehicle destroyed the artefacts on the track, the ones off the track would not be affected.

Equipment required to set up the squares included a camera, tripod, a planning frame (or drawing grid see Figure 14) of 1 x 1 m (Catling 2009: 83) in total measurement with a string line attached to the frame divided into 100 sub squares, a pen and recording forms, GPS, a metal detector, a compass, a tape measure, and a line level with string line.

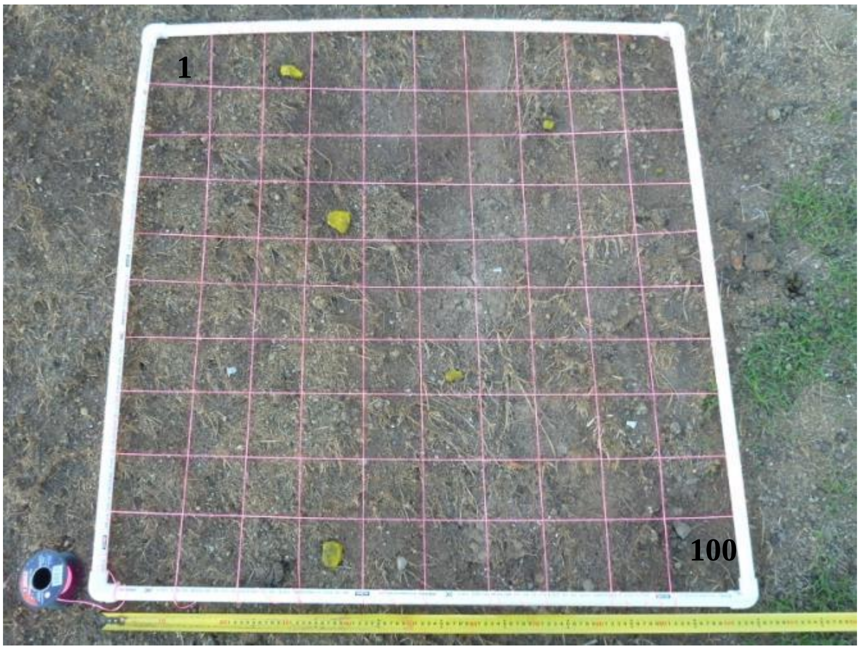


Figure 14: Example of setup

Five squares were placed at each location in Laura Creek, Lake Llangothlin, the Deer Park, Kirby Farm and Barley Fields, and an extra four squares were placed at Barley Fields for weather monitoring, these were set up to be reset after weather events like rain or high wind activity. The locations used for monitoring are listed below (see Table 3).

- Laura Creek: vehicle, sheet wash, cattle, and slope activity
- Llangothlin: rabbits, sheet wash and slope activity
- Kirby Farm: livestock (sheep)
- Deer Park: feral and native fauna
- Barley Fields: weather and erosion

Table 3

Location and Major Impact Table

Impacts	**Hooved/ Animals**	**Non-hooved**	**Native Animals**	**Vehicles Near track and on track**	**Slope**	**Vegetation**	**Weather (Rain, Storm, Wind)**
Location							
Laura Creek	X	X		X	X	X	X
Lake Llangothlin	X	X			X	X	X
Barley Fields				X		X	X
Kirby Farm	X		X		X	X	X
Deer Park	X		X		X	X	X

Prior to the squares being set up a metal detector was used to identify any background noise at the location; a note was made in the recording sheets. Outlining the (square) location and level of any background noise that was picked up by the metal detector. All attempts were made to ensure minimal background noise interfered with the metal detector.

Once a square was marked out, conditions within each square were identified, including the length of grass, erosion, scats, trampling, tracks, or traces. Each artefact was placed in a square based on the result of a random number function on a scientific calculator. For example, if the number 20 came up on the calculator then the mock artefact would be placed in square 20. No artefact was placed directly next to another to ensure that there was no interference with the other artefacts too early in the experiment. As discussed previously the artefacts were painted with yellow spray paint on one side and a white paint marker was used to number the other side (Figure 15). Each artefact was photographed with its unique identification number face up and then painted facing up (Figure 15). Artefacts were left in-situ with the painted surfaces facing upwards (Figure 16), except in the case of the broken keys, where the numbers were placed facing up. A photo was taken directly above the square and another photo was taken 5 m east of the square measured out from the south west corner to the 5 m mark in order to show that square's landscape context.

Figure 15: Photograph of setup before flipping takes place

Figure 16: Artefacts flipped onto painted side

3.7.1. Datum

The locations of datums were marked using two eight inch galvanised nails which were driven into the ground with a hammer. These nails were found to be very high in iron which allowed for easy detection with a metal detector. The datums were used as a point of reference so that the 1x1 m squares could be placed in line with the northwest and northeast nails. The squares were aligned north-south. Only the top of the nails were visible in order to reduce potential interference by people or animals. A GPS reading of the North West corner was also recorded for each square to produce a locality map indicating where each square was located within the New England Tablelands.

3.7.2. Rain Gauges

A single plastic rain gauge was placed in five locations where each experiment was situated. Rainfall monitoring is important because it can be used to accurately establish how much rain could impact stone artefact movement and position.

3.8. Monitoring

Monitoring was undertaken each month over a six month period, from November 2013 to June 2014. In all except for the first month, a two week timeframe was undertaken in order to better understand the results during a set monitoring period.

At each site visit the following information was recorded and questions addressed (see recording sheet):

- Flipping of the artefact and the suspected cause
- Movement of the artefact and how far it had moved?
- Breakage: how many pieces did it break into?
- If the mock artefacts have completely disappeared, what would do this? Where could they be?
- What has appeared in the square since the last time it was recorded?
- Vegetation growth was also recorded, including exposed ground, vegetation <3 cm and/or vegetation >3 cm.
- Rain gauge monitoring to determine how much rain has fallen since the last inspection (Figure 17).

- Sheet wash identification was also monitored including soil erosion, which may be more prominent since the last visit.
- Weather conditions on the day were also recorded, including whether it was a clear, sunny, windy, rainy or stormy day. An ‘other’ column was added to the recording sheet in the event that there is a combination of weather patterns or hail.
- Wind activity is a difficult aspect to monitor but this was accomplished by taking note of any fallen trees, sticks or deflated vegetation in the area.

Figure 17: Rain gauge reading

3.8.1. Recording Sheets

Two types of recording sheets were used. One of the recording sheets was designed to record information pertaining to the location of artefacts, other items in the square, such as length of vegetation, scats, tracks and traces (Triggs, 2004), and the presence of rocks, ants, and other bioturbation activity (Stein,1983).

The second sheet was designed to record how far artefacts had moved, whether they had flipped, if there have been breakages, or whether artefacts have gone missing. The potential causes of impacts to artefacts were recorded in a separate table. Examples of these recording sheets are provided below.

The recording sheets were simplified for ease of recording in the field. Each section contained prompts to allow the recorder to remember each item that needed to be recorded.

This included where the artefacts were currently and where they have moved to. Grass and vegetation growth was indicated in the scale drawing section. In the section for recording the location of scats, tracks, and traces, a square number can be written next to the word. Other objects like rocks and sticks can be recorded so that if any changes occur to them, these could be noted as well as changes to the mock artefacts. The GPS section was designed to record the northwest waypoint, indicating the location of each square. A photo section was included so as to keep a log including the photograph numbers and details. A notes section was included to record any extraneous information to the study. Conditions that could affect artefact discoverability and recording such as lightning, weather, time of day, etc., were required to be recorded. Background metal was recorded because if there was any additional metal in the squares when recording, it may have been more difficult to find the mock artefacts. For a full photographic record of the monitoring please see appendix B.1 in the DVD attached

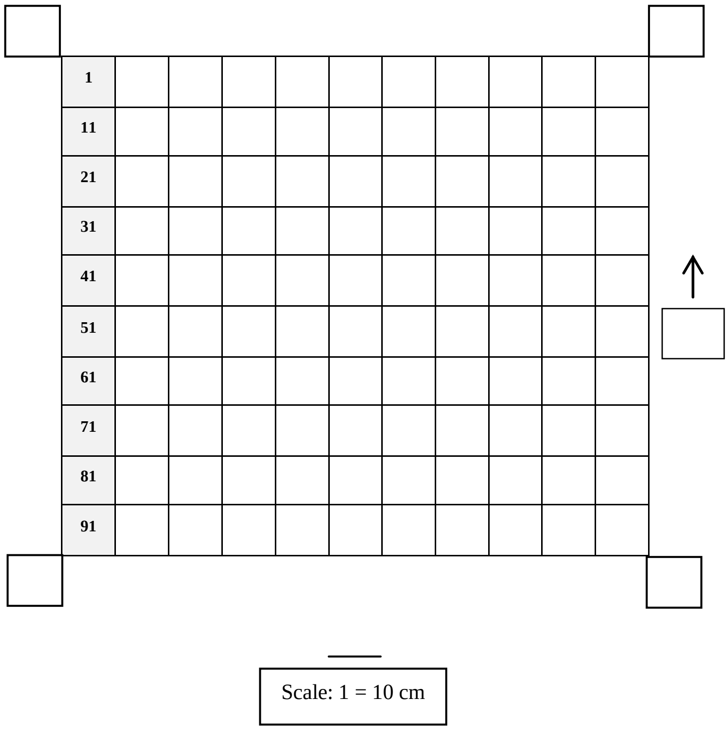
Recording Sheet Setup Sheet	**Date/Time:**
Square Location:	**Square Number:**

Artefact Numbers	**Sub Square**

GPS Reading NW Corner	
Easting	Northing
Conditions on the day (Tick)	
Clear:	Raining:
Cloudy:	Stormy:
Windy:	Other:
Animal Activity (Which square/s?)	
Scats	
Tracks	
Traces	
Trampling	
Background Noise (Which square/s?)	
Other Objects (What objects and which square/s?)	
Photos (Northern Aspect and General)	

Notes *(eg: square is on road etc)***:**

Description of Square	
Bare Ground (0 vegetation)	\
Short Grass (< than 3 cm long)	| |
Long Grass (> 3 cm long)	✖


1
11
21
31
41
51
61
71
81
91
Scale: 1 = 10 cm

Recording Sheet Monitoring Sheet **Date/Time:**

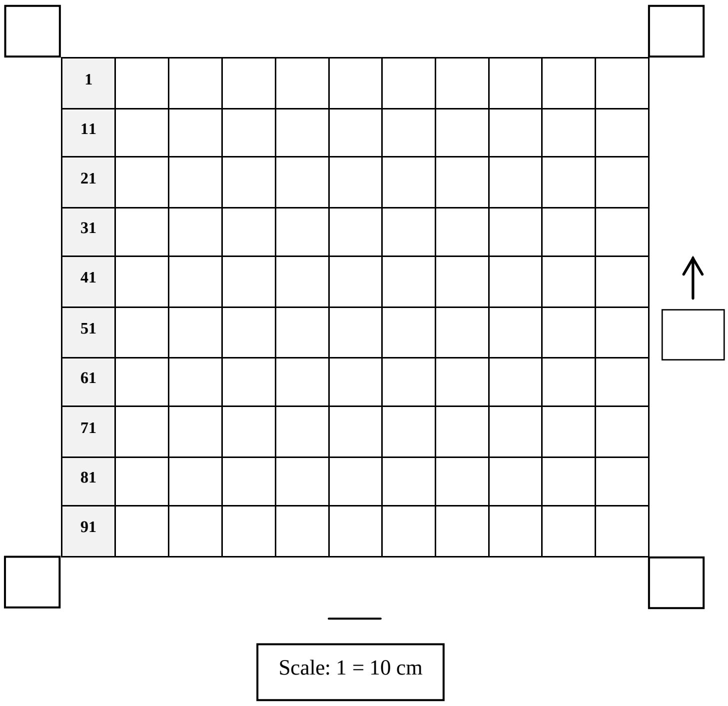
Square Location: **Square Number:**

Artefact Numbers	**Sub Square**

GPS Reading NW Corner	
Easting	Northing
Conditions on the day (Tick)	
Clear:	Raining:
Cloudy:	Stormy:
Windy:	Other:
Animal Activity (Which square/s?)	
Scats	
Tracks	
Traces	
Trampling	
Background Noise (Which square/s?)	
Other Objects (What objects and which square/s?)	
Photos (Northern Aspect and General)	

Notes *(eg: square is on road and vegetation visibility etc)***:**

Description of Square	
Bare Ground (0 vegetation)	\
Short Grass (< than 3 cm long)	| |
Long Grass (> 3 cm long)	✖


1
11
21
31
41
51
61
71
81
91
Scale: 1 = 10 cm

Monitoring Form

Artefact	Square	Flipped (How many times?)	Cause	Distance Moved (How Far?)	Cause	Broken (How many Pieces?)	Cause	Missing (Whole or Part?)	Cause	Comments

For examples of a filled out recording sheet please see Appendix C

3.8.2. Moving Pieces

The main crux of this experiment was to examine the movement of artefacts over the monitoring period. Each artefact movement was measured from where it was once situated to where it was located a month later. Any movement of artefacts was measured and a note of the likely cause was documented. Every attempt was made to understand the cause of artefact movement even when this was initially difficult to ascertain.

3.8.3. Flipping Pieces

Previous studies have identified that flipping of artefacts can occur. This was monitored for the mock artefacts as part of this study to attempt to identify the factors that may cause the flipping and turning of artefacts away from their original position.

3.8.4. Broken Pieces

Broken artefacts are a common element in the archaeological record. Normally it is the result of knapping events (Holdaway and Stern, 2004). As discussed in the literature review livestock can trample and break artefacts transversely. The examination of the breaking of artefacts in this experiment was limited to the magnetic hematite samples and not the broken keys, because it was the only stone type used (Figure 18). It was assumed that the keys would not break in this experiment.

Figure 18: Broken pieces within planning frame

3.8.5. Missing Pieces

A common issue in archaeology and particularly in experimental studies is the loss of artefacts (Midgley 1998; Cameron 1990). In this experiment all attempts were made to try and find all of the mock artefacts, but the metal detector had a range depth of 30 cm so this task proved difficult. Any mock artefact that could have moved lower than 30 cm would be undetectable. It was difficult to know where the artefact would end up and what else could be sitting under the surface. Even though a blind spot test was undertaken, items of a similar reading could impact on the metal detectors frequency. If an artefact could not be found, they were written off as missing.

3.8.6. Linear and Mixed Movement

Linear and mixed movement refer to whether the artefact moved in what appears to be a straight line over the monitoring period. If an archaeologist is trying to re-record a site and the artefacts are no longer present they might be able to predict where the artefact may have travelled to. For instance, if an artefact moved due north during one period and then north east over the next monitoring period it would be classed as mixed movement, whereas if it kept moving north in a straight line then it would be considered linear movement.

3.8.7. Comments

A section was included in the recording sheet for any additional information required to be noted in the field. For example, if an artefact was compressed into the ground or if something unexpected had happened, notes were made in this section.

3.8.8. Soil Analysis

The soil in each location was often a significant contributing factor in whether or not artefacts moved. If the soil was very sandy, the mock artefacts might move subsurface and could move depending on how heavy or light they are. However if the soil was silty or clayey (Speight, 2009) the artefact could move on the surface over great distances. Monitoring of each artefact in different soil types was important to analysing if artefacts would move, flip, break, or disappear.

3.8.9. Vegetation Growth

Vegetation growth was monitored over the course of the experiment. From the commencement of this study notes were made by determining whether the ground was exposed, whether the vegetation was < 3 cm or > 3 cm in length. Over long periods of time there is the potential that grass could grow substantially and push artefacts away from their original locations or even conceal or bury artefacts. If long enough, vegetation may also prevent the artefacts from moving subsurface or down slope.

3.8.10. Object recording

Recording object location at the beginning and end of the experiment was just as important as the monitoring of their movement of the mock artefacts. Objects such as leaves, branches, sticks, rocks, and even man-made items, could directly affect the mock artefacts. They could cover them, push them, and break them. Further, if branches had fallen over the squares, this would indicate that high wind activity had occurred.

3.8.11. Animal Activity

Animal activity was also monitored closely throughout the experiment (Figure 19, Figure 20). This included taking note of scats, tracks, and traces within and around the squares. Even though there are squares set aside to examine animal events at specific locations, there is no guarantee that animals would not affect the other squares. Any sign of scats, tracks and traces was recorded and photographed, especially if any of the mock artefacts had moved due to the animal impact.

Figure 19: Kangaroo activity at the Deer Park

Figure 20: Sheep activity at Kirby Farm

Photographic evidence

Photographic evidence was used to record the movement of the artefacts in the landscape. As a measure of movement, photographs were taken at the beginning and end of the month to indicate the specific initial and final location of every artefact. Photos were taken of the 1 x 1 m square facing north and also one 5 m east of the square (facing west) (Figure 21, Figure 22). Artefacts were photographed if they had moved out of the square, using a tape measure to indicate the distance it had moved from its original location. Other items were photographed including foot/hoof/paw prints or tyre marks or any other impact markers not previously seen from the initial setup. If an artefact had moved subsurface it was photographed using a tape measure to indicate the depth from its original location.

Figure 21: Monitoring photograph initial

Graphs and Boxplots

A series of histograms, tables, scatterplots and boxplots were created as a visual representation of the data. The data presents the disturbances observed including what happens to artefacts when deer, sheep, cattle, kangaroos, rabbits, goats, vehicles, rain and wind impact a site. Data presented will be in table, graph and boxplot form, the boxplots show median as a line in the middle of the 2 quartiles (50% of the observations), represented as the box, and the separate points at the end are outliers. Whiskers indicate 25% of the data in the lower instance and 75% in the upper instance. Outliers are >3% which are represented as circles and asterisks are 1-3% of the data (Ling, 2015).

Figure 22: Largest movement photographed at Kirby Farm

3.9. Preliminary Results

The following section contains some results that were documented prior to the main experiment. Laura Creek 1 was set up three days before the other squares. It was used to test the method of movement and to see if it was suitable for the study.

The first stage of Laura Creek 1 was a trial and had required additional monitoring compared to other squares due to the unpredictability of environmental processes at the location. This location was setup on the 1st of November 2013. After three days it had already been disturbed by vehicles. Large amounts of movement had occurred at the Laura Creek 1 site. The following day more movement had been caused by cattle, a whole herd was present at the site and hoof prints had disturbed the site. The trial was a success and proved that large amounts of movement and change had occurred in a short amount of time. No other square was trialled like this, because it was imperative that each square was set up as soon as possible. For the first month the monthly monitoring was reduced to two weeks from the set up date, just to see how quickly the artefact positions would change. After December monthly monitoring occurred.

3.9.1. Laura Creek 1 Setup

As discussed in the previous chapter artefacts were placed within a 1 m x 1 m planning frame which was divided into 100 10 cm squares. The mock artefacts used were labelled 172, 173, 174, 175, 176, 177, 178,179 and 180. These were placed into the following squares as dictated by the random number generator. The list below indicates which artefacts went where:

- Artefact 172, placed within square 65
- Artefact 173, placed within square 70
- Artefact 174, placed within square 45
- Artefact 175, placed within square 5
- Artefact 176, placed within square 33
- Artefact 177, placed within square 37
- Artefact 178, placed within square 50
- Artefact 179, placed within square 7
- Artefact 180, placed within square 88

3.9.2. Laura Creek Monitoring 1

Fresh vehicle tracks were noticed going through the square and it is more than likely that this was the reason why a key had moved 1.28 m and two had been fractured. The vehicle activity was because of weekend activities partaken by the general public. Artefact 174 (Figure 23) had experienced flipping and breakage due to the pressure of a vehicle driving over it.

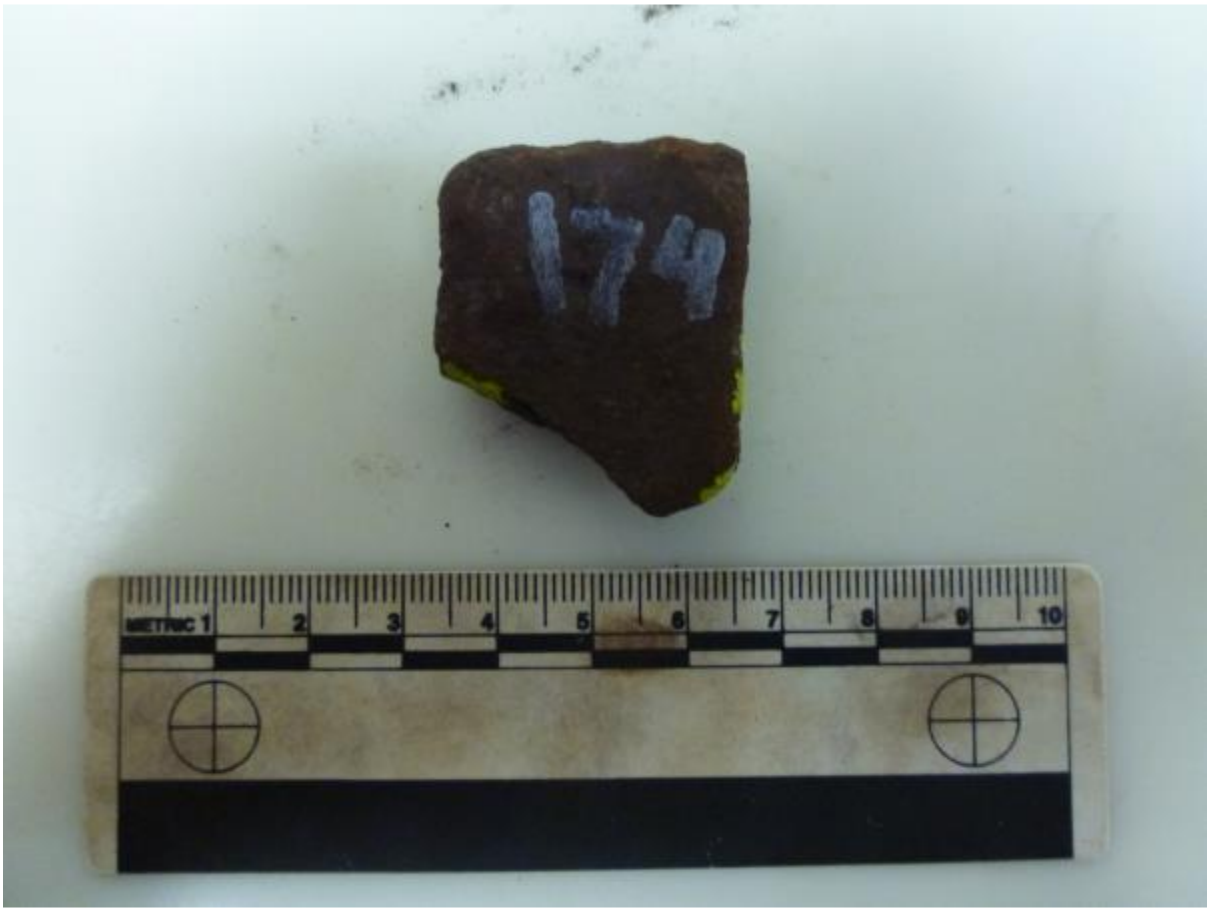


Figure 23: Mock Artefact 174

The following day after Laura Creek 1 had been recorded; cows were visible in and around the square, and hoof prints were photographed near it. On arrival they became spooked and stampeded away from the square, which was not enough time to photograph the impacts.

Laura Creek 1 was the first square to be set up. After three days, the other squares were set up and there had already been movement after the first day. It appeared that a vehicle drove over the top of the mock site, which had resulted in the crushing of one artefact and breaking of another one. One of the broken keys had moved 1 m 28 cm to the north east of its original location (Figure 24). After this, a site visit was conducted the next day which found that cattle had trampled the experiment, they were still in the area and there was a hoof mark to the north of the square. This resulted in a fragment of one of the broken artefacts moving 1.40 m north from its original position (Figure 25). Others had flipped and moved slightly. Only one artefact had not moved since the original set up. There was no issue in finding the mock artefacts once they had been impacted. The lack of vegetation in this square makes them easier to locate.

Figure 24: Laura Creek 1 broken Key moved 1.28 m 23°north due to vehicle activity

Figure 25: Laura Creek 1, movement of 1.40 m NNW 338° due to vehicle activity

The set up of Laura Creek 1 was a good test to observe the experiement in a public place. Fortuitously, cattle and vehicles impacted the site over the three day period so measuring could begin.With artefacts moving to over a metre in a short period of time it was decided that even month to month monitoring may be insufficient to fully comprehend the full impacts of artefact disturbance.

The trial revealed initial answers about artefact movement in a short amout of time in one site in the New England Tablelands. Laura Creek 1 results confirmed movement was possible after short amount of time validating the experimental design that the measureing of artefacts could be achieved with the tools acquired and facilitating dataconsolidation. From this trial more squares were set up as previously planned and the monthly monitoring commenced. The following section outlines key limitationsof the study, a sample of what was observed over the six month monitorng period.

3.10. Discussion

This experiment is unique to the New England Tablelands and was undertaken in order to better understand how stone tools move, break, and disappear in this landscape. There are limitations associated with this research which have been considered. They have been encountered prior to this experiment in similar experiments, including in studies undertaken by Cameron (1990) and Midgley (1998), which both reported missing artefacts and found difficulties in understanding the exact reasons for artefacts to go missing.

3.10.1. Innovations

The innovative nature of this study lies with the idea of examining multiple locations across an area within a region. It also can be attributed to the fact that a planning frame was more accurate and precise in regards to locating the mock artefacts and visualising their movement. Further, by using items that have a magnetic field combined with the use of a metal detector, this study was able to re-locate more artefacts, inevitably minimising the amount of artefacts “disappearing”. This study used material that is not from the New England Tablelands, so that no local material could be confused with the mock artefacts. Finally, impacts to the mock artefacts were examined by looking at multiple possible causes including slope, livestock, vehicle, native fauna and flora, and weather activity. Further understanding these natural and cultural processes affecting stone tools could facilitate the creation of better site avoidance techniques which can then be incorporated into future management plans within the New England Tablelands.

3.10.2. Limitations

Artefacts have gone missing in previous studies, whether they were mock or real artefacts. By using magnetic objects and the metal detector, this study aimed to increase the chances of finding all of the mock artefacts and gaining a more complete understanding of disturbance factors.

When artefacts sank more than 30 cm into the soil, there was a high potential that the artefacts would have gone missing. This is because the metal detector can only detect metal at a maximum depth of 30 cm. In this case they were recorded as missing and therefore a depth reading of >30 cm will be noted. The artefacts could also break into smaller pieces which may have been too small to detect with a metal detector. If there was evidence of breakage and only part of it could be identified, then the rest of piece/s were recorded as missing and an unknown location number was written down in the recording sheets.

Another limitation of this study was the identification of the exact processes that were directly affecting the artefacts. The landscape was analysed by looking at the slope, animal activity such as scat tracks and traces (Triggs, 2004), rain (Wood and Johnson, 1978), wind (Cameron, 1990), vehicle (Sampson, 2007) and human activity, and vegetation growth (Crow, 2004). This study would have been enhanced through the use of motion cameras set up in all five locations because this would have captured the motion of animals and people. However a total of 29 cameras would be needed and this is not a viable undertaking, due to costs involved and the potential for vandalism from the public. In addition, in a real monitoring scenario where an archaeologist is re-identifying a site, cameras are not generally used. Due to these factors, this study has only incorporated the reading and understanding of the landscape and changes exhibited since the initial date of observation.

Intentional vandalism could be an issue for this study. For instance, people go out and destroy the mock sites by picking up the material. To reduce impacts from vandalism, this experiment was designed to be as discreet as possible. Examination of vandalism would be very useful for future studies to consider, since this is a common problem impacting on archaeological sites across Australia. No one has recorded vandalism impacts impacting stone artefact scatters before.

3.11. Conclusion

The methods described within this chapter have been developed to understand artefact movement and change observed in the New England Tablelands. As previously mentioned, this is the first time multiple locations and causes have been analysed on such a large scale. The use of magnetic objects was needed to accurately understand the degree of change with the use of a metal detector to help find the objects. The use of a planning frame which was divided into 100 squares and positioned in a north/south direction was needed to accurately pinpoint the location each time for each month of the monitoring program. The monthly monitoring facilitated the efficient tracking of the artefacts. The use of magnetic hematite was used to support Godwin's (1990) claims of vehicles and cattle being the cause of transversely broken artefacts in the New England regions Magnetic experimental design also allowed investigation of other environmental and non-environmental disturbances from rabbits, kangaroos, weather, human impact, deer, and also sheep by observing the scats, tracks, and traces of the animals. The methods listed in this chapter will hopefully describe what can happen to artefacts on a regional scale.

In the next chapter, the preliminary results will be analysed. This includes the test square at Laura Creek, Laura Creek 1. A sample of the monitoring will be documented in the following results chapter followed by a data analysis chapter indicating the total disturbances.

4. Results Summary

4.1. Introduction

This chapter provides the information and data produced from the monitoring experiment. After each square had been set up, they were inspected in a fortnight. Initially it would have been monthly, but because of time constraints and delays establishing the squares, a shorter period was established until the end of December. A selection of artefacts and squares were used in this analysis because they experienced the most amount of disturbance in the six month period. The first monitoring phase is Laura Creek 1, which began at stage two of the investigation (see the preliminary results from the trial for more information). Laura Creek 2 and 3 were also disturbed dramatically in the first couple of months. The squares at Llangothlin 1 and 3 were dramatically disturbed by rabbits and cattle. Deer Park 1 and 4 experienced the most amount of disturbance in the Deer Park; Deer Park 1 was disturbed by kangaroos and humans and Deer Park 4 was disturbed by deer. Kirby Farm 3 and 4 had the most dramatic changes at the farm, over the six month period, with Kirby Farm 4 being disturbed by a kangaroo instead of sheep. Barley Fields 1 and 8 were extremely disturbed also. Barley Fields 1, 2, 3, 4, 7, and 8 were all harmed by animals, weather, and severe vehicle activity. Only two or three were selected from this study to be used as a sample of what happened in the study from each location. Squares excluded were Laura Creek 3, 4, and 5; Llangothlin 2, 4, and 5; Barley Fields 2, 4, 5, 6, and 7; Deer Park2, 3, and 5; and Kirby Farm 1, 2, and 5. The squares all experienced movement, breakage, and cases of disappearance. Although these were not included in this section, they were included in the following chapter (5).

4.1.1. Laura Creek 1 Monitoring 2

On the 20th of November 2013, more monitoring was conducted at Laura Creek. Square one was analysed first. This was a shorter period of monitoring because of the amount of rain that had fallen in this period of time and time constraints due to the holiday season. The rain gauge had 30 mm of rainwater in it upon arrival.

Vehicle damage had been noticed here, so further breakage and movement of the artefacts was recorded. It should be noted that there was more flipping and breaking than previously recorded. It appears that the artefacts moved dramatically in the first four days of monitoring and not during the second four days. Ant activity was noticed within the squares, but did not appear to be affecting the experiment significantly.

4.1.2. Laura Creek 1 Monitoring 3

The next monitoring was conducted on the 12th of January 2014. It appeared that much activity had occurred throughout the site since the last monitoring in November (Figure 26).

Vegetation appeared to be an inhibitor of movement for one artefact, artefact # 7. It had not moved from the original square where it had been placed. All the other artefacts had moved, flipped, and broken. Some were almost unrecognisable due to the vehicle and cattle activity in the area.

Since the monitoring started in November, Laura Creek 1 (Figure 26) had high degree of impacts from vehicle activity. More monitoring is needed to understand the anthropogenic processes completely.

Figure 26: Laura Creek 1 North Aspect, much activity observed

Laura Creek 2 maintained integrity during the first monitoring period once it had been set up. The most movement was within the square itself and no artefacts had broken, disappeared, or shifted outside the square (Figure 27). Since it is a control square, very little was suspected to happen off the road. It does appear that other elements have not affected the artefacts at all.

Exposed soil was not present within the square due to dense grass cover. The grass could be a contributing factor as to why the artefacts have not moved very far. This was examined further throughout the monitoring period.

Figure 27: Laura Creek 2 minimal movement indicated

As of February, 2014, **Laura Creek 3** had no artefacts present within the 1 x 1 m square. Nine artefacts were not visible within the 1 m x 1 m square. The two last recorded sightings of artefacts were on the 6th of November and the 26th of November, 2013. In fact, no artefacts are visible within the 1 m square (Figure 28). It is suspected that vehicle and slope activity is responsible for the destruction and movement of the artefacts in this square.

Figure 28: Laura Creek 3 no artefacts present within the square

4.1.3. Llangothlin

Llangothlin 1 was placed near a large rabbit burrow. After setting up the square, monitoring commenced on December 12th, 2013. Upon arrival at the square one month after December, the northwest datum had gone missing, it was also noted that two artefacts had disappeared from the surface. The datum was found with the metal detector at depth of 11 cm. One of the broken keys was also found at this depth. In addition a piece of magnetic hematite was uncovered at 9.5 cm (see Figure 29). It appears that items placed within proximity to the rabbit entrance were affected by the activity of rabbits. The softer soil that rabbits often prefer to burrow in would also be a contributor for the sinking of artefacts. Llangothlin is very sandy, whereas, in other locations, silt and clay soils are more common. This may have been why it was easier to relocate artefacts on the surface at other sites.

Figure 29: Magnetic hematite 9.5 cm below datum due to rabbit burrowing within two weeks of the setup.

Llangothlin 3 did not experience large amounts of movement until February 2014, when one artefact had moved down the slope closer to Llangothlin 4. It was observed to have moved 7.20 m downslope (See Figure 30).

Figure 30: Mock artefact moved 7.20 m 270° west in a five month period due to cattle and slope activity

4.1.4. Deer Park

The Deer Park monitoring was to observe the impact animals such as deer and kangaroo have on artefact scatters in the New England Tablelands. Kangaroos were in one section and the deer were in another with a large fence separating the two.

Humans caused the main impact to artefacts in two of the squares near the kangaroo habitat at the beginning. This was due to ongoing maintenance in the deer park, including feeding the kangaroos and driving through the deer park. It is also possible that the two artefacts that had moved outside of the square more than 1 m to the north were because of vehicular activity. Matthew, the grounds keeper, mentioned that he was mowing in the area two days before the monitoring so the artefacts could have been disturbed by him.

Prior to January 2014, artefacts at **Deer Park 1** had moved no more than 20 cm within the 1 m x 1 m square. After January, one artefact had moved uphill over 1 m (See Figure 31). Kangaroo activity is the most likely contributor for the movement. Other artefacts remained within the square, moving roughly 20 cm or less.

Figure 31: Mock artefact at Deer Park 1 moved over a metre in a 315° NW direction over a two month period

Deer Park 4 is one of two squares in the deer enclosure and had less impact or movement compared to artefacts in the other section of the Deer Park. Artefacts experienced a maximum movement of 59 cm there (see Figure 32).

Figure 32: Artefact has moved 59 cm 135° SE due to deer trampling. This has been the maximum movement in a five month period

4.1.5. Kirby Farm

Kirby Farm 3 was situated on a flat surface with very loose exposed silty sand. Movement of up to a metre was recorded here. The magnetic hematite moved significantly due to the looseness of the soil and the high impact of trampling. The broken keys, on the other hand, experienced discolouration due to the sheep scat (see Figure 33), making it difficult to see the mock artefacts. This is why the metal detector was so useful in re-locating the keys.

Figure 33: Mock artefact moved 14 cm 158° SSE due to sheep activity and has also been discoloured due to sheep scat

Since there were no sheep in the paddock at **Kirby Farm 4** and no rain had fallen at this location, it is difficult to determine why one artefact here had moved 3 m east south east from its original location (Figure 34). There could be two factors contributing to the movement, native fauna and/or wind deflation. Since there were a number of weather events around this time, this particular location was open and exposed to wind deflation and aeolian activity. This artefact had moved 3 m south east from an exposed location to a highly vegetated area.

Figure 34: Kirby Farm 4 artefact moved 3 m 113° ESE one week from setup. Kangaroo and wind activity identified

4.1.6. Barley Fields

Barley Fields 3 had only two artefacts visible inside and outside the square as of January 2014, due to high vehicle activity impacting the square. Barley Fields 4, 8, and 9 also experienced similar vehicle activities (Figure 35). One artefact had moved over 5.2 m, which was the highest recorded movement in this experiment. One galvanised nail had disappeared from square 9 from what appears to be vehicle activity. Barley Fields 1 and 2 were not monitored until January due to them being submerged from several rain events (Figure 36).

Figure 35: Barley Fields 8 and 9 impacted by vehicle/"donut" activity

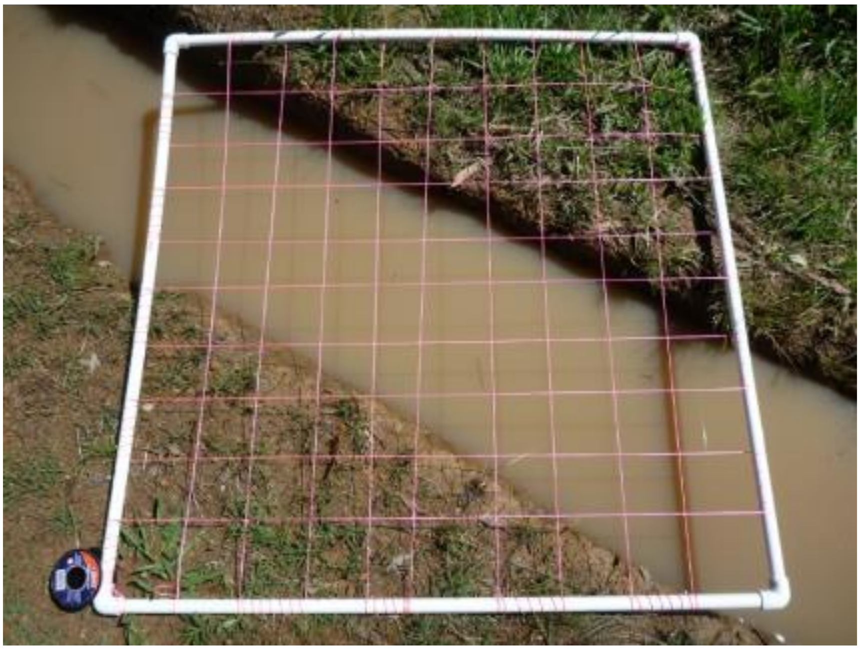


Figure 36: Barley Fields 1 artefacts submerged in vehicle track

4.2. Discussion & Conclusion

The following list summarises observations from monitoring activities undertaken between November 2013 and March 2014.

Movement

- Artefacts sizes 20 mm or less can move up to 7 m in as little as a month
- Artefacts no matter what size or shape can move distances of up to 8 m in 5 months
- After artefacts have been recorded need to be protected from the elements
- Geomorphology has a large influence on artefact disturbance

Visibility

- Artefacts can go missing, but can be found again, resulting in a better understanding of the processes affecting the artefact
- Artefacts can sink underground in a short amount of time
- Artefacts are not always visible on the surface
- Vegetation can grow and cover a site

Animal Activity

- Rabbits, deer, kangaroos, livestock, and insects (ants, grubs, worms, etc.) can harm a site

Weather

- Erosion can harm/destroy a site
- It takes high amounts of rain and aeolian activity to harm a site

In the next chapter these factors are examined in more detail. Results gathered so far from this experiment have yielded important data, which requires further investigation. Since this study is the first of its kind in the New England Tablelands, more parameters affecting artefacts need to be investigated, including weather reset monitoring (see Figure 37) and ant bioturbation (see Figure 38).

Figure 37: A total of 30 mm of rain had fallen in a two week period, 4th November 2013 to November 19th

.

Figure 38: Separate monitoring program for surface disturbance of artefacts is needed. Large green-head ants (*Rhytidoponera metallica*) identified at Llangothlin 2

The above results revealed numerous artefact impacts since the setup of the experiment between October and November 2013. Even in the monitoring undertaken prior to February 2014, artefacts had experienced changes in size, positioning, and appearance. Further investigation is recommended to fully understand what is occurring at these five locations and significantly more time is required to fully evaluate impact patterns. One limitation noticed was stationary or zero movement artefacts from the experiment setup to the final monitoring phase. This was not necessarily a negative result as it could change expectations about artefact site impact, for instance if one area has experienced more movement than another area, then one can differentiate harmful from non-harmful impacts. If an area of stationary artefacts is identified then the presumption can be made that the environment is the main contributor to this. This is important for the consideration of an expansion of this study to include other locations to compare the likely causes of artefact movement in some areas with zero or minimal artefact movement in others.

This chapter was a summary of some of the disturbances noticed at specific locations and squares throughout the experiment. The following data analysis chapter contains graphs and box-plots indicating the total data collected over the six month period. Comparisons will be made on what factors disturbed the most artefacts and also what disturbances were recorded at each site.

5. Data Analysis Results

The following tables and graphs show the qualitative and quantitative results of the monitoring study over a six month period. The monitoring period ran from November 2013- June 2014. Rainfall was observed first to see the amount that fell over the six month period and what kind of impacts it had. Slope was the next factor analysed because there is a consensus in the heritage consulting industry that artefact movement varies directly with slope gradient. However, this finding was not evident in my experiments. Different slope types were examined to see if more artefacts moved on a slope than the flat. Animal activity was then added to the data analysis because there appeared to a large number of artefacts that were disturbed by animals. Distance and movement was measured for each monitoring period separately, and compared with the previous one [ie. not the total movement from the origin], along with weight, direction of movement, breakage, and recording of artefacts that were detected and not detected. Finally the total impact was assessed by observing the total damage, and interpreting the scat, tracks and traces left behind by animals and humans.

5.1. Rainfall

Rainfall was monitored over the six month period, by placing rain gauges at every site and also by studying the moisture in and around the square after the rainfall. Rain was monitored to observe the effects it had on the artefacts within the five site locations. Rainfall only had a minimal impact throughout the monitoring period. The histogram below indicates how much rainfall fell over the six month period with total ranging from 10 to 80 mm per month. The largest monthly fall was recorded at Kirby Farm and the smallest at Lake Llangothlin and the Deer Park sites. Monitoring period four showed the highest amount of rainfall overall (See Figure 39). Located at Barley Field on exposed ground in squares one and two, nine artefacts were affected by rain during the monitoring period (see Figure 40). They were completely submerged by water. Rain did encourage growth for vegetation such as grass; this would then grow above 3 cm and eventually cover some of the artefacts.

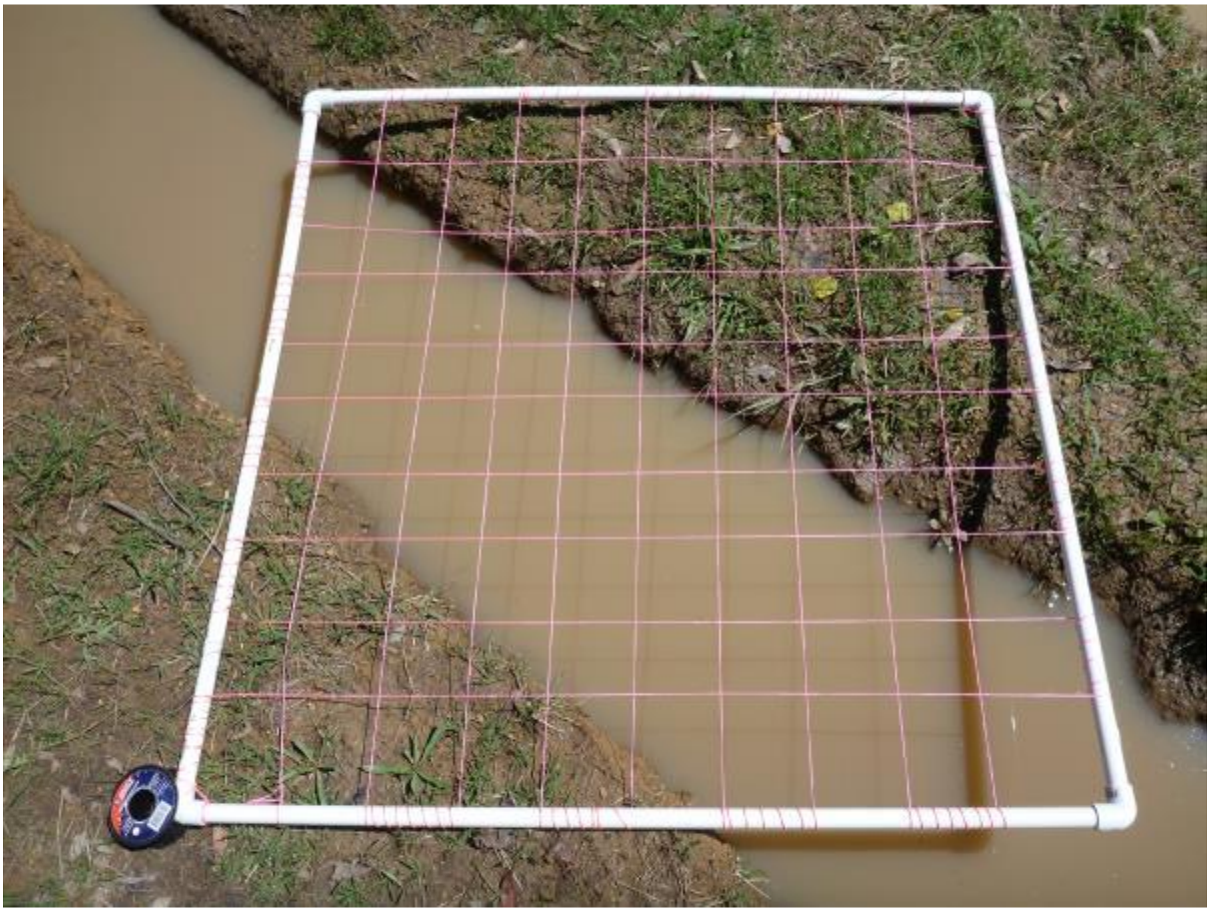


Figure 39: Square 1 Barley Fields, unusable vehicle track filled with water after rain

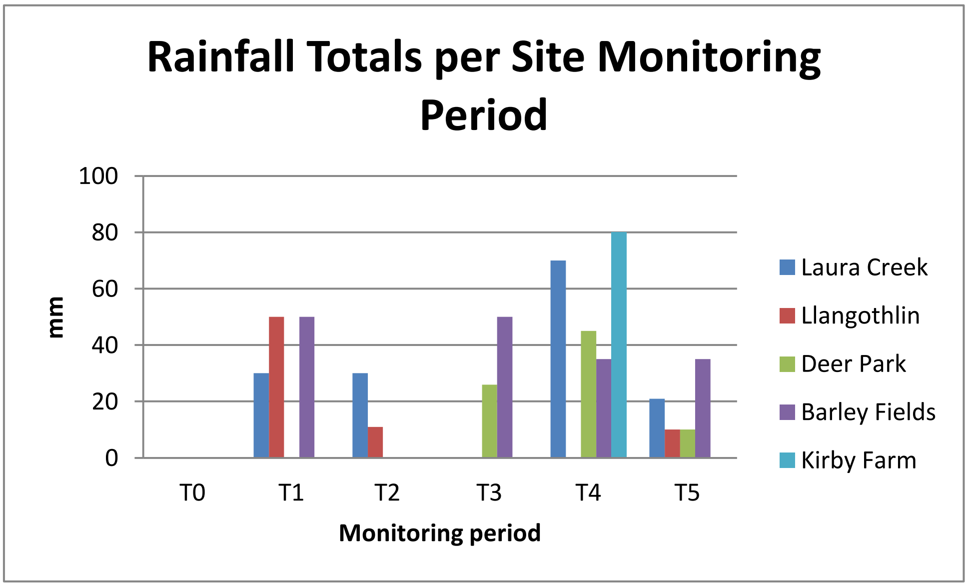


Figure 40: The highest rainfall fell at Kirby Farm which was 80 mm and the lowest rainfall was only 10 ml which fell at Llangothlin and also at Deer Park

5.2. Slope

The degree of slope was analysed in the experiment because there is a common assumption that slope has something to do with the movement of artefacts. In a way it does, however artefacts were just as likely to move on the flat as they were on a 30 degree slope. The research question is: how is slope related to movement of artefacts over a six month period?

Outlying occurrences of artefacts movement are shown as small circles and extreme outliers were represented by small asterisk. The median was the thick black line represented in the middle of the box. Whiskers showed the minimum and maximum representation of movement on the slope.

5.3. Slope and Distance Monitoring Period 1

In Figure 41, the Y axis is the distance artefacts moved, the X axis shows the degree of slope and the boxplots are the distributions of all the individual artefacts that moved within each gradient the observations indicate the distributions of the movement/gradient relationships for all the sample artefacts. An 8 degree slope appeared to have the most average movement, the median shows that the average was over 10 cm. Several outlying instances can be observed within the slope gradients 0, 4, 7.4, and 11.5, but are only isolated cases. The highest total movement in the first month was 5 m, on a 0° slope due to vehicle activity. This means that slope does not have any effect on movement at all, since artefacts on a 0° slope also moved in the first month. What appears to be more important are other disturbances inflicted upon the artefacts. Following this section the analysis of the artefact movement slope relationship was continued per monitoring period.

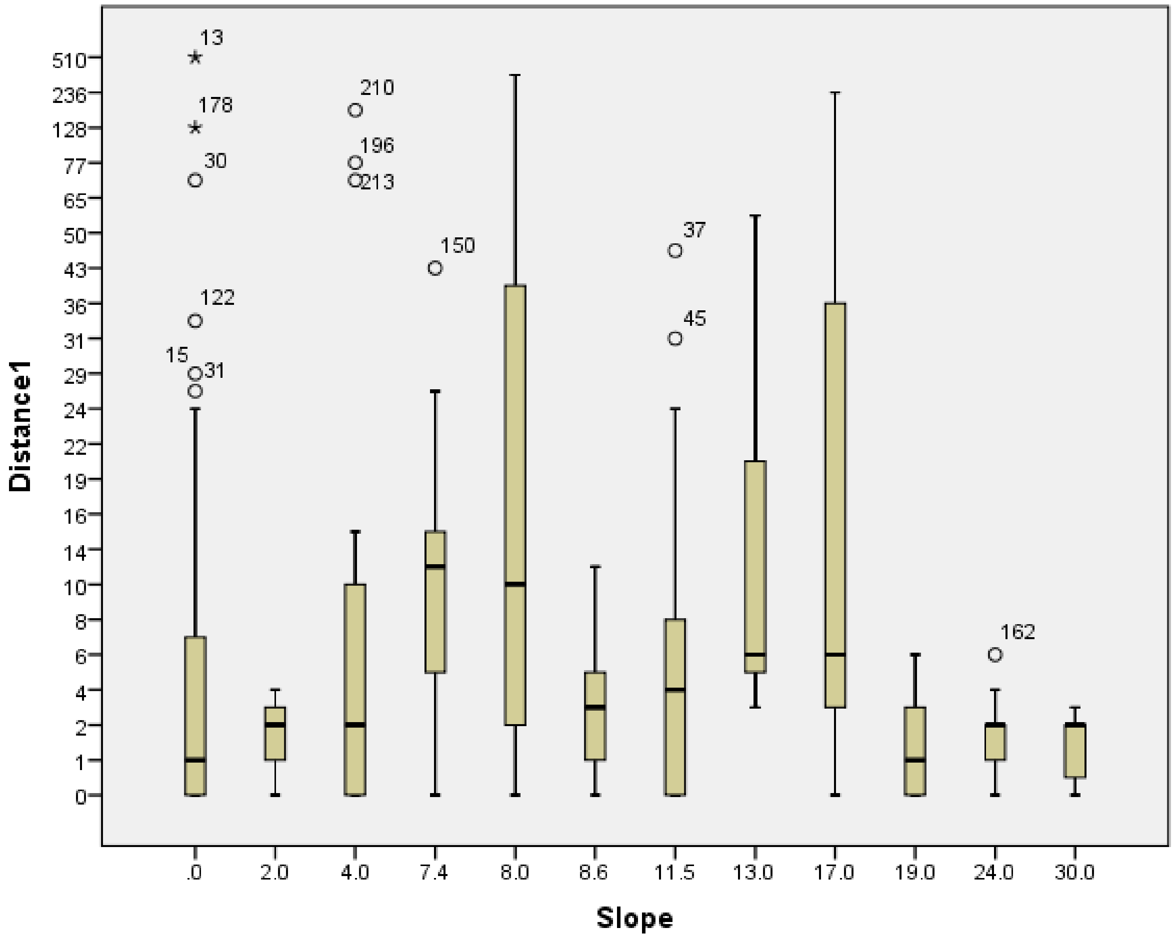


Figure 41: Slope and Distance Measurements during monitoring period 1

5.3.1. Slope and Distance Monitoring Period 2

In the second monitoring period the 13° slope had the most clustering. The 30° gradient had a higher distance movement than in monitoring period with a mean of 0-35 cm and outliers of over a metre (see Figure 42).

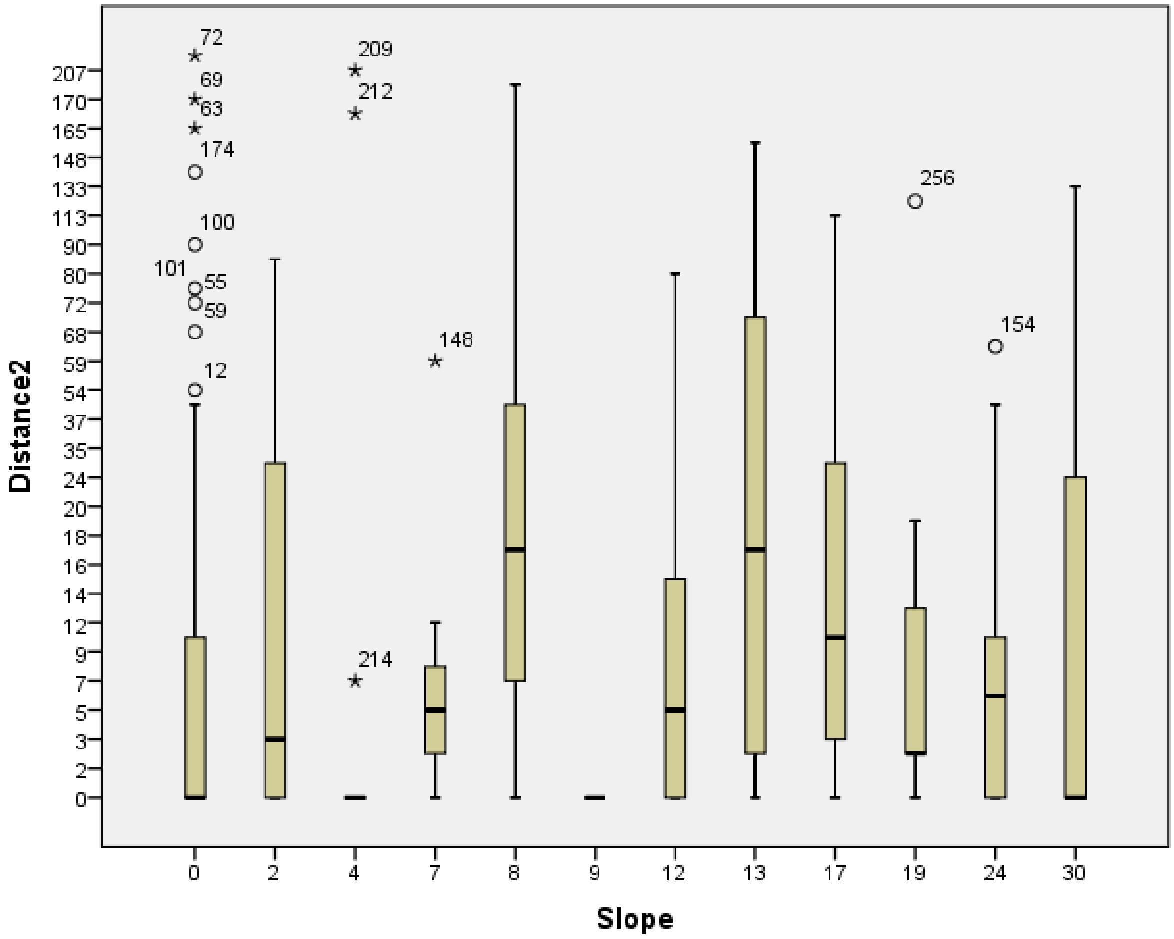


Figure 42: Slope and Distance Monitoring Period 2 (NB: Slope on X Axis is in degrees and Y Axis is in cm.

5.3.2. Slope and Distance Monitoring Period 3

All gradients experienced movement; the graph depicts the overall distances moved per slope gradient and the spread of distances for which artefacts moved. The 8 degree slope also had the largest amount of movement, similar to monitoring period one. Isolated cases can be seen for a number of slope gradients. For instance, a 0 degree gradient had three extreme values and seven outlying values separated from the median. There is no pattern and it appears that artefact movement is sporadic and hard to predict no matter what the slope is. This means that in some minor cases exhibited in the experiment, artefacts moved greater distances if disturbed by a vehicle or animal. Lower distances were observd on the flat, whereas slope 8 had half the artefacts move more than 16 cm downslope. The clustering is seen between median and whiskers. The range for slope 13° was 0-6 cm, very little movement. However, artefact 234 in an extreme outlier and artefact 227 was also an outlying occurrence (see Figure 43).

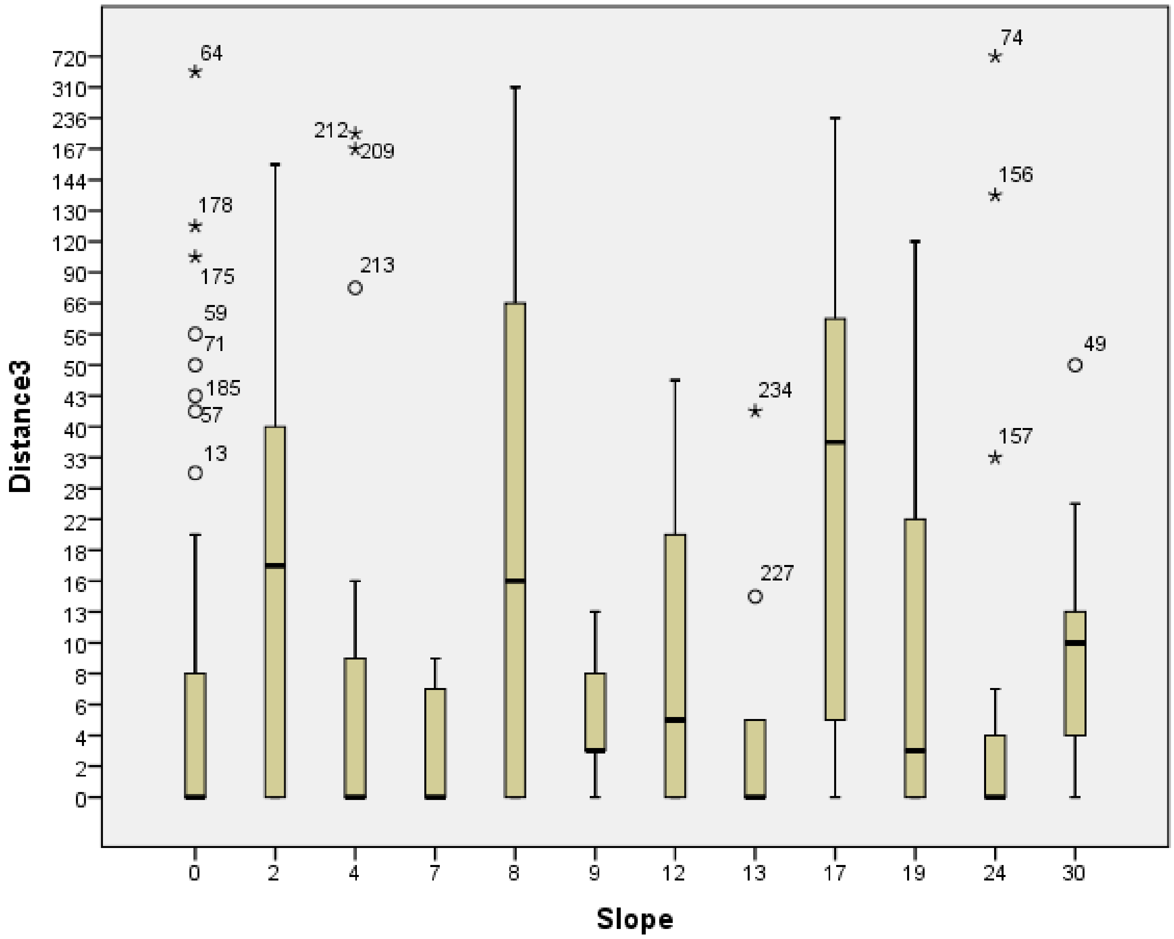


Figure 43: Slope and Distance Monitoring Period 3

5.3.3. Slope and Distance Monitoring Period 4

Monitoring period four had less movement on the slopes than on the flats. It is due to the decreased amount of activity from external factors like animals. (see Figure 44).

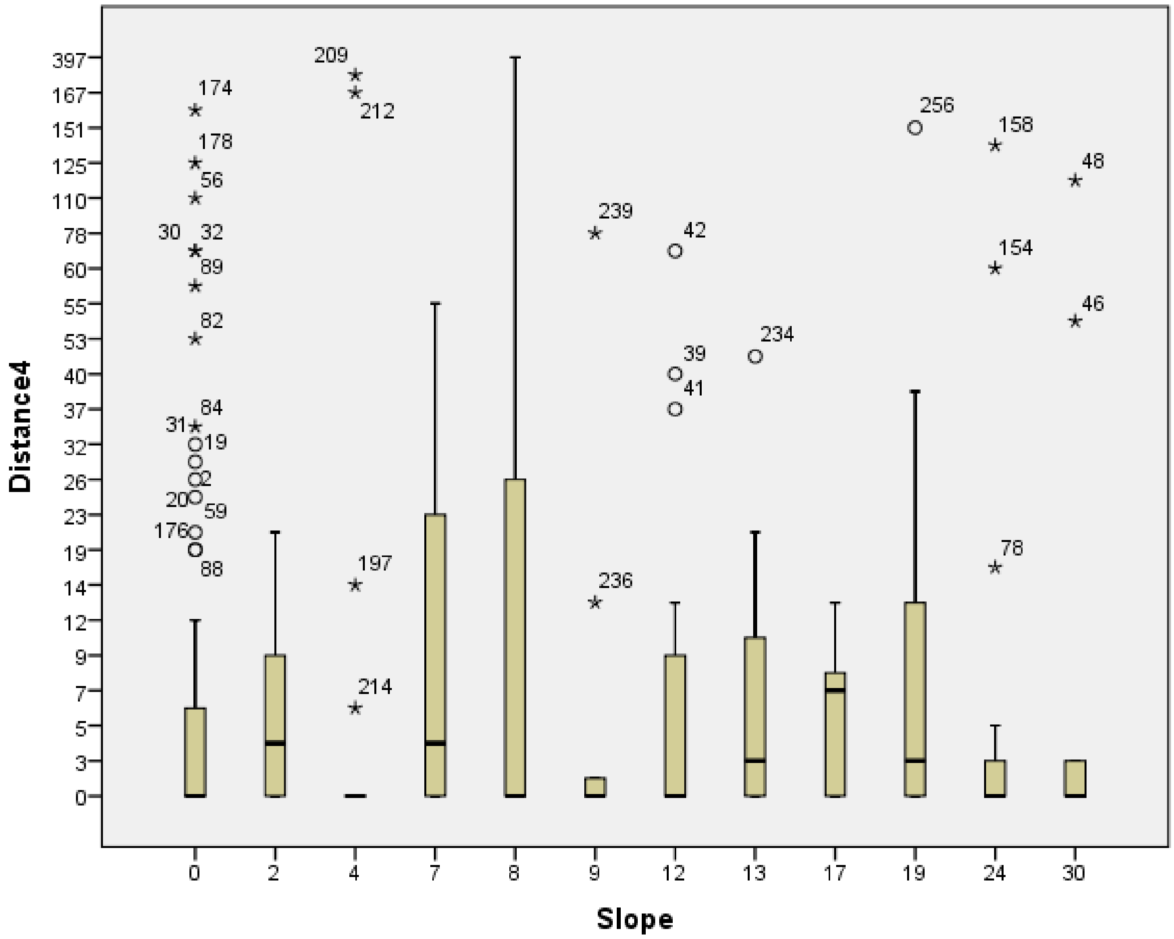


Figure 44: Slope and Distance Monitoring Period 4 (X Axis is degrees and Y is cm)

5.3.4. Slope and Distance Monitoring Period 5

It appears that slope now has no bearing on how far an artefact moves. For instance in monitoring period one there was a large amount disturbance, then in monitoring period two there was not as many disturbances then monitoring period three there were a large a large amount of movement recorded (see Figure 45).

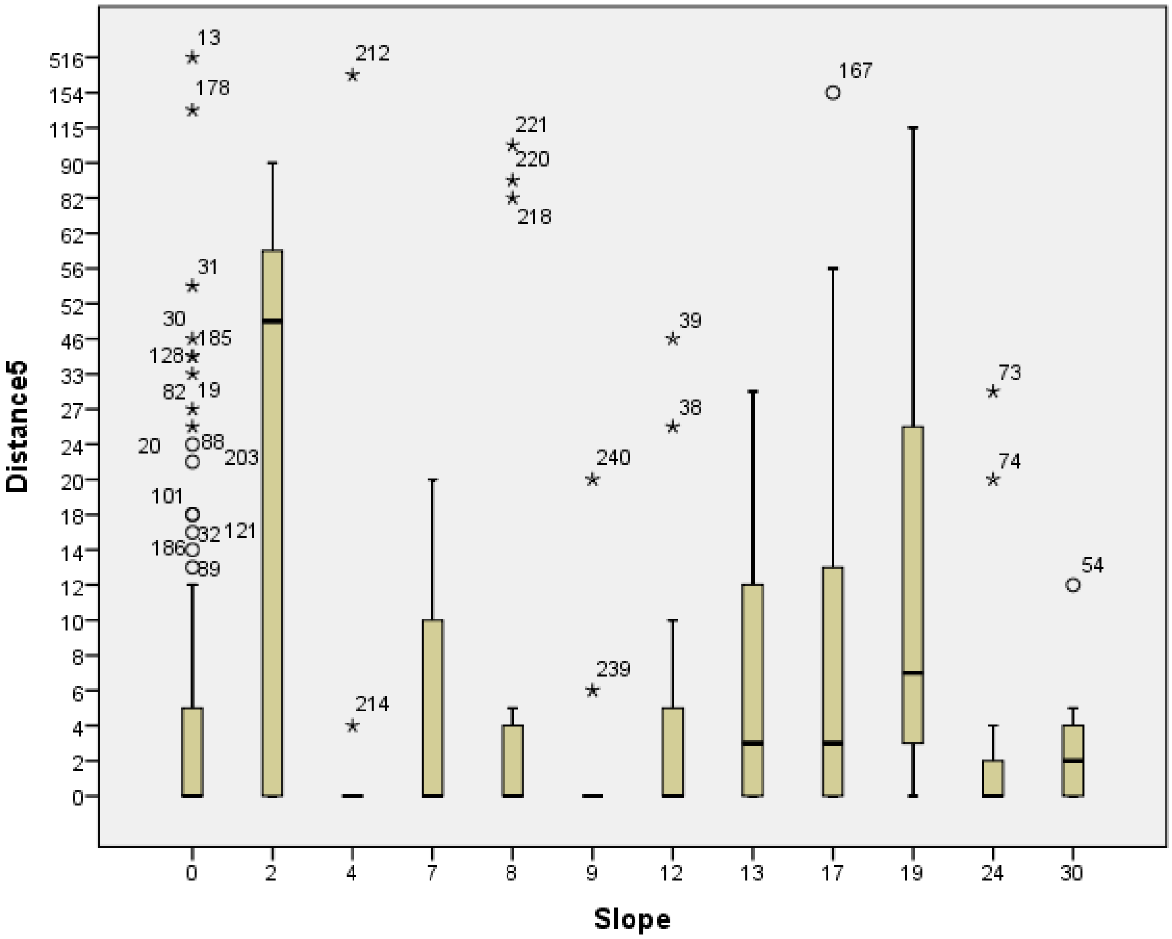


Figure 45: Slope and Distance Monitoring Period 5

The slope gradients were tested further for each individual location in the next section. This was to see if an artefact was moved upslope, downslope or across the slope, as well as an analysis of the amount of artefacts that moved on the flat.

The minimum movement on all the slopes was as little as 1 cm whereas the maximum movement recorded was 7.2 metres. This is not the total movement recorded; however it is the recorded movements over one month.

5.4. Slope Gradients

The following graphs show the entire slope gradients used in the experiment from Laura Creek, Kirby Farm, Llangothlin and the Deer Park. This is site specific and each gradient is shown lowest to highest. It also indicates whether more artefacts moved downslope, across slope or upslope. If an artefact moved a cm or more then this movement direction was recorded The Y axis shows the total number of artefacts that moved and the X axis is the monitoring period. The key shows the total observed across, upslope and downslope movement.

Laura Creek 3 had the most movement in monitoring period 1; mostly downslope and across-slope movement. No upslope movement was recorded (see Figure 46)

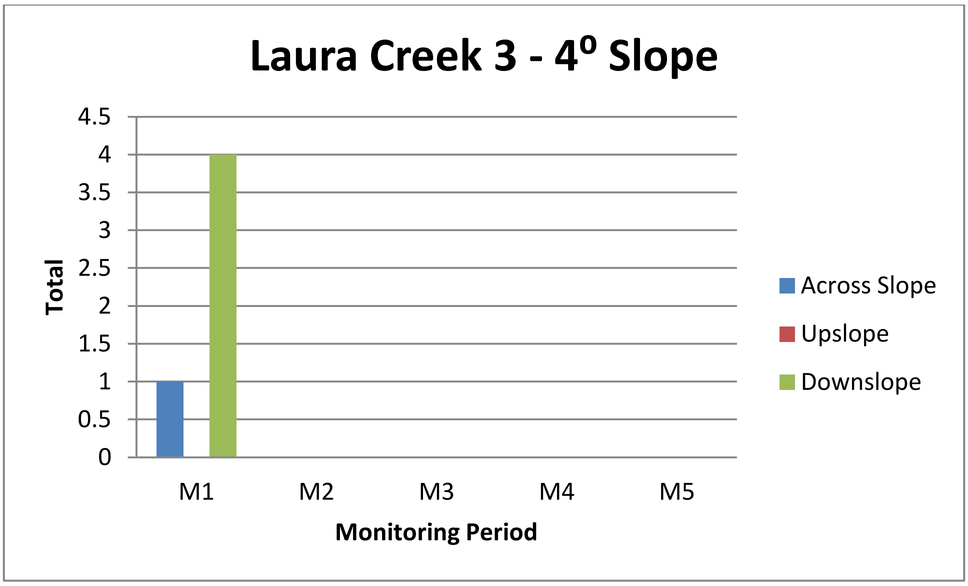


Figure 46: 4 degree slope at Laura Creek Square 3

Laura Creek 4 had the most downslope movement in monitoring period 1. Monitoring period 2, 3, 4 and 5 all experienced downslope movement. There was one instance of upslope movement in monitoring period 4. No across movement was recorded (see Figure 47).

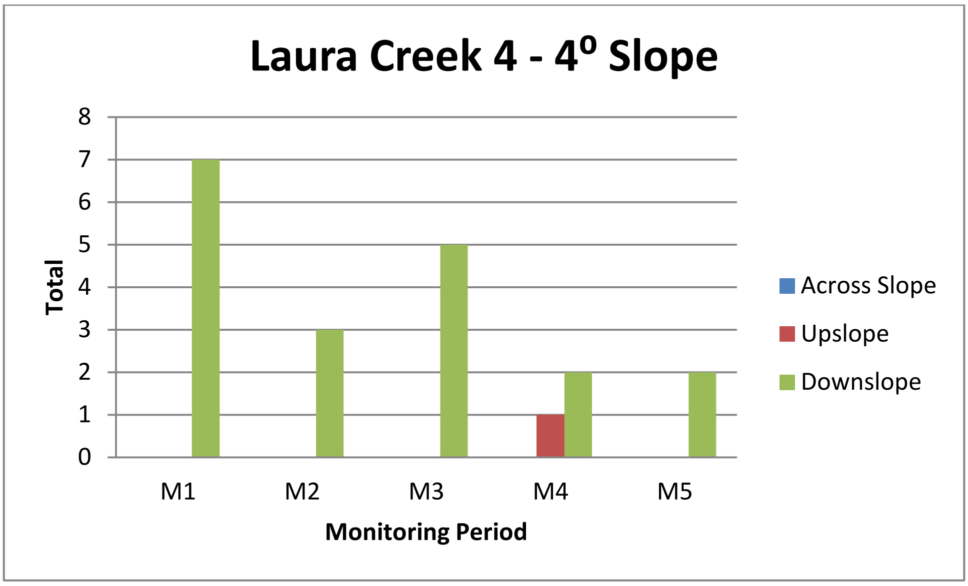


Figure 47: 4 degree slope at Laura Creek Square 4

Laura Creek 5 had the most consistent across slope movement out of all the squares and the experiment overall. The main factor causing this was vehicle activity. Vehicle impact on the slope was the main contributor to slope movement here (see Figure 48).

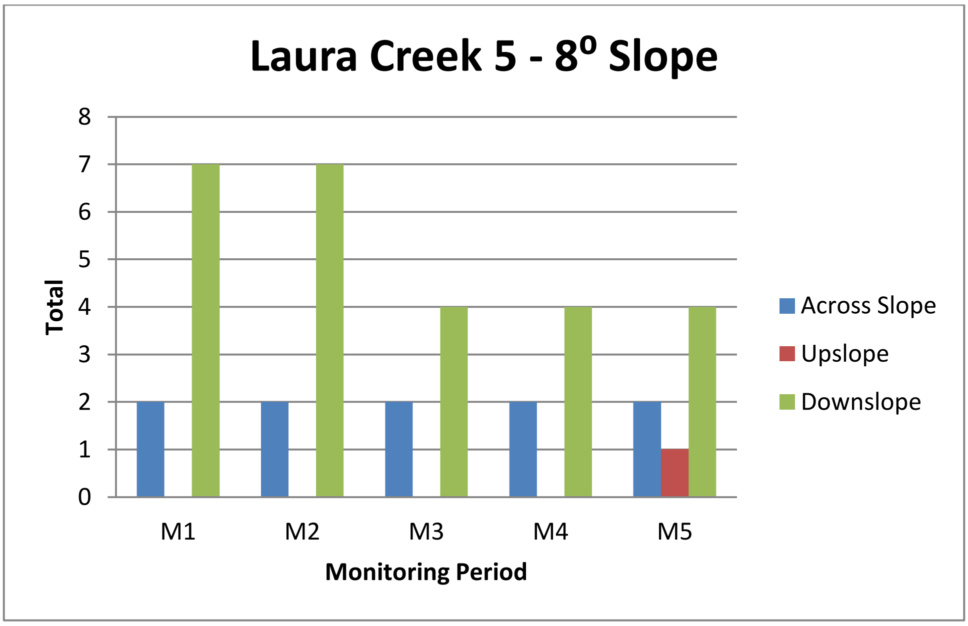


Figure 48: 8 degree slope at Laura Creek Square 5

Laura Creek experienced more downslope movement than any other direction. This is probably due to the steepness of the slopes and from vehicles moving up and down the slope.

Deer Park 1 had an extremely varied movement downslope, across slope and even upslope. It would appear that kangaroos move in an unpredictable manner and one cannot predict where artefacts will end up. If kangaroos are present in the area it is highly likely that artefacts will move in any direction. The Kirby Farm results can be used to generate a disturbance prediction model for sloped terrain where sheep are present. In this context, artefacts are almost always moved downslope (see Figure 49).

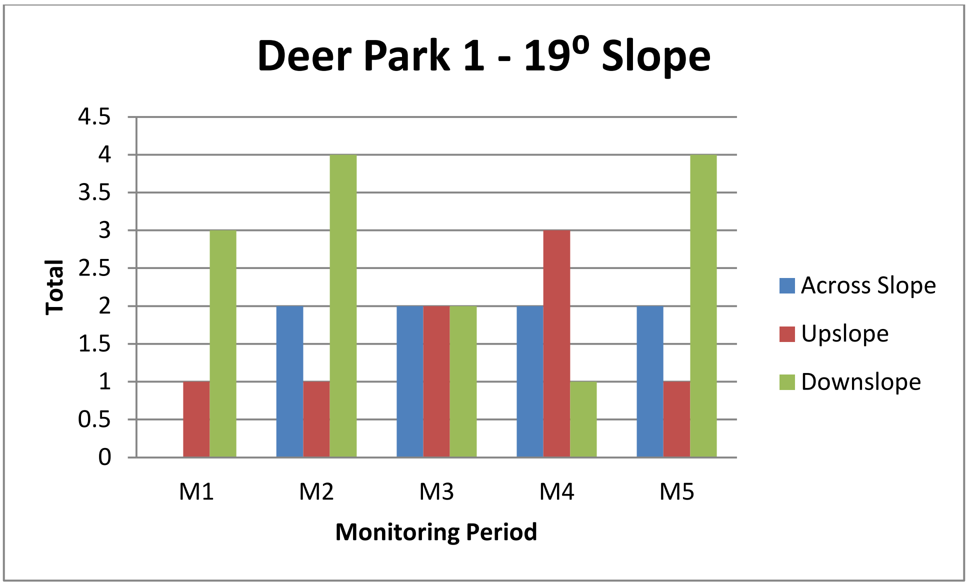


Figure 49: 19 degree slope at Deer Park Square 1

Deer Park 2 has a 13 degree slope and has had more downslope movement than upslope movement. One instance only was identified for across-slope movement (see Figure 50).

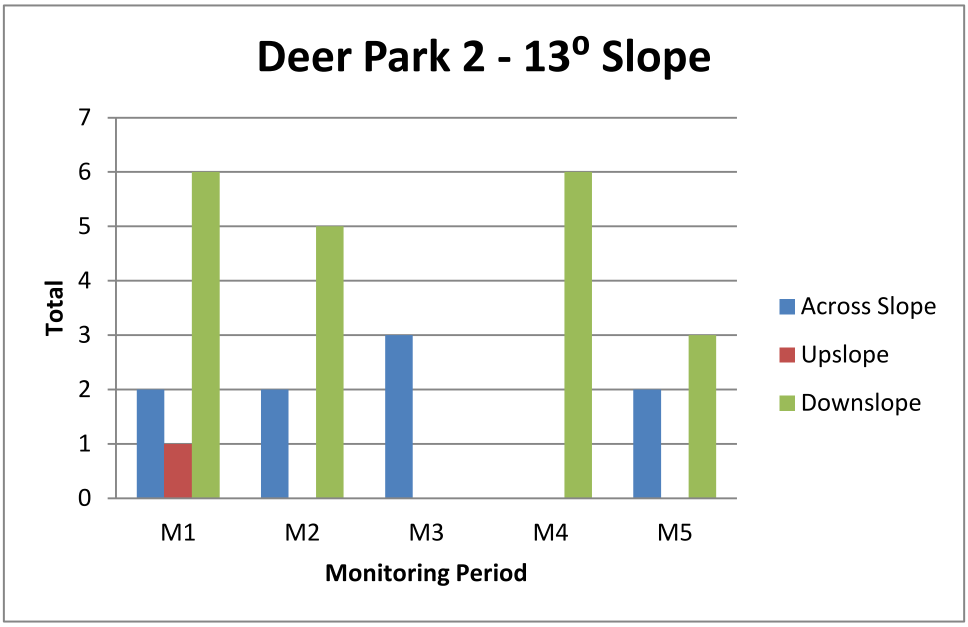


Figure 50: 13 degree slope at Deer Park Square 2

Deer Park 3 experienced more downslope movement probably due to kangaroo activity. It should be noted that the slope was quite steep here and it is likely that gravity may have affected this one as well as the sporadic movement of the kangaroos in the deer park. The steeper the slope the more common the movement, however it would also mean that kangaroos can in fact move artefacts in any direction (see Figure 51).

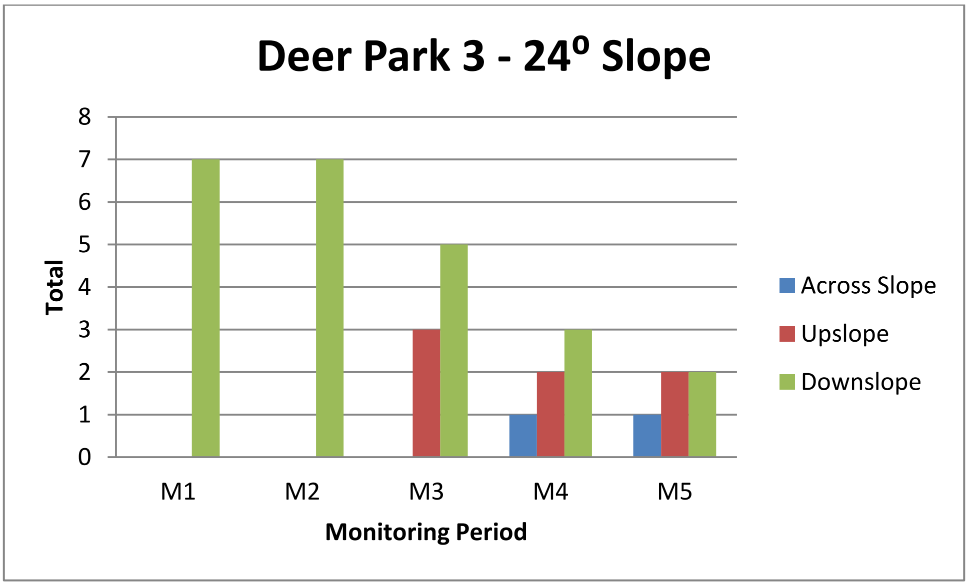


Figure 51: 24 degree slope at Deer Park Square 3

Deer Park 4 had more downslope movement, but also had instances of across slope and upslope movement. One could argue this is due to the herd of deer shuffling up and down the slope to feed (see Figure 52).

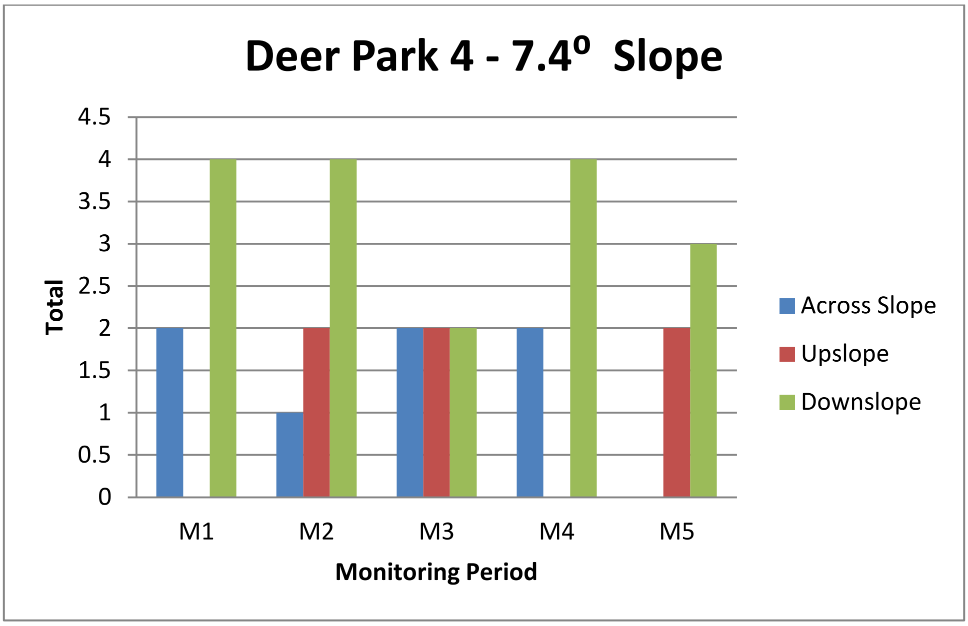


Figure 52: 7.4 degree slope at Deer Park Square 4

Deer Park 5 had more downslope movement but still had peaks in across and downslope movement (see Figure 53).

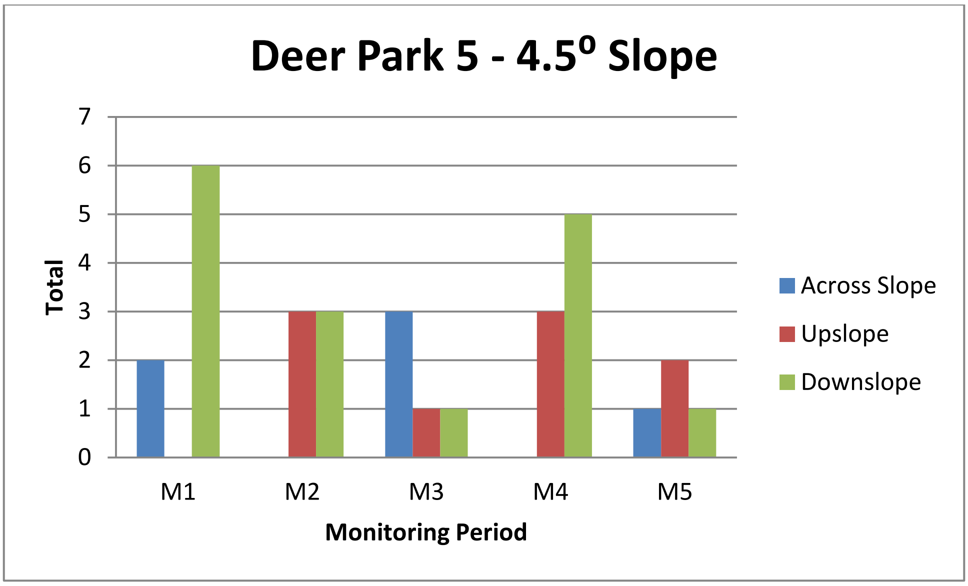


Figure 53: 4.5 degree slope at Deer Park Square 5

Over the six month period, the Deer Park had 91 instances of downslope movements which is a large amount. Next was across slope movement with 35 instances and there were 28 instances, of upslope movement. The large quantity of downslope artefact movements suggests that the downslope gradient is less significant compared to biotrubation via an external factor such as a deer or kangaroo. Such interaction does not rule out potential upslope or across slope movement by any means Nevertheless this Deer Park data highlights the interaction between steep gradients and animals as a potentially significant cause of downslope artefact movement Further similar studies need to be conducted to confirm this finding as the potential degradation of artefacts could be minimised by the adoption of protocols such as cheap fencing or entry barriers that prioritise the protection of artefact rich steep gradient locations where there are animals.

Llangothlin 3 had more downslope movement, most likely due to gravity, cattle and rabbit activity once again confirming the likely relationship between slope gradient and animal impact. Nevertheless there will be the odd occasion where upslope movement can occur (see Figure 54).

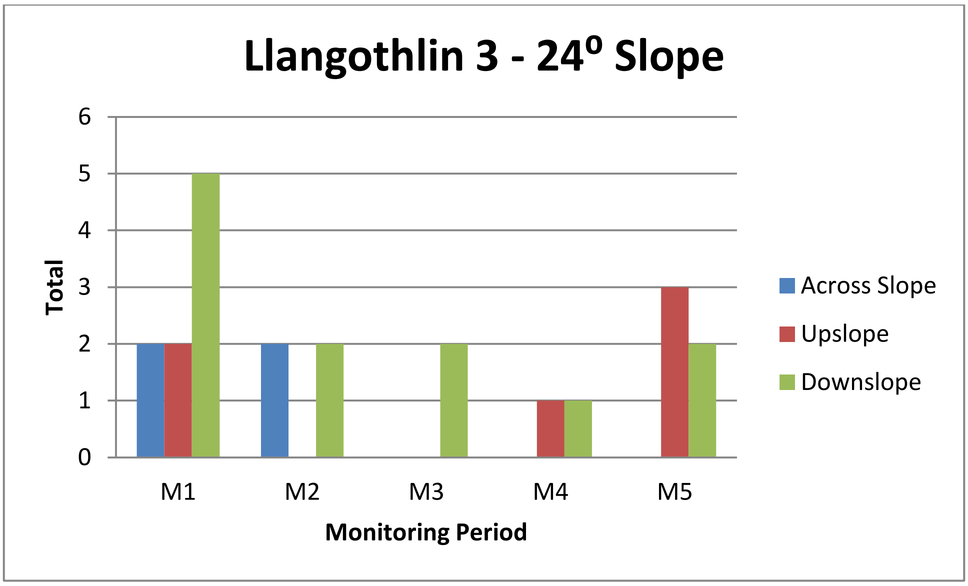


Figure 54: 24 degree slope at Lake Llangothlin Square 3

Llangothlin 4 also had more downslope movement, most likely due to the steepness of the slope, and also cattle and rabbit activity. Once an external factor is introduced gravity will inevitably assist the artefact to move downslope (see Figure 55).

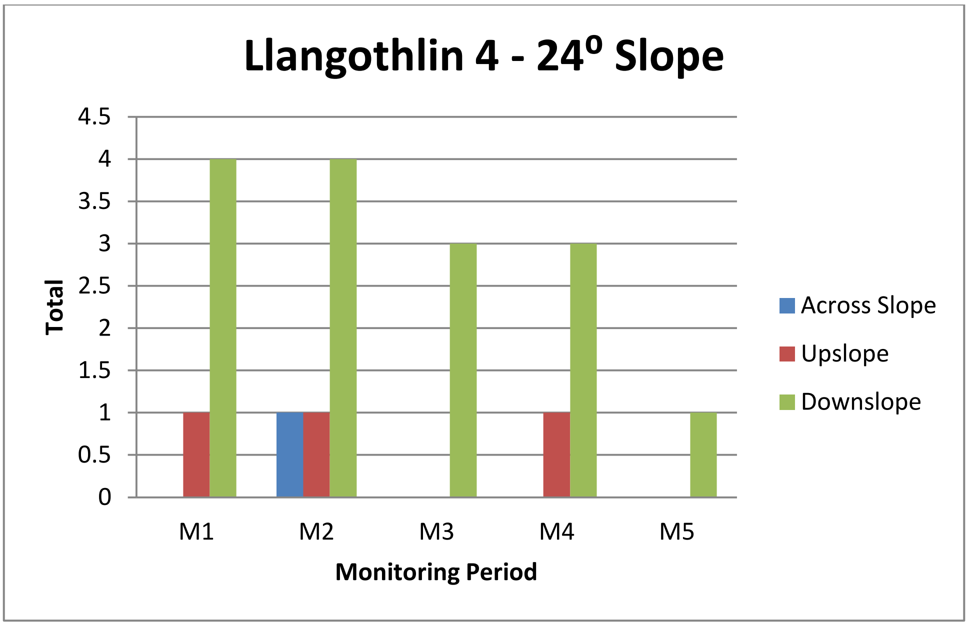


Figure 55: 24 degree slope at Lake Llangothlin Square 4

Llangothlin 5 had the steepest incline at 30 degrees, but was situated on the lower section of the slope, which may have resulted in the greater distance of movement if disturbed. More artefacts moved downslope than across or upslope due to animal activity (see Figure 56).

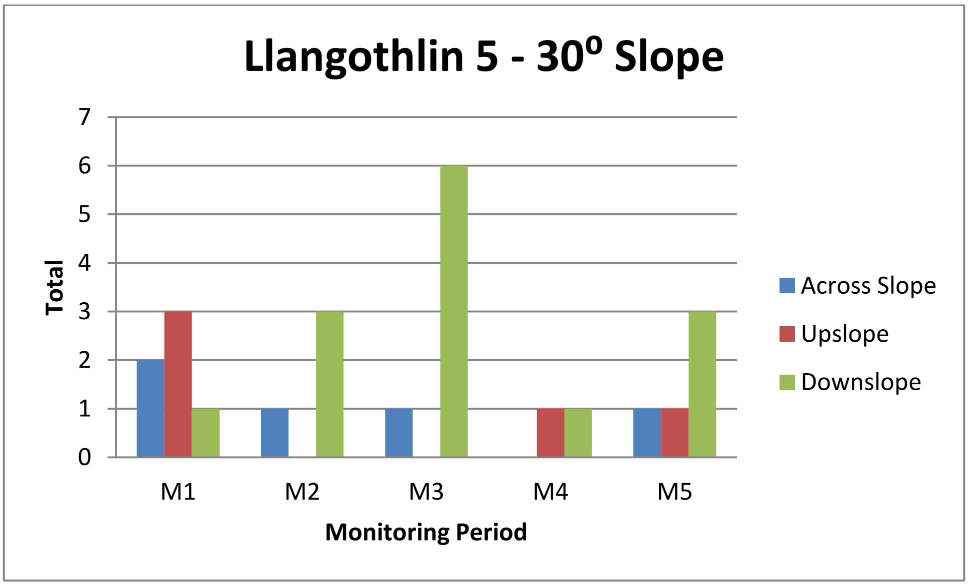


Figure 56: 30 degree slope at Lake Llangothlin Square 5

Kirby Farm 3 had more downslope movement even though it was only a 2 degree slope. It would appear that sheep can kick and shuffle artefacts downhill. Even though there were other movements uphill and across hill, downslope was the most prominent (see Figure 57).

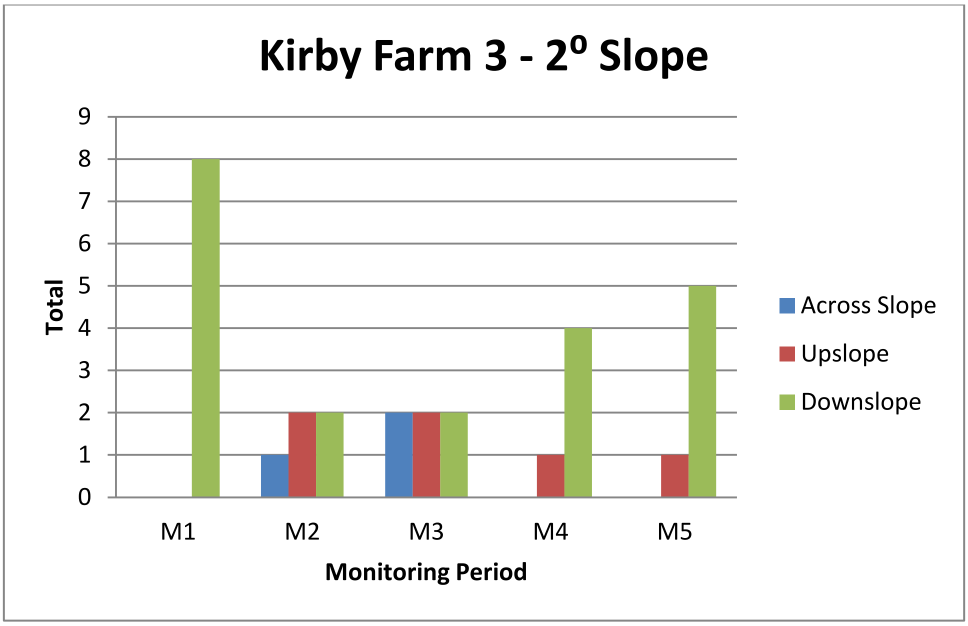


Figure 57: 2 degree slope at Kirby Farm Square 3

Kirby Farm 4 again had a higher quantity of downslope movement. Even though it was an incline of 8 degrees, not many artefacts moved upslope or across slope. This is not due to the incline of the slope, but to the amount of sheep trampling over the square. In Kirby Farm 5 the steepest slope had more upslope movement rather than downslope movement (see Figure 58).

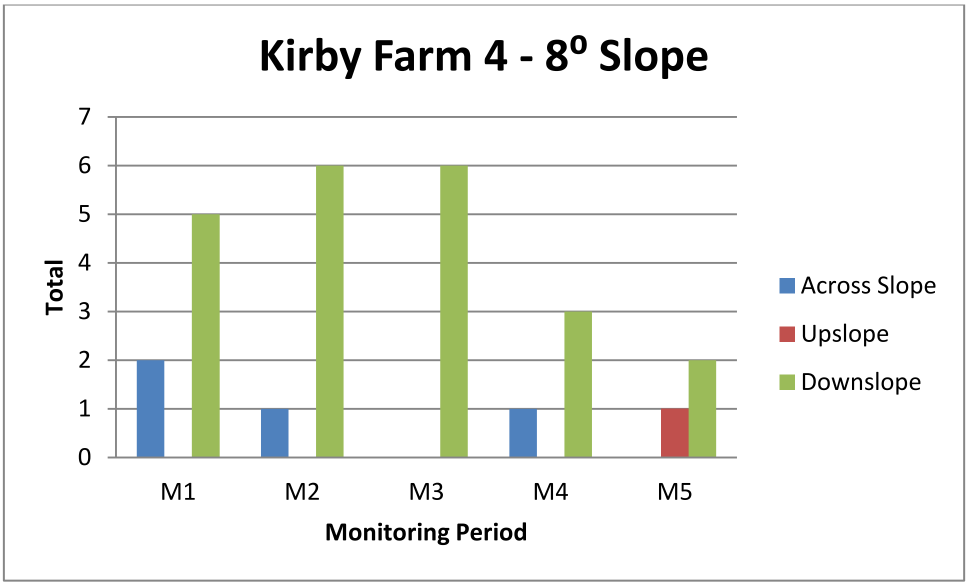


Figure 58: 8 degree slope at Kirby Farm Square 4

Kirby Farm 5 had a surprising amount of upslope movement. This could be due to the higher/thicker vegetation content. The grass was thicker here, meaning than when sheep would walk uphill or downhill artefacts might get flicked up and caught by the grass instead of falling down an exposed patch of soil. In fact this area had the steepest incline at this location and it also had the thickest vegetation here (see Figure 59).

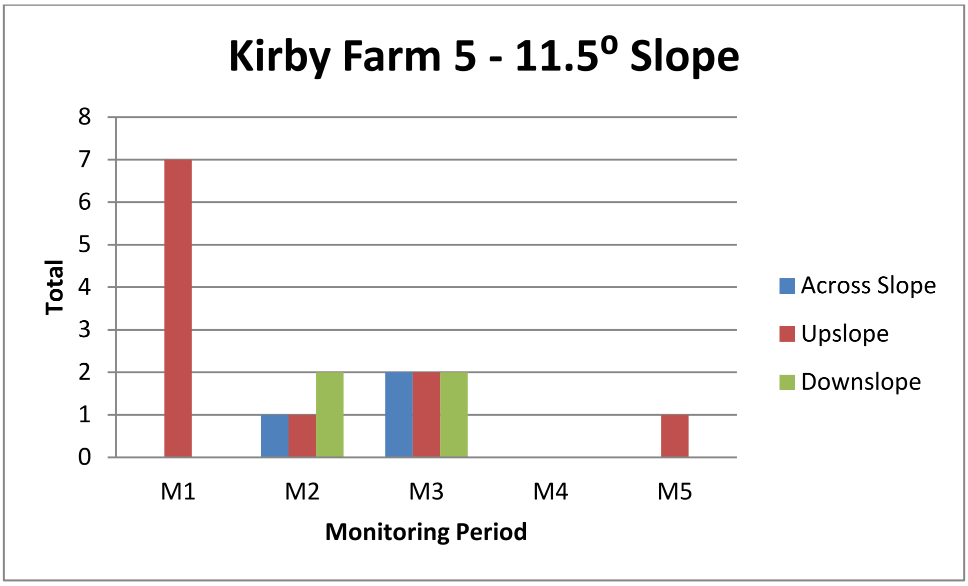


Figure 59: 8 degree slope at Kirby Farm Square 5

In this section across slope, upslope and downslope movement was analysed at locations that had some form degree of a slope. In a later section, all totals are combined from each monitoring period to discern the most common direction. The flat was not presented since it had 0° gradient gradient, however this will be analysed in the next section. If slopes were an important aspect determining artefact movement, they would be moving every monitoring period. In the case of Kirby Farm 5, monitoring period 4 had no movement at all and in monitoring period 5 one artefact moved upslope. It was only until cattle, kangaroos, rain or vehicles were introduced that the artefacts moved. In some cases the artefacts did not move at all and if slope was the main factor for movement in gradients above 0 then movement would be more common. From the Kirby Farm results, one can predict that if sheep are present in the area and there is a slope, one can almost guarantee that the artefacts will move downhill.

5.5. Artefact Movement Over 0-30 degree Gradients

The following boxplot shows the total distance of artefact movement, over all monitoring periods and slope gradients. If one was to combine all slope movement it would be expected that the maximum movement would be downslope compared to artefacts on the flat. However, the following histogram (fig 60) shows it is not the case. The box and whisker plot show distances moved by artefacts over the six month period. On a flat surface movement was recorded in 62 instances. It would mean slope vs flat are not significant. The graph below also shows that no matter what the gradient, some artefacts move regardless of how steep or how flat. Note that out of all 12 boxes in figure 60, 25% extend to 0, meaning that in the total six month period these mock artefacts were stationary (see Figure 60). These overall findings seem to contradict those at Deer Park Square 5 and Llangothlin Square 3 that suggested that steeper slopes are the most significant factor explaining artefact movement if they interact with animal activity.

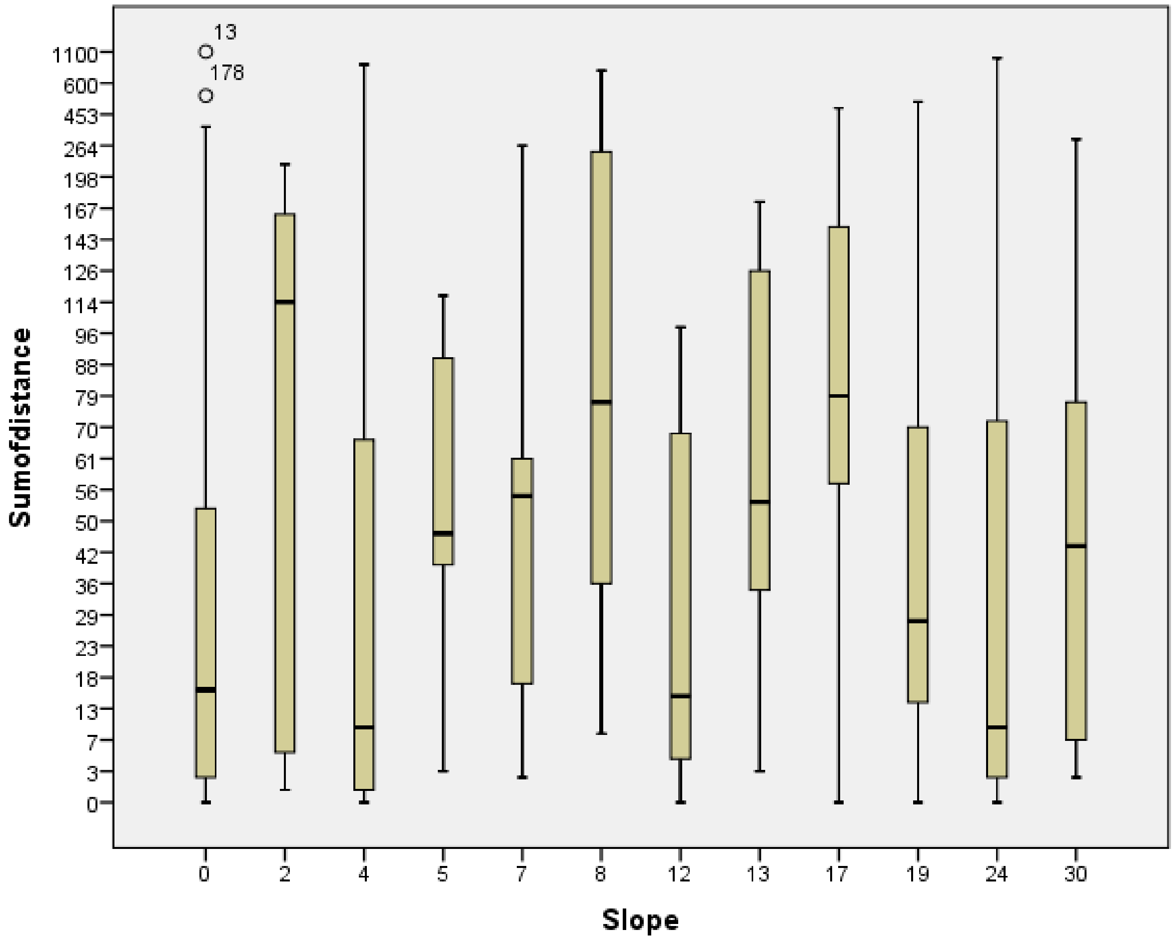


Figure 60: Total Slope and Total Distance artefacts had moved

5.6. Total Occurrences of Slope Movement

In this aspect of the experiment, the total slope movement was analysed across all squares and locations in the experiment including Downslope (228 instances), Flat (290 instances), Across Slope (63 instances) and Upslope (65 instances). These figures represent movement from monitoring period 1 through monitoring period 5. What was surprising is that the difference between the movements on flat verses downslope was only 62 instances out of 646 occurrences of movement over the six month period. Artefacts on the flat moved the most frequently no matter what the factor (see Figure 61).

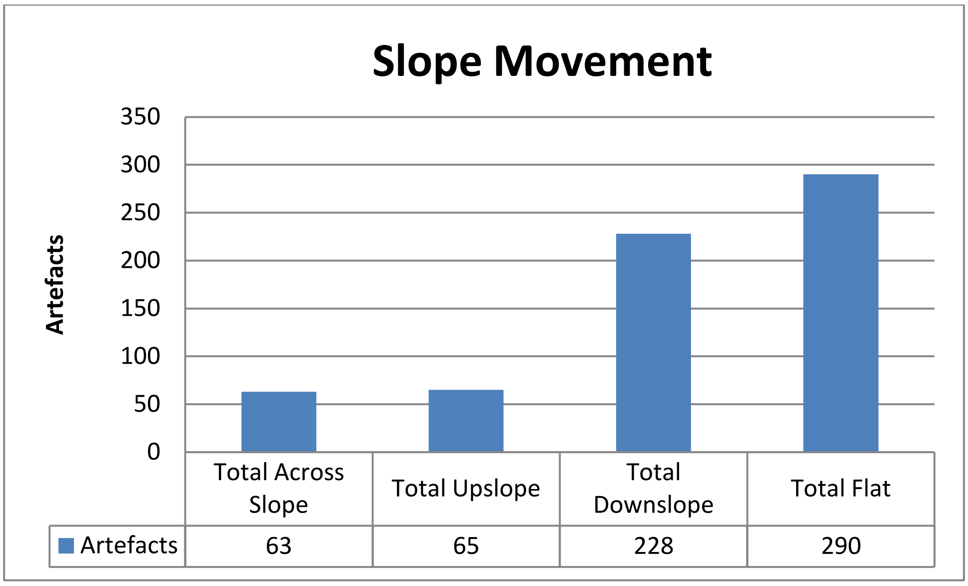


Figure 61: Slope movement

If one added all the artefacts together over the six month period the grand total is 1566, and within this total, movement occurred 646 times was divided into the following instances downslope, upslope, across and flat categories.

5.7. Artefacts that did not move

Zero artefacts exhibit no movement at all. Then, the first monitoring period there was 88 instances of non-movement then in the second monitoring period 131 did not move. 136 did not move in the third monitoring period, 163 in the fourth monitoring period, and 162 in the final monitoring period. The data presented here also includes the missing artefacts. These may have moved or may have broken down to indistinguishable pieces.

5.8. Factors Effecting Distance of Movement

Artefacts moved, broke, or were concealed over the six month period due to a number of factors. The following graphs indicate these factors (see table 1 in methods chapter) separated into three graphs including Factor 1, Factor 2 and Factor 3. Factor 1 was the primary factor impacting impact artefacts throughout the experiment at each designated area (see Figure 62 Figure 63). Factor 2 describes the additional factors that disturbed the artefacts (Figure 63). Factor 3 was solely for artefacts disturbed or covered by plants (see Figure 64). Each factor appears to have some direct involvement for the total movement of an artefact. This means that no one factor is responsible for moving an artefact even though each factor is separated into three different box plot representations, and each artefact was documented as having multiple factors disturbing them. The maximum distance is indicated on the Y axis, the factors are listed on the X axis.

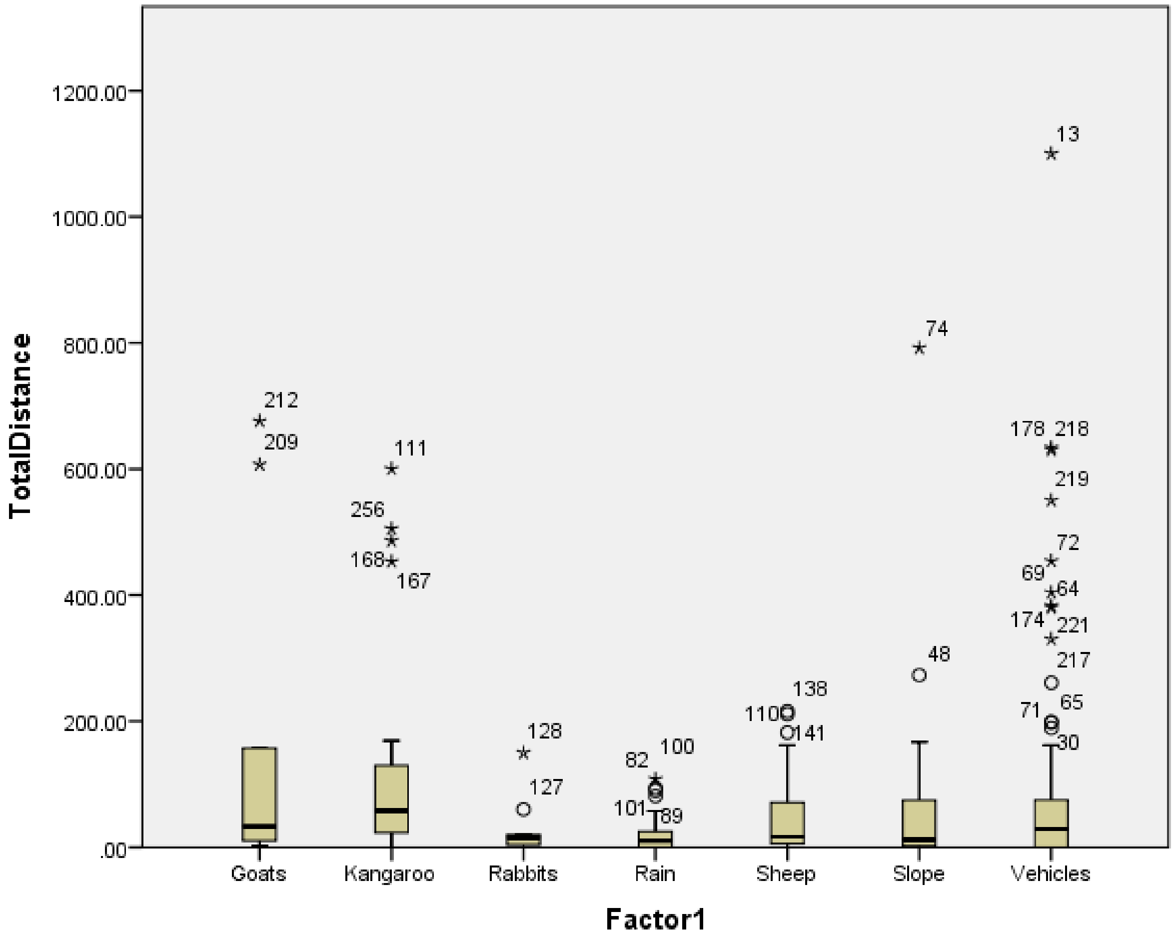


Figure 62: Total influences moving artefacts

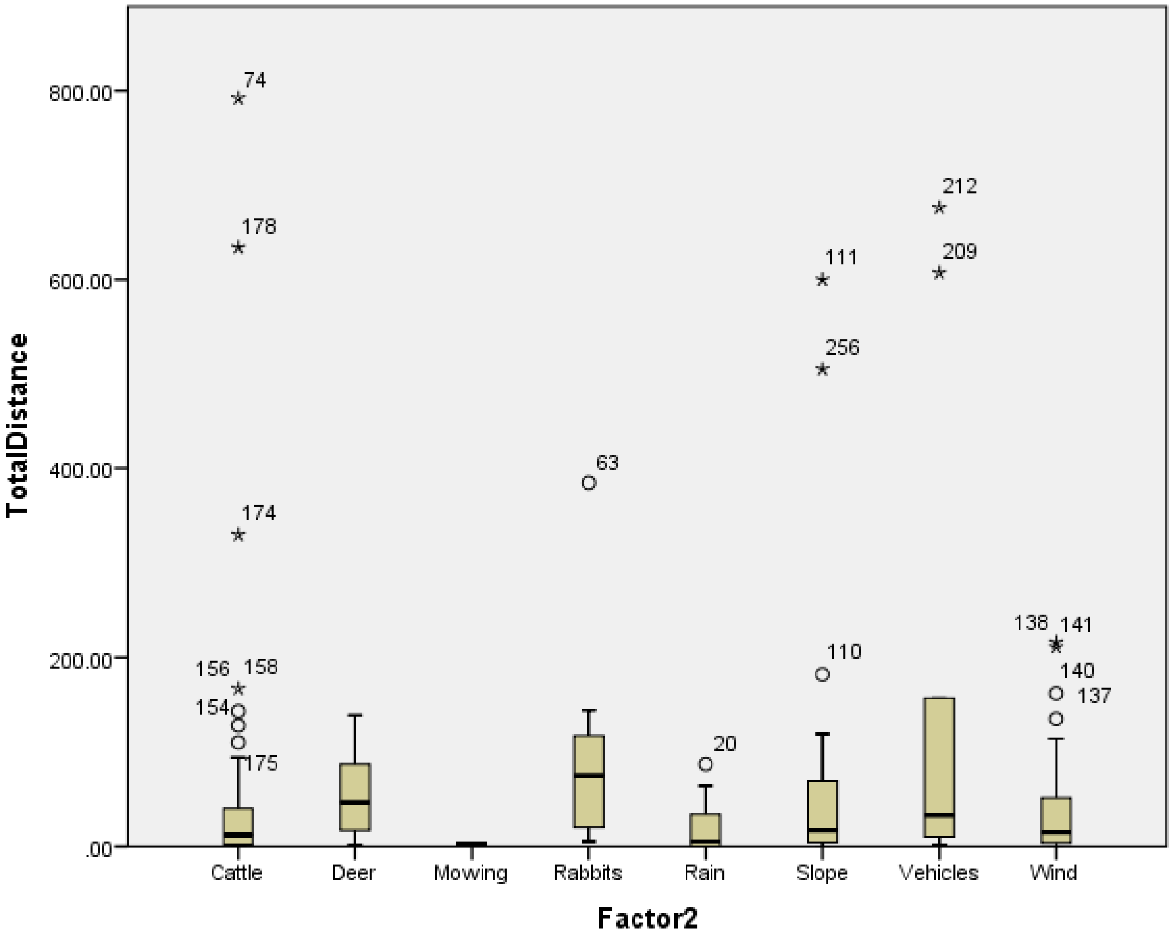


Figure 63: Factor 2, Other unexpected or non-predicted instances of disturbances

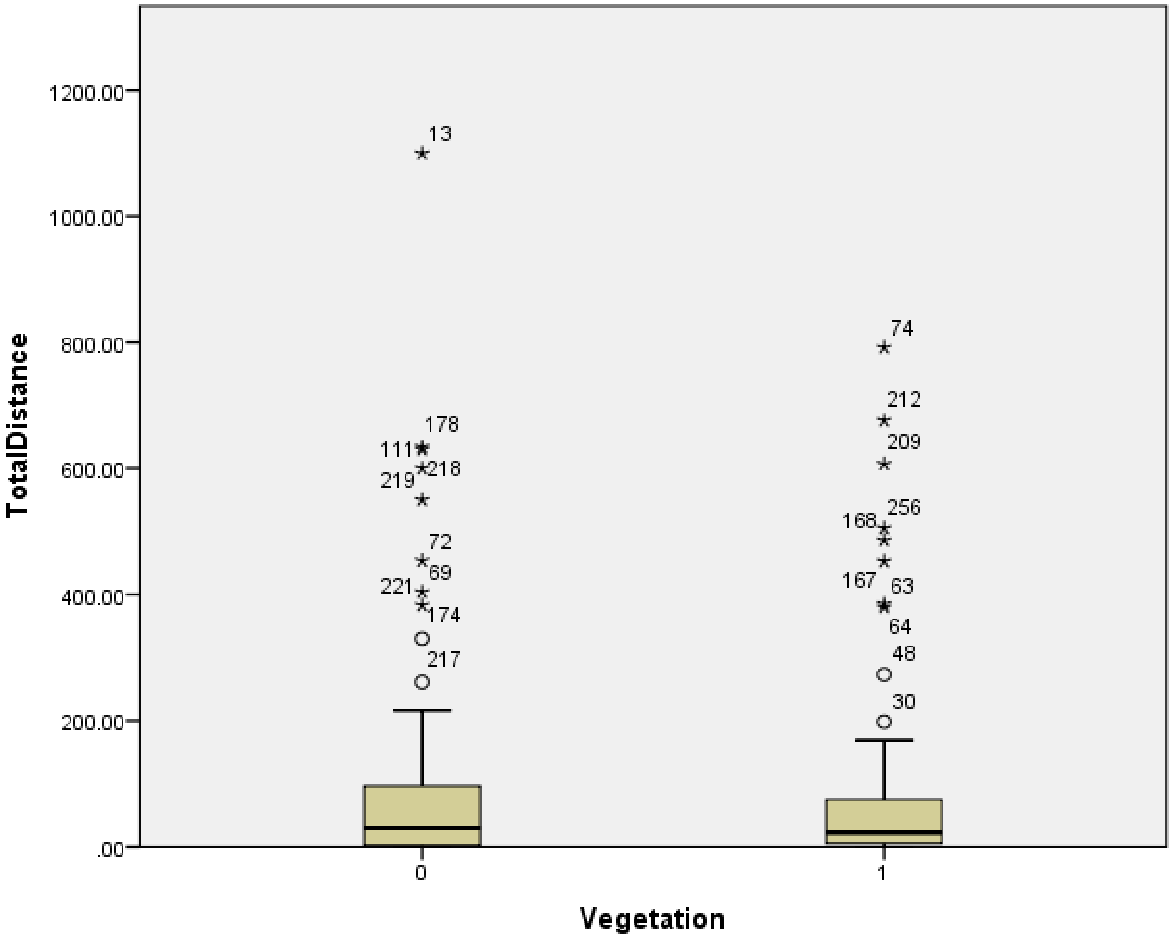


Figure 64: Total artefacts moved due to vegetation. 0 = no vegetation present and 1 = vegetation present

Artefacts had multiple factors impacting upon them and in some cases would not move unless there was an external factor introduced. For instance, in the case of artefact 74 (see fig 64, represented by a star) even though it was on the slope it did not move until cattle were introduced to the area. In this case the artefact moved a large distance of 140 cm. Factor 1 and Factor 2 showed this artefact as an outlier and the large distance it moved; in addition, factor 3 shows that 74 had vegetation that could have held the artefact in place. If the cattle had not been introduced to the area the artefact may have remained stationary.

5.9. Animal Activity

Throughout the experimental process animals had one of the highest impacts on artefacts, as discussed in the previous section. The following compares the quantity of artefacts that experienced disturbance from animal activity with those that did not. The three tables outline the frequencies with which artefacts were harmed by animal activity.

5.9.1. Animal Activity Boxplot

Figure 65 indicates that one of the main factors that affected the artefacts over a six month period was animals, this box plot indicates that out of all 261 artefacts, 189 were affected by animals and this contributed to artefact movement. A total of 72 artefacts were not impacted by animals. Distance is given in cm (see Figure 65). The most extreme case of non-animal movement was due to vehicle activity represented by 13 in the box below.

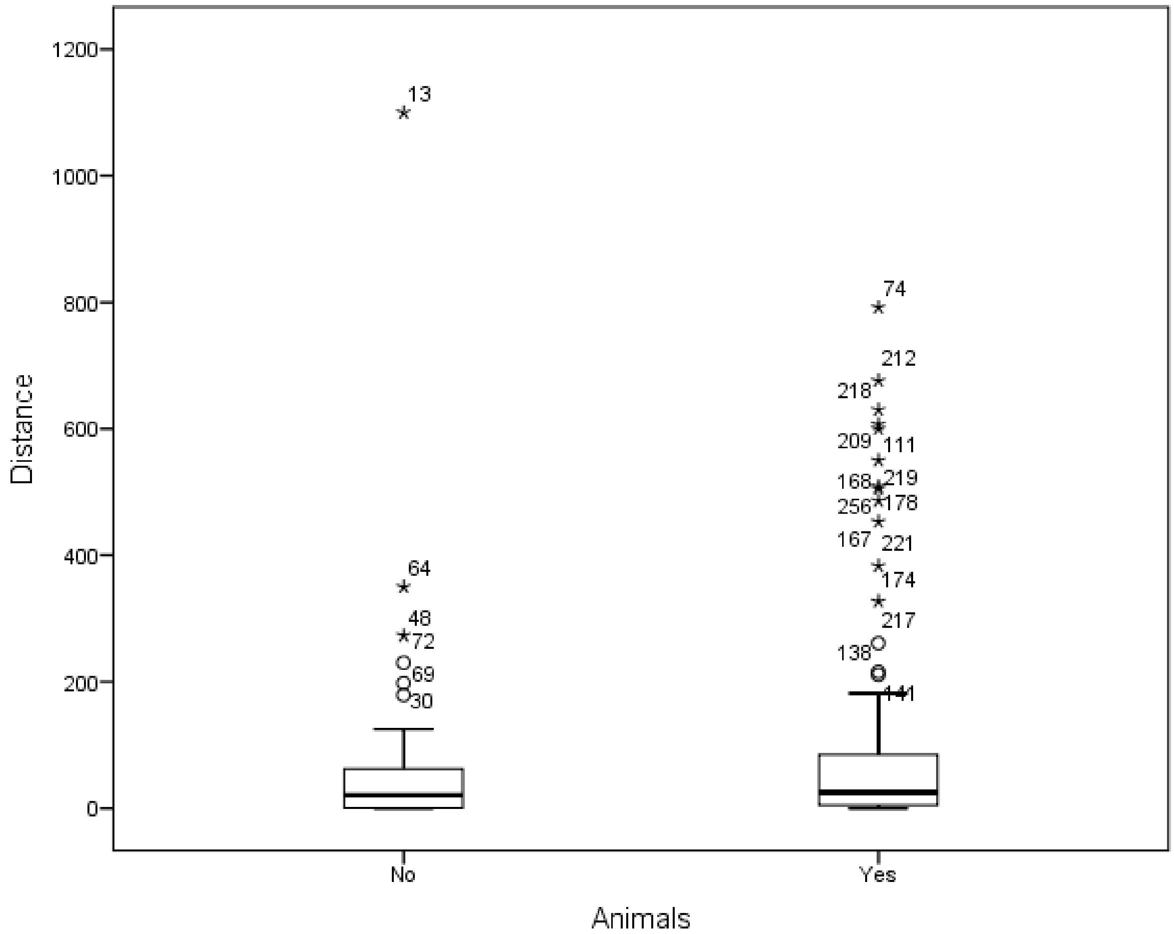


Figure 65: Artefact movement due to animal and non-animal activity

5.10. Weight of Artefacts and Distance Travelled

The aim of this part of the experiment, was to understand the importance of artefact weight in relation to distance moved?

The scatterplot below (Figure 66) represents the total surface distance in mm each artefact moved over the six month period. It also indicates the weight of each individual artefact. The data suggests it does not matter how heavy an artefact might be it can still move a great distance. Isolated cases of movement above 1 m can be seen for one of the heaviest artefacts (140 g) and also one of the smaller artefacts (<20 g). The longest distance travelled was 1100 cm and the shortest was 0 cm. The average distance moved was under 200 cm.

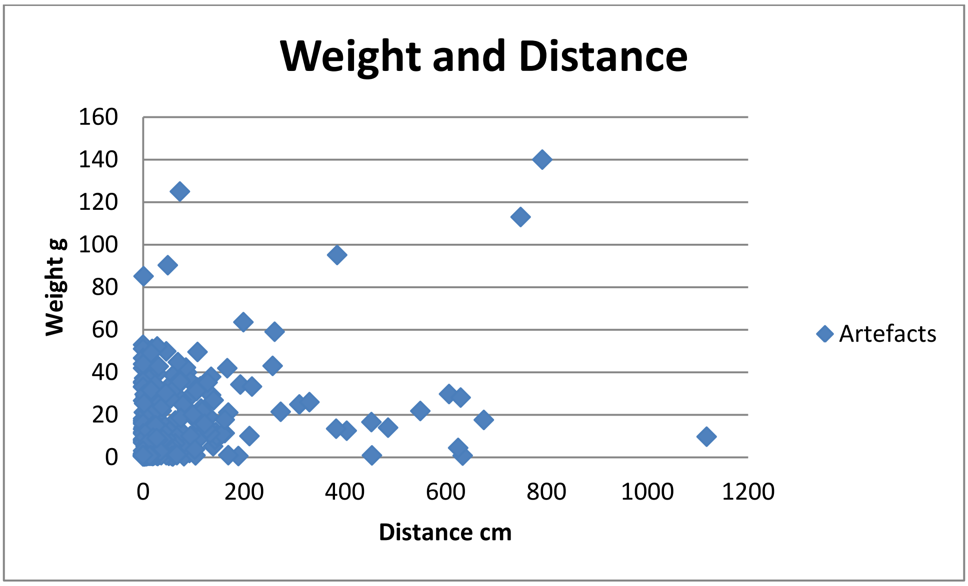


Figure 66: Scatter plot of weight and distance of artefacts

5.11. Subsurface Movement

Finally, the following graphs examine subsurface movement (see Figure 67 & Figure 68). Archaeologists are aware that artefacts move subsurface due to particular circumstances, but what causes them to move and how deep something moves subsurface in a short amount of time can be puzzling. Figure 67 & Figure 68 show that in the New England Tablelands rabbits can move artefacts subsurface dramatically over a six month period, up to 11 cm, and even make them disappear or make them reappear on the surface. However, since 109 artefacts went missing, it is hard to determine where the artefacts ended up. The fact is that only observed cases, can establish the direct subsurface movement of artefacts. In some cases rabbits would push artefacts to the surface again after a couple of months, due to their burrowing habits.

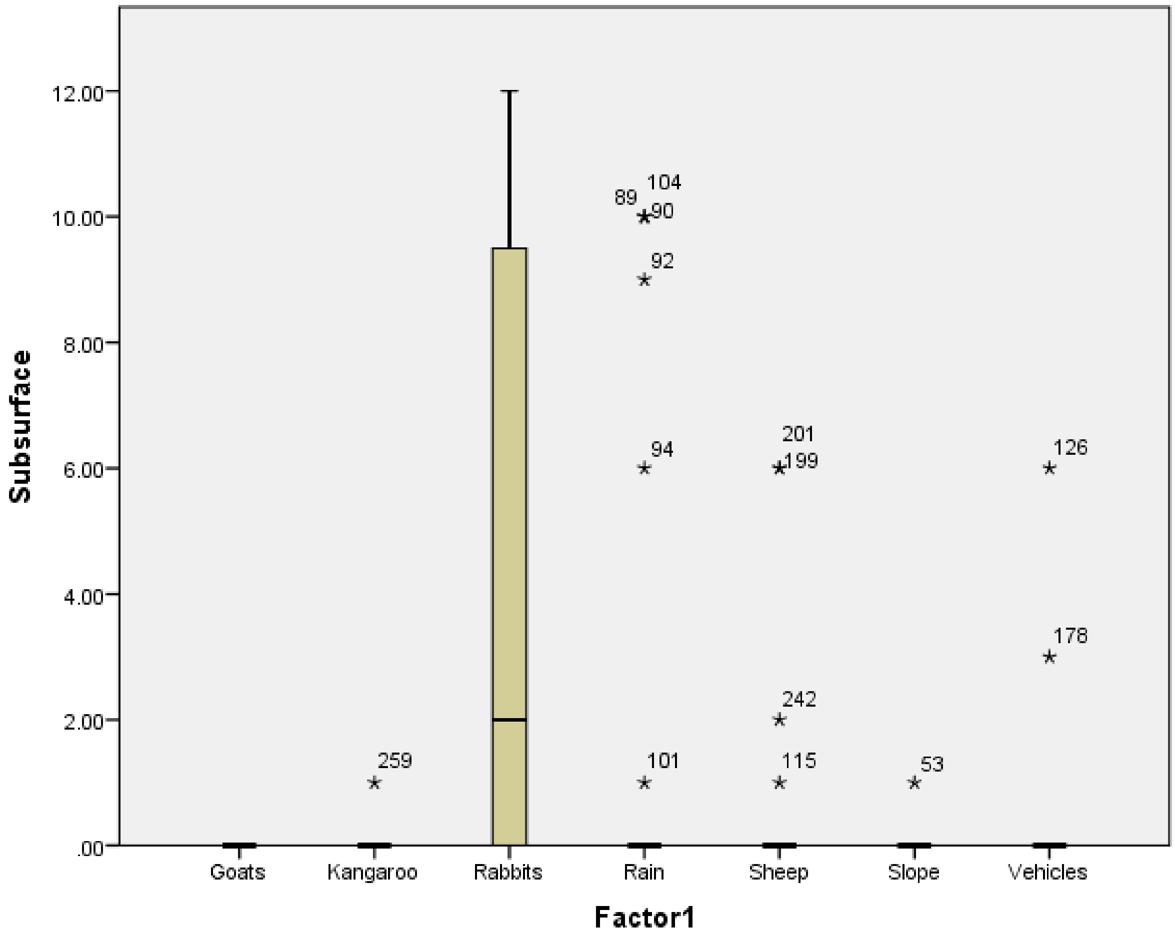


Figure 67: Subsurface movement due Factor1. Y axis in cm. X axis initial factor that disturbed the artefact.

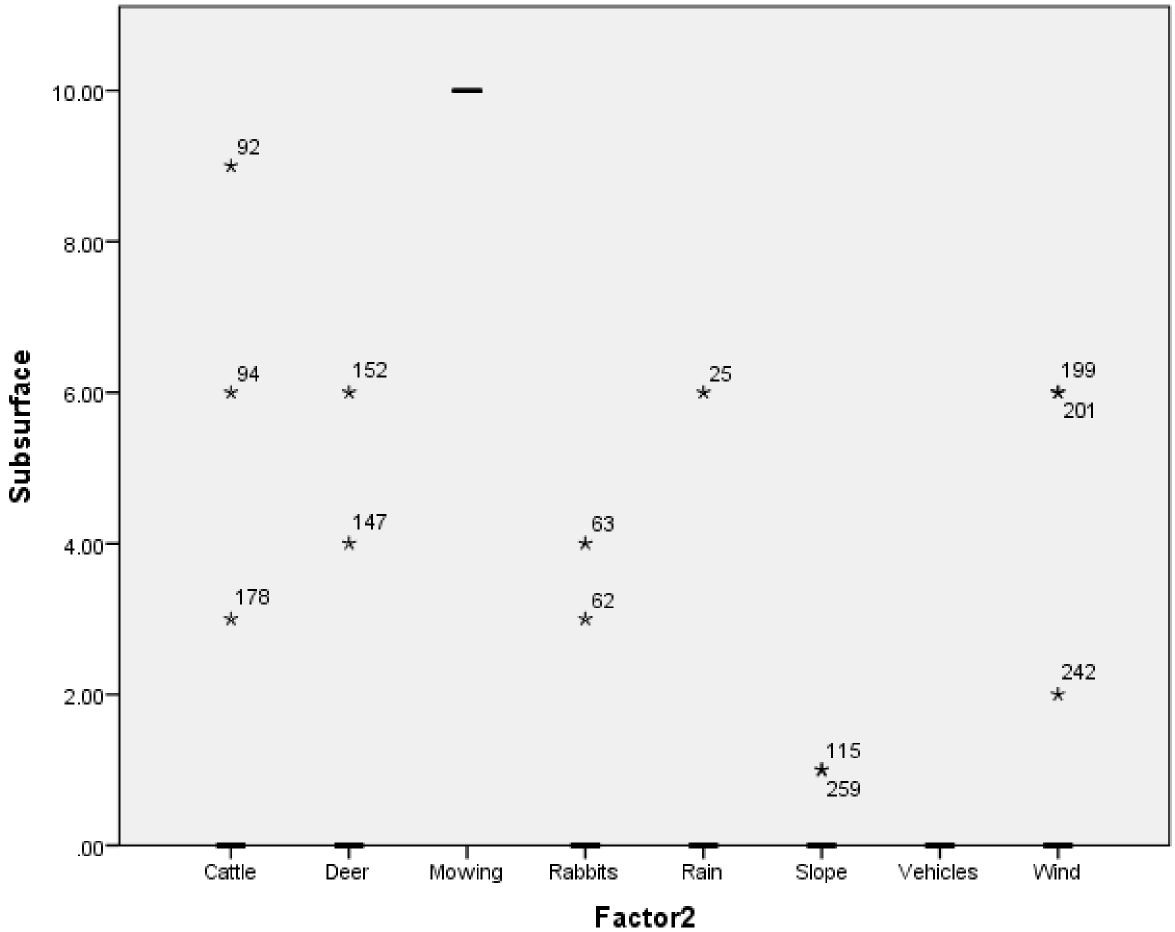


Figure 68: Subsurface movement Factor2. Y axis indicates cm. X axis indicates secondary factors contributing to movement.

5.11.1. Concealed Artefacts

Rabbits were the main factor contributing to artefacts moving subsurface. When vegetation grew due to rain, artefacts became well hidden (see Figure 69); technically still on the surface, just concealed. NB: All measurements of grass growth were in cm to see the amount of growth over time. The table shows that vegetation present is represented as 1 and no vegetation scored as 0 present.

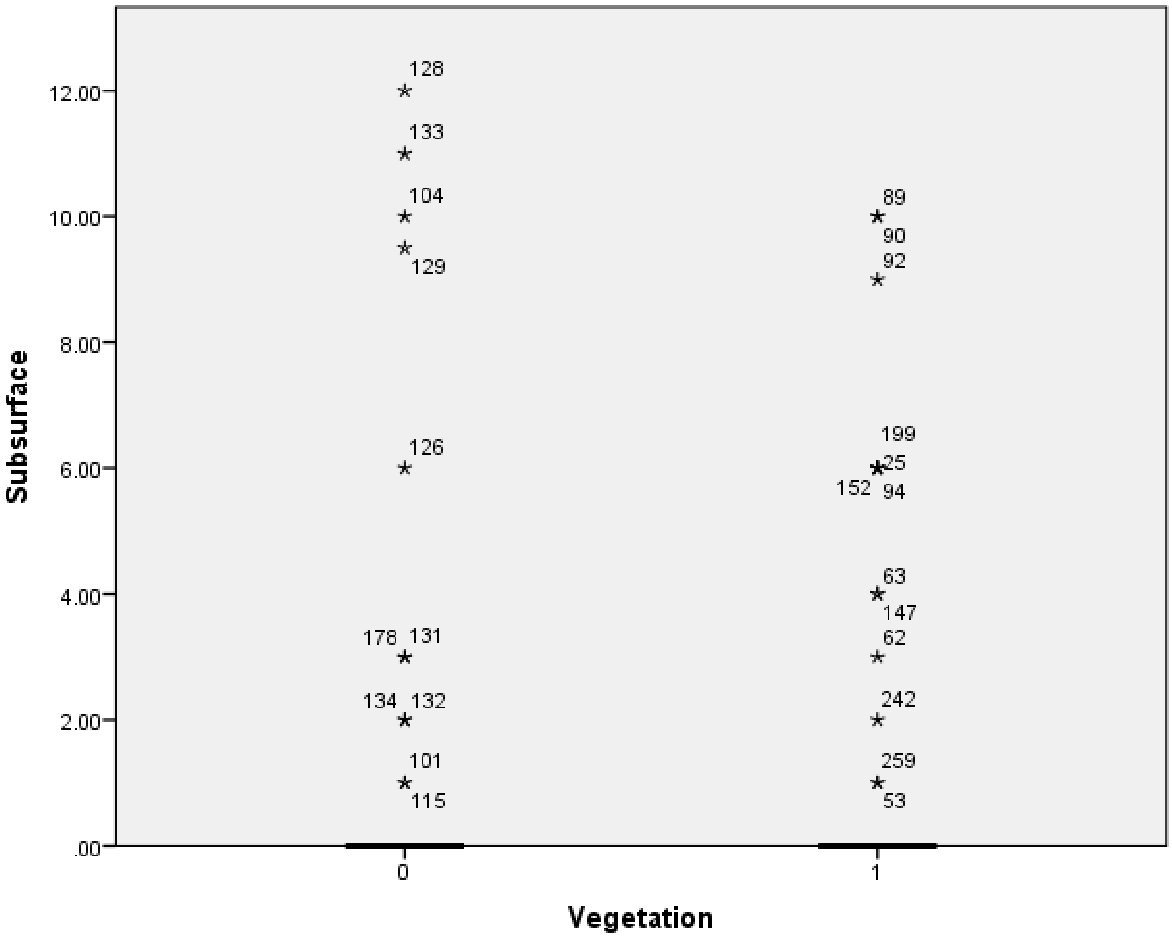


Figure 69: Total artefacts concealed by vegetation

5.11.2. Subsurface Movement and Artefact Weight

The artefacts that were detected with the metal detector below the surface had varying weights and depth. Looking at the scatter plot (Figure 70) there is no correlation between lighter and heavier artefacts and depth. There needs to be an external factor like rabbit bioturbation to push the artefact subsurface. The greatest depth recorded in the monitoring period was 12 cm and this was with an artefact of 26 grams, the second deepest was only 1 gram.

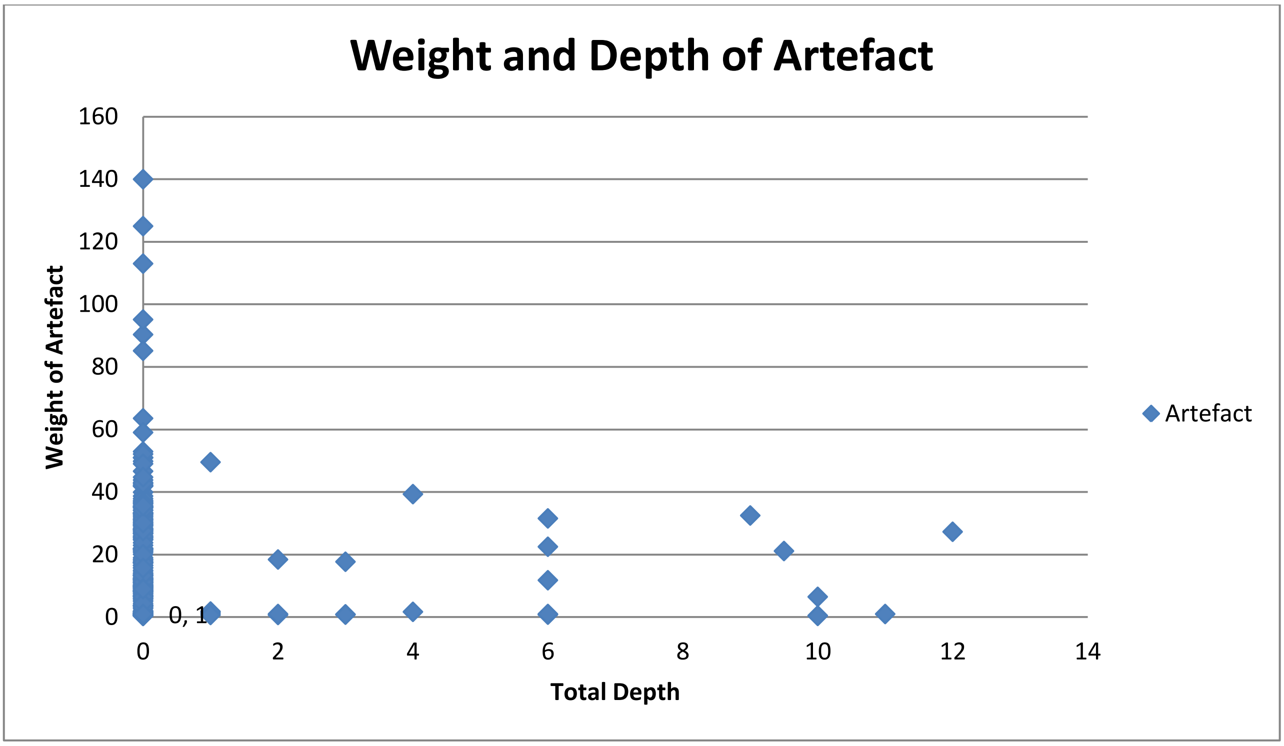


Figure 70: Total depth in cm and weight in grams

5.12. Linear and Mixed Movement

Figure 71 shows how many artefacts moved in single linear and also a mixed direction throughout the monitoring period. Multiple directions were the dominant feature, with 145 recorded cases noticed through the monitoring period. It is important to note this because when re-locating artefacts in the field, there were only 73 artefacts which had moved in a linear direction from their original position. The way in which this was determined was per month and monitoring period. This might be important when trying to predict where an artefact may end up. Tracking artefacts can be useful when trying to re-locate them.

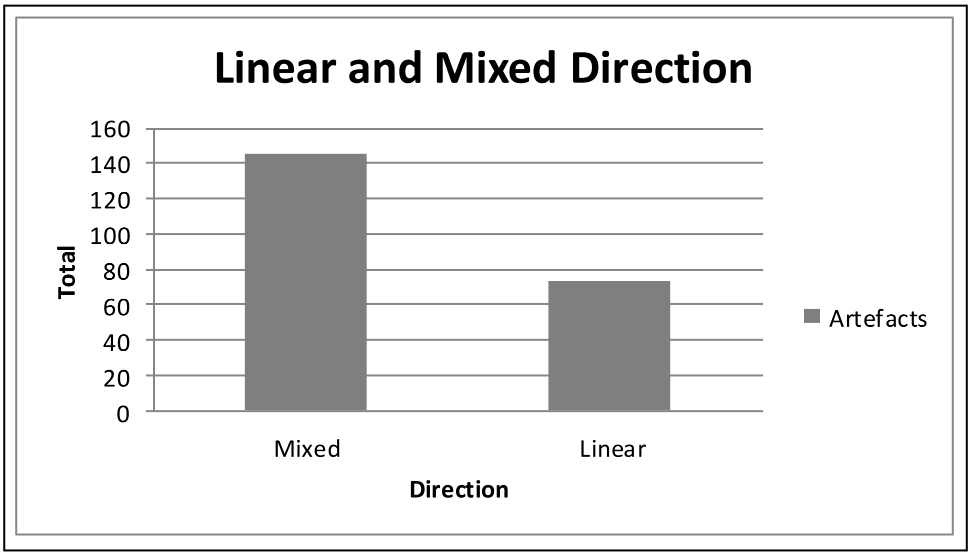


Figure 71: Linear movement verses mixed movement (incorporates 218 artefacts that moved)

5.13. Movement Due to Magnetic Properties

It was important to gauge whether or not the magnetic properties within the mock artefacts were affecting the movement. This was to determine if the magnetic hematite would be attracted to the magnetic poles. Since this was the first study to use magnetic objects to map stone tool disturbance, it was a potential factor that needed to be analysed. It was found that magnetic north had no effect on movement of mock artefacts (see Figure 72). M1 is monitoring period one, compass degrees of movement are on the Y axis and artefact totals are on the X axis.

Artefacts predominately moved south, southeast and southwest, side of the compass and the least amount moved was 271 degrees to the 89 degrees of the compass. The following figure shows that artefacts tended to move toward the south rather than north. This does not have anything to do with the magnetic properties of the material. Magnetic north does not have any role in how the magnetic objects move at all, which means that animals and vehicles are the main disturbance factors and are more likely to move the artefacts in different direction. There is nothing significant about this; just that one cannot predict movement at all.

M = refers to Monitoring Period (Monitoring Period 1 = M1)

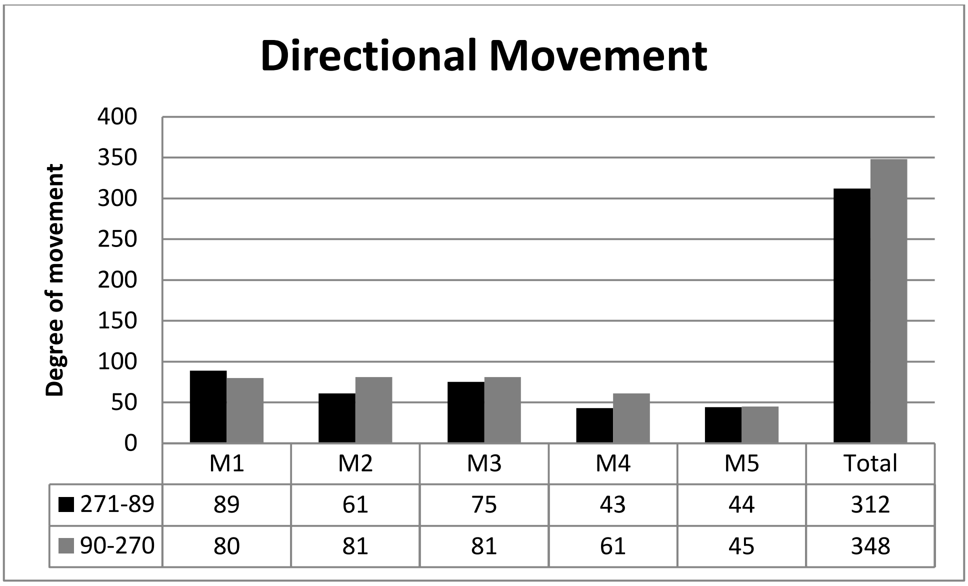


Figure 72: Directional Movement

5.14. Factors Contributing to Recorded Breakage

Breakage was a common observation in the monitoring experiment, effecting 5% of the total. Magnetic hematite was the only material that could be broken. Breakage at each location was obvious when the labelled artefact had pieces broken off it; the however factor contributing to the breakage was more complicated. If an artefact was located among fresh vehicle tracks then the vehicle was presumed to be the cause. If an artefact was in the kangaroo enclosure, it was highly likely that it was kangaroo activity. This goes the same for Kirby Farm with sheep and Deer in the deer enclosure. Breakage at Llangothlin and Laura Creek was more difficult to determine, but cattle were observed trampling artefacts. Scats tracks and traces were also recorded in close proximity to artefacts in order to determine what impacted the artefacts. Vehicles did the largest amount of damage with 49 artefacts broken (see Figure 73) indicating that vehicle disturbance is greater than animals. Seven artefacts were damaged from deer; livestock was next with seven. Four artefacts broke as a result of being on a slope; this could have been due to rain contributing to this kind of breakage. Sheep broke three and kangaroos did not break any. The Y axis indicates the total number of broken artefacts and the X axis are the factors contributing to the breakage.

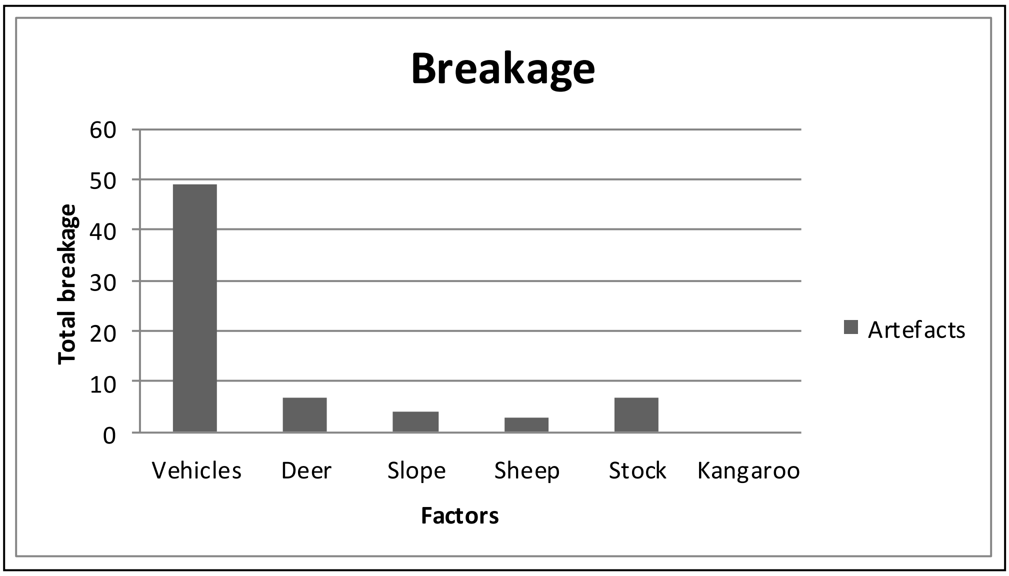


Figure 73: Factor totals causing breakage over a six month period. (stock indicates goats and cattle)

5.15. Artefacts Detected and Not Detected

One of the greatest problems with conducting such an experiment is losing artefacts during the monitoring process as previous work has shown in Chapter 2. This is why magnetic material was used and a metal detector to find them. Unfortunately as figure 74 indicates, the longer you leave an artefact, the more likely it is going to disappear. Monitoring Period 1 was only two weeks from the setup process, making artefacts easier to locate. Artefacts begun to disappear from site as the months went on. In monitoring period 1, the number of missing artefacts was 26. Monitoring period 2 was 64, and M3 was 80. Monitoring period 4 indicated that a higher rate of artefacts were lost, however monitoring period 5 shows that artefacts do reappear under certain circumstances. This could mean there are obvious interferences with the metal detector such as other magnetic fields affecting the metal detector and that a contributing factor has moved the artefact from subsurface to surface.

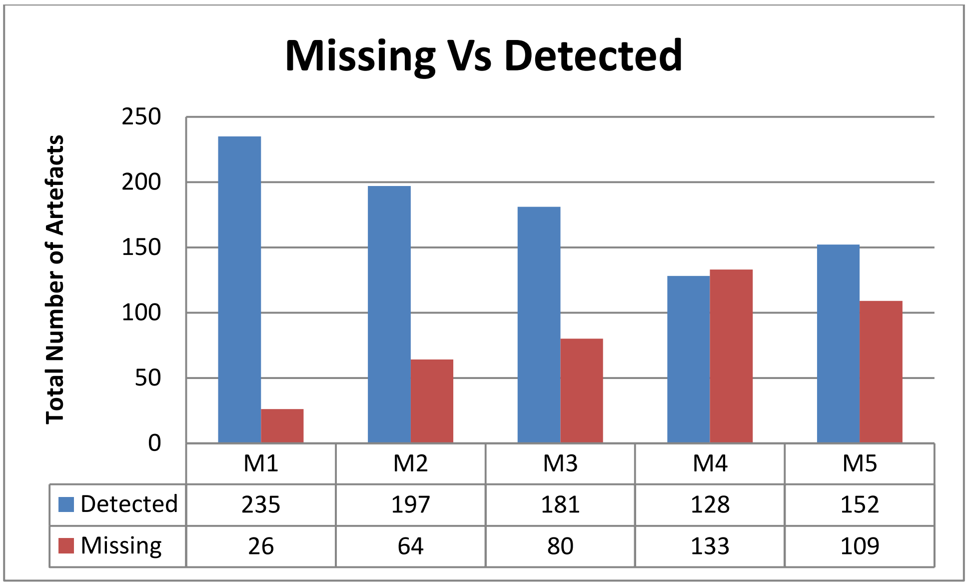


Figure 74: Histogram indicating missing and detected artefacts. [M1=Monitoring Period 1]. NB. As time increases detectability of artefacts falls and missing artefacts increase

5.16. Total Impacts per Monitoring Period/Instance

It is clear that the main result of disturbance impacting artefacts in this study over a six month period was horizontal movement (n= 646), closely followed by artefacts that went missing due to vehicles, rain and animal activity (n=407) (Figure 75). Unfortunately the materials that were magnetic were not as detectable as previously thought. The metal detector only proved useful if the mock artefacts were at a depth that was not beyond 30 cm. Even though magnetic objects were used to increase the locateability, of the artefacts it did not limit their disappearance. The use of magnetic objects and a metal detector was supposed to develop a better understanding of where artefacts might end up over a six month period and if archaeologists can predict where they would be. Observations were made around the square up to 7 m away in one month, but if they were not within this buffer they were written off. Movement and disappearance were the main aspects recorded throughout the experiment, vehicles and animals were the main contributor to these disturbances.

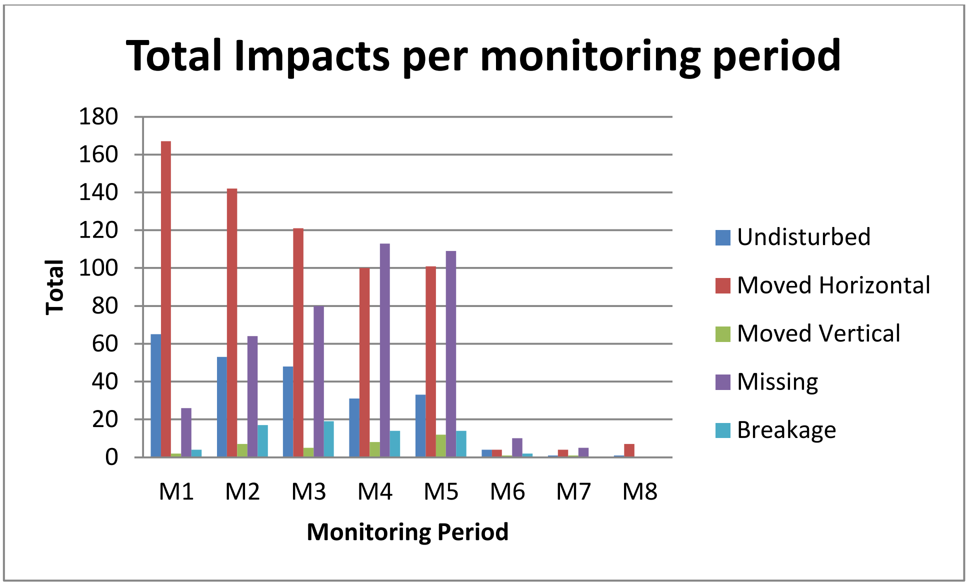


Figure 75: Total number of artefacts and impacts affecting them

The data above showed that artefacts will be affected if an external factor was introduced or was present at a site. Artefacts moved in the first three months, and then more artefacts started to disappear by months four and five. Not many artefacts sank subsurface, but these could be the missing artefacts that travelled to an un-recordable depth. Breakage was only 5% of the total impact over the six month monitoring period, but the missing artefacts could have also been broken into smaller unidentifiable pieces. The next figure indicates the total distance moved by the artefacts over the six month period. Movement is depicted in cm on the X axis and the artefacts are represented as totals on the Y axis (see

Figure **76).**

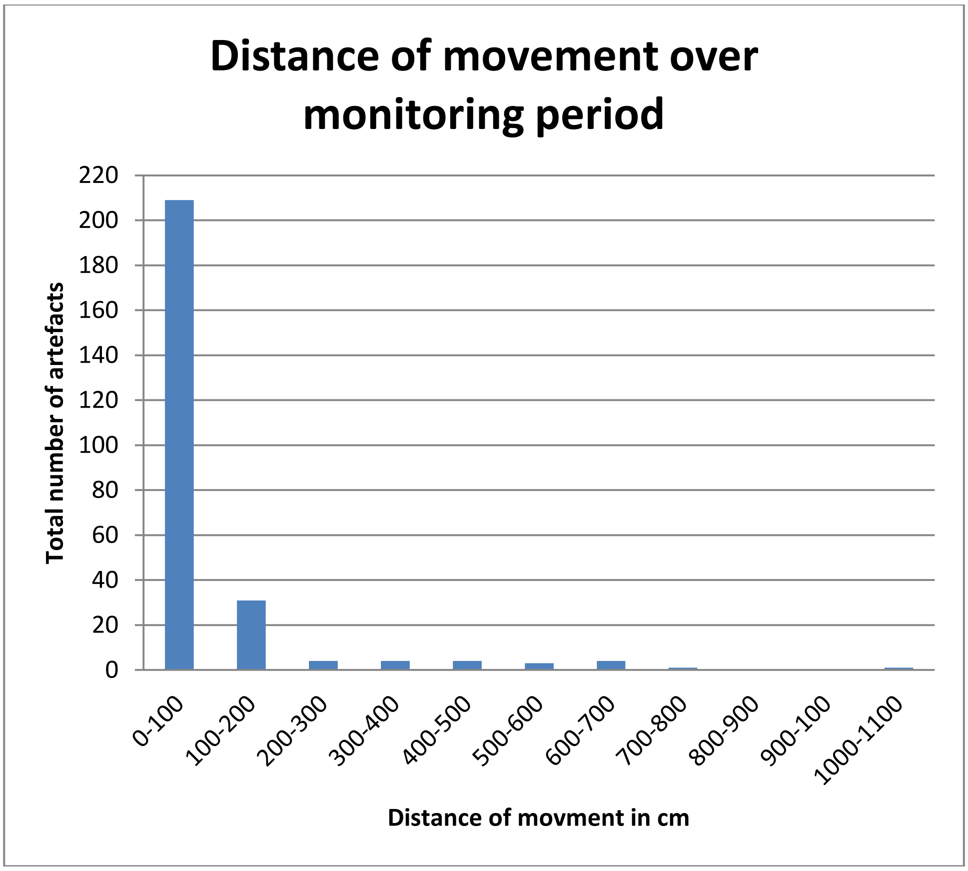


Figure 76: Total distance moved

This data shows that artefacts will be disturbed provided there are potential harming factors in the area. Multiple factors can collectively harm artefacts rather than just a single variable.

6. Discussion

The aim of this study was to evaluate how and why artefacts were being disturbed in the New England Tablelands. The discussion that follows will explore the contribution of this thesis to taphonomic research and CRM and outline the future research of similar studies. It was also to determine the main to factors disturbing them. This chapter also assesses how these impacts can be properly managed. The methods were experimental and the results verified that artefacts are disturbed by cattle, sheep, goats, kangaroos, weather (rain & wind), vegetation, deer, rabbits, and vehicles. At the beginning, a null hypothesis was created theorising that it is possible to quantify disturbance using experimental monitoring in the New England Tablelands. In addition, the literature was missing a considerable amount of important considerations relating to disturbance.

6.1. Contribution to Actualistic Studies

The research and experimentation conducted over the course of the project established that artefacts can be disturbed by a number of factors over a six month period. My study confirmed that due to these factors, artefacts will break, move, and disappear. Movement of up to 11 m was recorded over the six month period and this means that extending site boundaries when recording should be recommended when registering sites.

6.1.1. Questions

At the beginning of the study the main questions posed were: what factors are disturbing artefacts in the New England Tablelands? Do artefacts move? Do they break? What is the rate of disappearance? Where do artefacts go? What management recommendations can be put in place to mitigate the disturbance? How long does it take for an artefact to be disturbed and does using magnetic objects limit the number of missing artefacts in the experiment? Can artefacts be tracked?

6.1.2. Answers

It is conclusive that artefacts do move, break, and disappear and that there are a number of factors that affect artefact integrity. According to the study it can take only two weeks for a site to become disturbed. Factors that had profound impact on the artefacts included the following vehicles, weather, animals, landscaping, and vegetation growth. Using magnetic objects in this type of experiment increases the likelihood of artefacts being re-identified, and therefore potential impacts can be assessed more easily.

Over the six month study period artefacts had moved, disappeared, and broken due to various external factors including vehicles, animal activity, and the weather. Artefacts of all shapes and sizes moved up to 7 m and as little as 0 cm. Almost 50% of artefacts went missing and 27% were broken.

6.2. Findings

6.2.1. Movement

The results gathered from the experiment have shown that artefacts do move on a monthly basis. The repercussions of this are that a site re-identified by a different archaeologist may be in a slightly different location and/or condition at a later date than when it was originally recorded. Even though other studies have documented the movement of artefacts over months and sometimes years, they failed to look at the combination of variables contributing to the movement. For instance, in Cameron (1990), only wind activity was monitored over a three year period, and the monitoring was not as frequent as this study. The study also determined that small artefacts were moving across the landscape more than the larger ones. Subsurface movement data also indicated that larger artefacts were generally found deeper than smaller ones. The artefacts also only appeared to move up to 3 m in a three year period. Disappearance was mentioned but an exact number was not documented. My study found that artefacts could move up to 7 m in one month or up to 11 m in six months. They also had a tendency to disappear as the experiment progressed. Similar to Odell and Cowan's (1990) ploughing experiment, artefacts moved up to 15 m.

Downslope movement as explored by Rick in 1976 (Rick, 1976) found that fluvial impact was responsible for artefacts moving downhill. In this study, there was no evidence to suggest that fluvial disturbance moved the artefacts at all. The results indicated that the main contributors to movement in this study were vehicles and animal activity. There were also cases of uphill and across slope movement, which was not noticed by Rick. It can be argued that slope has no significant bearing on how far artefacts move or how frequently it happens, what appears to be important is the actual factor which moves the artefact. The aim was to assess if an artefact was more likely to move upslope, downslope, or across the slope laterally, with an analysis of the amount of artefacts that moved on the flat. More studies should be conducted in other locations to identify similarities in other regions.

6.2.2. Breakage

Macrofracture is a common occurrence with medium to large artefacts. The study conducted by Parteger (2011), is a classic example of this. The study showed how trampling from cattle and humans can break stone tools. Vehicles were not observed to be a breakage cause in this study or in any other previous study. My study, however, found that vehicle as well as animal activity could be contributing factors further evidence for this was that some of the mock artefacts were destroyed or rendered completely unrecognisable.

6.2.3. Disappearance and Concealment

Disappearance and concealment was a common problem in the experiment, i.e., artefacts would go missing after an external factor had impacted them. Over six months of monitoring, rains caused the grass to grow at a longer length, inevitably concealing artefacts. Significant disturbance such factors as vehicular activity and animal impacts could result in artefacts going missing. The data presented in the results chapter indicated that almost 50% of the total number of mock artefacts used for the experiment went missing. Reappearance of artefacts happened in the final monitoring period. A total of 24 artefacts reappeared due to rabbit burrowing activity and sheep trampling.

The most consistent revelation from this experiment was the fact that artefacts go missing. A total of 109 artefacts went missing out of the total of 261. Artefacts will move when an external factor is introduced, however, disappearance is far more common in these experiments than is generally acknowledged in previous experimental studies (Cameron, 1990), (Midgley 1998) and (Hiscock 1985).The experimental design of this study required the minimisation of disappearance. Magnetic objects and a metal detector were used to increase the detectability of the mock artefacts. Unfortunately, as the experiment progressed up to 50% of the artefacts were no longer locatable. The figures for the final monitoring period were 152 artefacts detected compared to 109. This happened at the end of the first month after the experiment was set up. The statistics for the first month were 235 artefacts found compared to 26 which went missing. Numerous artefacts went missing even with the use of magnetic objects and the metal detector.

6.2.4. Bioturbation

This study has highlighted that further investigation into insect bioturbation is needed to understand artefact disturbance. Intense ant activity was observed at Llangothlin and these ants were not the same size as the ones in the Robins' (2011) study conducted on the Gold Coast. At Llangothlin, large green-head ants *(Rhytidoponera metallica)* were observed rather than small black ants, which may have had an impact on the artefacts there. It would be ideal if more experimentation was conducted with different genera of ants and different species of animals. It is easy to generalise in archaeology when excavating a trench and stating that there is obvious bioturbation. Do ant holes disappear after time? If they do, it could mean that previous ant activity has disappeared and will go unnoticed. Do ants pick up artefacts and move them elsewhere when making their nests? Do larger ants have a bigger impact on archaeological sites?

In Australia, there is a large amount of native and non-native fauna that burrow. Further investigation of disturbance is needed into how different types of animals can affect the archaeological record. The rabbits at Llangothlin certainly had a large impact on square one, where artefacts were moved subsurface and to the surface as a result of burrowing.

6.2.5. Conflicting Explanations

In the literature review (Chapter 2) sources like Cameron (1990), Midgley (1998) and Hiscock (1985), all concluded that in places like South Australia and New South Wales, there are areas with one factor disturbing a site. The results of this study show that it should not be only one aspect that is observed, for there is almost always more than one factor at work. In Godwin (1990) only one form of disturbance was noted but there was only one location. This finding did not occur where there were multiple locations with different slope gradients or different macropods. It is important to understand that humans are not the main elements harming archaeological sites.

6.2.6. Unexpected Findings

It was hypothesised that artefacts would move at an alarming rate over the six month period and that an element of disturbance was likely. This did, in fact, happen. What was not expected was that artefacts did not have a weight threshold determining movement, but moved despite their size so long as an external factor existed. The distances moved by light and heavy artefacts were more similar than expected. This means that artefacts will move when a car or animal is introduced to the environment regardless of artefact mass. It was also revealed that the type of soil or vegetation that was observed in the area did not adversely affect artefact movement. The maximum weight for recorded artefact movement was 140 g and the minimum weight was 0.4 g. The 140 g artefacts maximum movement was 720 cm in one month and the maximum movement of an artefact under 1 gram was 220 cm in one month. Unexpected findings such as these are valuable indicators for the archaeological record. An archaeologist must consider that an artefact can and will move under certain circumstances.

Hiscock (1984) describes the significance of weight as a good indicator of artefact size. This study suggests that weight is a good indicator of artefact size and that he could determine the average weight of artefacts gained from the location. Weight is important because it does give an accurate indication of the size of the artefact, especially the type. For instance, in considering a flake and core, a flake can generally be assumed to be smaller than a core. What can be viewed from this study is that when it comes to artefact movement, it does not matter how heavy or how light the artefact is, it will move under certain circumstance and it will move up to 700 cm, or as little as 2 cm. This means that an actual artefact scatter would experience movement no matter if it is composed of cores, flakes, or tools, the size really does not matter.

6.3. Contribution to CRM

One question remains unanswered; what management recommendations can be put in place to help mitigate and lessen the disturbance of artefacts? The fact is that to halt artefacts from being moved, broken, or disappearing one would have to halt all external factors impacting the artefacts. It is not possible to have that kind of control over a natural landscape. Even though avoidance is considered one of the best management strategies for protecting a site, there is no guarantee a rabbit will stop digging a burrow within the site and there is surely no preventing a deluge of rainfall from washing the artefacts away. Mitigation options might prevent external factors from impacting the site, but realistically an archaeologist can do little to prevent post depositional process from affecting artefact deposition.

Salvaging a site and diligently recording where the artefacts are in-situ is one way of keeping the memory of the site at a single point in time intact. This makes preservation by record very important when dealing with continually changing sites.

6.3.1. Legislation

The *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (2010) states that a proponent is protected from prosecution if the land has been previously disturbed by human activity that has changed the land's surface, being changes that remain clear and observable (*Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales, 2010*). What it does not say is that sites are continuously disturbed whether this is an anthropogenic or natural. The findings from this experiment feature aspects of disturbance that have not been previously analysed, some of which can be devastatingly harmful to archaeological sites. Vehicle activity and animal disturbance is included as disturbance under the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. One is man-made and the other is natural. Archaeologists and heritage consultants will not usually identify these factors as disturbance unless it is obvious.

Generally speaking these kinds of disturbances are considered "low impact" whereas a housing or mining development is said to be "high impact" disturbance. Below is a table of what the *Due Diligence Code of Practice* considers as disturbance and what has affected the mock artefacts throughout the experiment (DECCW, 2010b). These are common disturbances found in the New England Tablelands (see Table 4):

Table 4

Due diligence disturbance table

Human Activity	**Seen within or around the Experiment**
Ploughing	No
Roads	Yes
Trails	Yes
Tracks (fire and walking)	No
Buildings	No
Clearing of Vegetation	Yes
Erection of Structures	No
Electrical Infrastructure	Yes
Water Pipelines	No

Sewerage Pipelines	No
Stormwater Drainage	No
Earthworks	No
Dams	No
Fences	Yes

The table indicates that roads, trails, clearing of vegetation, infrastructure, and fences were associated with the experiment sites. The tracks and roads were the main disturbances that were considered constant disturbance. Artefacts that are on trails or tracks are going to experience the most amount disturbance. If not on a track the artefact might be disturbed but it may not be as great as on a track or trail.

6.4. Cultural Resource Management Literature Review

Heritage professionals and archaeologists have a job to make sure that all archaeological and cultural heritage sites are protected under different legal Acts. One way of doing this is applying cultural resource site management skills. Below is an informative guide to some of the main regulations that heritage consultants follow to make sure that archaeological sites are properly managed.

The avoidance strategy is one of the most favoured archaeological management strategies. After the six month experiment it was concluded that a more scientifically viable approach needs to be used when creating avoidance buffers in combination with avoidance strategies. For instance when a botanist or an ecologist needs to protect a native tree they need to follow a simple strategy and equation to come up with a good tree protection zone. Avoidance buffers are good if one knows the integrity of the site is going to remain the same in a six month period, and if not, then a new strategy needs to be put in place, such as salvage, fencing or continual monitoring of the avoidance buffer.

6.4.1. Regulations

In NSW, an artefact scatter can be avoided, salvaged, repatriated, or moved (DECCW, 2010: 28). If an archaeological site is found, an archaeologist must record every aspect of the site and if working for a proponent the archaeologist may determine a strategy on how to re-position a development footprint to avoid the site, incorporating a no development section within the footprint (DECCW, 2010: 13). An Aboriginal Heritage Impact Permit (AHIP) is required if the site cannot be avoided in any way which makes buffers ineffective. Salvage is necessary to collect and relocate artefacts from the site. Avoidance is a strategy that needs to be thoroughly considered first and foremost.

Some sites are just given a point on the map, as seen in the following consulting reports, without an extended avoidance buffer. Essentially, the extent of the site is recorded to the extent of the outermost artefact location, then an avoidance buffer might be added on to the site, but it does not incorporate artefactual movement within and out of the site.

6.4.2. Recording a site

If anyone identifies an archaeological site in NSW specifically there is various information one can add to the form, including rock art, artefact stone tool information, etc. There is also a section to put GPS co-ordinates ("Aboriginal Heritage Information Management System," 2013). There is no section for an avoidance buffer or an extended site boundary to protect the site from external disturbances. When an archaeologist does a search on AHIMS they usually use a 2 km x2 km radius out from the project area. A search of two easting and two northing co-ordinates indicate how many sites are within this zone. After further request, the search maps show exactly where these sites are and what they are and the archaeologist then has to request the report to understand how the recorder got that information. It usually is a point on a map with no information about avoidance buffers; if there is it will be in the previous report. It is not designed for CRM purposes or to allow for artefact movement within the site boundary. Most consultants in their recommendations state the following, which has been paraphrased from a multitude of CRM reports:

> *The client is advised to avoid the artefact scatter using an avoidance buffer of 20 m. No artefacts are to be harmed or disturbed within this buffer.*

Most would consider this a fair strategy, but as this thesis has shown artefacts move and can be heavily disturbed by outside influences. There appears to be a big problem here: a massive gap in the research. The buffer mentioned above is common in other states and territories, but has not been tested. It is the continuation of an outdated best practice CRM plan that many consulting firms have adopted. How are they getting these numbers? There are no equations or monitoring programs to test these avoidance buffers and site boundaries. There is no regulatory strategy stating that one buffer is better than the other, nor are they trialled or tested. Only one consulting report was found discussing the scientific validity of avoidance buffers under water and that was as recent as 2004. It was argued that most buffers are not even established using an equation or formula and that monitoring was a possible option to see if the buffer was working. If a client needs to avoid a site they can use GPS coordinates and flagging tape. Clients may need to develop near the site at a later date, which can happen if there are budget constraints. The site might need to be revisited after, over a one to six month period. The strategies used to avoid the site will not stop natural and other cultural practices that can eventuate near or within the site. Sites need extended boundaries and buffers to protect the artefacts, but monitoring is the only way to determine how artefacts are being disturbed.

6.4.3. Re-location – Problems

It is no secret that when re-identifying a site from a previous study, it can be difficult to find. There are a number of things that can cause this including incorrect mapping techniques and, of course, disturbance. My results show that in fact, loss is surprisingly common. Below are some examples of consulting projects not being able to re-locate previously recorded sites. All reports have been filtered for this report and only the key information has been excerpted for the purposes of this thesis. The companies are in no way incompetent for being unable to find the sites, but are challenged with the common issue of site re-identification. Some sites may have been recorded months or years before they had been re-recorded.

6.4.4. Consulting Reports and Avoidance Issues

The following two companies agreed to let me pull out relevant information for this thesis. All confidential information was omitted and only avoidance aspects and the struggle to re-identify a site was used for this thesis.

Environmental Resources Management

One of the first reports studied was an ERM report from 2012 for a Gunnedah transmission line (May, 2012). In this assessment a total of nine sites from 1985-2010 were identified in the AHIMS search. None of them were re-located in the survey in 2012. In the report the reason was that levels of visibility and exposure had changed since 1985 and 2010. The length of time from the last recording period was between 27 years and two years, but over half the artefacts in my study disappeared in a period of six months.

The second report was for a CSIRO site in a paddock and had similar limitations in re-locating the previously recorded artefacts (Blackmore, 2015: 23). No artefacts were re-located successfully, however the marker of the vicinity where the artefacts were supposed to be was re-identified. This happened again in another location; no previously recorded artefacts were found, but the marker was successfully re-located (Blackmore, 2015: 24). Evidently, the fixed marker was easily locatable due to its fixed position, whereas the artefacts themselves were not, making them likely victims of the potential impacts in the area.

Comber Consultants provided two report examples for this study. One was for a cycle share-way in Wollongong and the other was for a housing development site in Penrith.

The assessment conducted in Penrith in 2014 was for a housing development site and had two previously recorded sites, which were re-located using GPS co-ordinates recorded by Kayandel Archaeological Services (Stening, 2014). The site AHIS 45-5-4319 was recorded as a flaked piece and a core and the other site AHIMS 45-5-4320 was recorded as an isolated find. When Stening conducted the investigation no artefacts were re-identified due to soil movement, rain, and human activity (Stening, 2014). It was suggested that these artefacts moved either horizontally or vertically, which is highly probable. The requirements state that all sites are to be recorded and GPS co-ordinates are to be attached to the AHIMS recording form, but this may not be enough.

The next Comber Consultant Report studied was for the Illawarra Shareway in Wollongong. A total of eight archaeological sites were originally identified in two out of the four areas of the project footprint and none of them were successfully re-located. Again, this was due to poor visibility from high vegetation (Comber, 2010: 30-31).

The next section will visit two possible strategies used when protecting trees in environmental science and one maritime archaeological strategy used in the USA.

6.4.5. Buffering strategies

Two buffering strategies were studied in this section. The following two avoidance techniques were analysed: tree protection zone equations and the maritime archaeological buffering strategy for shipwrecks.

In other areas of CRM scarred trees are protected using environmental buffering strategies including the tree buffering strategy equation used. Environmental scientists and botanists determine buffer zones using the DBH method. The DBH method determines the buffer by calculating the diameter at the breast of trees height x 12 (Vezgoff , 2010: 18). Then the structural root structure or SRZ is calculated SRZ radius = (D x50)0.42 x 0.64 (Vezgoff, 2010: 18). An arborist can calculate an accurate buffer so that works will not harm the tree trunk, canopy or root system. The same technique can be used for the protection of scar trees as well. Unfortunately, artefacts do not have the same equation. This avoidance strategy works in this context because the items of interest are in a fixed position and not likely to move. Artefacts, on the other hand, are constantly moving and would need a sophisticated equation to cater for the movement within the site boundary.

In 2004 the US Department of the Interior Minerals Management Service conducted an investigation of offshore dredging impacting on maritime archaeological sites. It was argued by this organisation that the size of the buffers in archaeology need to be beyond individual opinion (Baird, 2004: 56), as appears to be common in the consulting industry, rather than actually having them being scientifically tested or analysed (Baird, 2004: 56). The maritime archaeology organisation attempted to come up with a strategy in determining buffer radius to consistentlyprotect the underwater archaeological sites. They determine it using the distance of the dredge limit (L), the uncertainty of the buffer for the resource location (possibly the percentage of the width of the resource footprint) (Ub), the dredge buffer zone (Bz), the cumulative depth of dredging from original sea bed elevation (Dd), and final slope (S) (Baird, 2004), 2004 : 47-48). The equation is this: L1=Ub+Bz and L2=Ub+Dd/S (Baird, 2004 : 47-48). The buffers that were determined were of 150 m and 350 m (Baird, 2004 : 47-48). These are quite extensive, however it would appear to be reasonable due to the unfamiliar nature of protecting sites on the sea floor. None of the above methods are relevant to artefacts possibly due the unpredictable movement of the terrestrial artefacts.

On land there appears to be no scientifically viable strategy in placing avoidance buffers around a site. Some give 5 m buffers, some 100 m. It appears that this subjectivity is common practice in the consulting industry. This is a problem because most archaeologists and heritage consultants are not taking into account the potential risks to sites that can happen over time. Although most clients will do their best to avoid a site based on GPS co-ordinates, there are other factors at work that need to be considered as evidenced by the consulting scenarios discussed, in which various consultants have tried to re-locate/re-identify previously recorded sites that had an extended site boundary and avoidance buffer could not do so. If the previous recorder had allowed for artefact movement then it might have been easier to find the artefact at a later date. This could only be achieved by monitoring the site and potentially coming up with an avoidance buffer equation.

6.4.6. Buffers

How sufficient are current and best practice site boundaries and avoidance buffers when protecting archaeological sites? If the results from this study can answer that question, one could safely say they are not incorporating the potential for movement. Even though avoiding a site is considered one of the better options, one has to wonder if consulting firms are also considering other potential hazards rather than just a client's needs. As noticed in this study, a whole range of impacts can destroy the integrity of a site. Not only has the archaeology probably been disturbed over a long period of time, it is constant. From an archaeological perspective there are questions in relation to the archaeological assemblage and human behaviour. Artefacts move when they are first dropped by humans, then they move due to environmental factors. Even once a site has been recorded there is no guarantee that the same artefacts will be present in six months’ time. Site buffering may assist in this dilemma.

6.4.7. Solutions and Recommendations

There are number of aspects that need to be considered when placing an extended site boundary and an avoidance buffer around a site. Consideration must be given to the current disturbance level on the site, the kind of current or even future disturbances that could impact the site and who the stakeholders are who can monitor the conditions of the site.

Ideally, testing the site extent boundary and buffer would assist in determining if it is sufficient to protect the site. An equation could be the best way to create or determine buffers, and if standardised, this formula could be part of AHIMS forms so that archaeologists in future might understand the effect of environmental impacts on site changes ("Aboriginal Heritage Information Management System," 2013). In addition, monitoring sites could also determine the effectiveness of the buffer. One has to be aware that certain unpredictable events can happen from month to month as was the experience with this study so some hindsight and predictive modelling is required. This would also allow an archaeologist to observe the current conditions. For example, if an artefact scatter is on a dirt road/track then there is potential that it will be exposed to ongoing low to high levels of vehicle activity.

Currently, the use of motion cameras is impractical, as filtering through the footage could take a significant amount of time, however judicious use of these might help identify the post-exposure process by record. Motion cameras would also need to pick up all aspects, not just animal activity, including weather events and the direct movement of the artefacts. The archaeologist can then revisit the site to document artefact movement measurements or animal entry inside the site boundary.

Management recommendations and problems

- Better buffers need to be in place to protect artefacts
- With site management plans all potential disturbances need to be observed properly to facilitate the effective protection and locateability of artefacts
- Artefact protection from human activity is serious concern Site degradation and destruction is attributable to multiple components.
- Site integrity should be a loose term since a site is never truly intact; rather it is always experiencing change and movement

6.4.8. Equation

If there is enough data from the monitoring phases then an equation could be determined to approximate the potential movement in the area. One way of creating an equation is to assess what disturbances an area presents near or within the site and what disturbances are likely to impact the artefacts in order to cater for any movement within the buffer. For instance, if there are vehicles likely to impact the artefact, this will be given a number of 1 (it could be written as D1). If there is more than one potential factor that could disturb the artefact for instance animals, weather, or people walking through the site, this number could then be represented as D4. The amount of artefacts needs to be represented as A. If there are 10 artefacts then it should be written as A10. Next should be the project impact zone, the total square metres of the project if the project area is 10 sqm then it can be represented as PA for project area. The total buffer that should be avoided can be represented as B. The equation could be written as follows (DxA) +PA=B which would be (4x10) + 10 = 50. The buffer is 50 m, this is more than enough, and, as suggested in the maritime archaeology report, monitoring would need to be tested. Slope can be added to the D category. If a slope is over 5 degrees it should be added and time could be added to the equation if the consultant feels it necessary. Again, this aspect would need to be trialled and tested from month to month to determine what the best strategy would be. Another important strategy to consider is to preserve a site by record, making sure that every part of the information of the site has been written down for future reference.

6.5. Preservation by Record

Preservation by record is conceptualised by archaeologists when a site has to be recorded. It is important to record as much as possible, so if someone else has to re-identify the site they can. Or in some cases if the site is destroyed it can be recreated. An archaeological site can yield extensive information for an archaeologist, especially when dealing with stone tools. Stone tool artefact scatter sites in particular can require a number of designations for an archaeologist, including artefact types, locations, raw materials, and past and current disturbance to the site. Preservation by record is an important aspect in archaeology because by recording every detail, an archaeologist can display a site without actually being there (Andrews, 2000). For instance, if a site is destroyed, an archaeologist could recreate the site as it was originally recorded (Huggett, 2015). An archaeologist should be very wary of every little detail because it could be important to the site’s integrity, including about how it once was and original condition and external impacts. As discussed throughout the study vehicles, animals, and weather can harm a site significantly; an archaeologist cannot stop this from happening completely. When dealing with site boundaries and re-recording sites, archaeologists and heritage consultants cannot assume that the site or artefacts have gone missing by any means. One must understand that the site is still present even though there may not be any visible evidence. In NSW AHIMS has numerous sites registered, many without any visual reference to what was there when originally recorded ("Aboriginal Heritage Information Management System," 2013). Sites are hard to deregister and it is not advisable to do so. Even if visual evidence is not present on the surface, the site could be subsurface now or it has been redeposited in another location. The factors that contributed to artefacts going missing and reappearing were vehicles, animals, rain, and vegetation growth.

6.6. Mapping

Maps can show landforms in great detail, which can also aid in determining sensitivity. Maps have been created which can show natural processes at work including fluvial and aeolian depositions (El-Baz, 2007, 54-56). Disturbance maps have been generated in for example Africa where the Saharan winds have affected sites significantly (El-Baz, 2007, 54-56). Maps of this nature have different zoning and different colour schemes to emphasise the different types of disturbances to the environment.

Mapping has changed dramatically in archaeology. In addition to remote sensing, geophysics and GIS have made mapping more precise and elaborate (Connolly and Lake, 2006: 10). Predictive modelling has benefitted from advanced maps indicating where potential sites might be (Ridges, 2006, p. 123). In NSW, AHIMS maps can be generated for previously recorded Aboriginal sites (DECCW, 2010). These make it easier for a consultant to determine if a development is going to impact an Aboriginal site or not (DECCW, 2010a). In the New England Tablelands, mapping of such quality is not currently available, although it would be useful for indicating potential disturbances over time. It could even assist in future predictive modelling applications. For instance, it would be useful to map the natural and cultural impacts that can affect an Aboriginal artefact scatter.

6.7. Limitations

The study revealed that there are more limitations when dealing with the monitoring of mock artefact disturbance than previously thought. The experimental squares were setup in areas where certain disturbances were more common than others; however other unforeseen disturbances affected the artefacts. In the weather monitoring experiment four wheel drive activity destroyed the site. There was no way to track all the artefacts after they had been driven upon. To clarify this contradictory evidence a study would be needed at a large number of sites where there are sloped of different gradients including a flat area. The type and frequency animal and other impacts could be recorded over a long monitoring period to ascertain an interaction between gradient and animal activity. The amount of vegetation would attract animals to some areas more than others and non-animal impacts could be significant too.

6.7.1. Metal Detector

Etrac Minelab metal detectors have an accuracy reading of up to 30 cm depth and have a number of settings to help the individual find what they are looking for ("E-Trac Instruction Manual," 2008). In this experiment high iron content was the desirable setting. Unfortunately it does not stop other sources of metal or iron being detected, such as fences, creating substantial “noise” and making it difficult to relocate mock artefacts.

6.7.2. Depth

In the methodology chapter it was discussed that once the magnetic hematite or a broken key moved below 30 cm sub-surface, the metal detector could not detect it. There could have been multiple times when the artefact had dropped below the 30 cm mark or when the magnetic hematite broke down enough so as to disintegrate. As determined in the initial methodology the larger the object and the higher the metal content the easier it was to re-locate. If the object had reduced size and had gone deeper than the surface it is possible that the metal detector could not get a reading, making relocation unfeasible. One could have excavated each individual square extensively, however this would have been time consuming and each object would have had to have been placed back into the position in which it was found. Having mentioned that, some squares were excavated carefully, roughly where the artefact was in the previous monitoring period. In some cases this was successful; especially at Barley Fields and Llangothlin.

6.7.3. Interference

Initially, squares were placed far away from other metallic objects and structures including sheet metal, nails, surveying markers and fences, to minimise background noise exhibited when the squares were set up. There were still issues with fences and other foreign metal objects. If there was a large amount of disturbance that had impacted the mock sites to the point where objects may have moved close to the fence line, then it would be safe to say that the artefacts had been lost. Metal fences were not far enough away from the squares. If someone was to replicate this experiment, the experiment should be located at least 7 m away from introduced metal objects. Perhaps more of the mock artefacts would have been found if the fence line was further away at Barely Fields.

The setup of the squares at Deer Park had a larger amount of interference than previously anticipated. A natural deposit of iron stone was noticed in the initial setup, however each square was tested beforehand, and the surrounding soil was checked as well. Again like at Barley Fields, a buffer of about 7 m should have been considered to halt any close interference.

6.7.4. Unforeseen Circumstances

Barley Fields was set up to be specifically for weather monitoring, where each square was going to be reset after a weather event. The unforeseen circumstance was that after or during a rain event people from the local area would come onto the traveling stock route land and drive erratically in a circular direction over the experiment and on other parts of the track. This occurred in the first monitoring period and decimated six of the nine squares. A new study was conducted to understand the level of devastation vehicles can have on an archaeological site. An extra three monitoring periods were added to this particular location to understand the level of disturbance. No study has ever produced vehicular vandalism in an artefact monitoring experiment before and or considered vehicular vandalism. It was found to have the most devastating impact to artefacts, due the amount of artefacts that went missing, moved, and disintegrated.

More questions for further study emerged from this external factor: Do artefacts get stuck in the tyre treads of cars and then re-deposited in other locations? How far do the artefacts travel if indeed they do get stuck in tyre treads? These are important questions as vehicles could move artefacts considerable distances.

6.7.5. Implications of the Findings

The results have generated more unanswered questions in regards to artefact disturbance due to the locational uncertainty of the reposition of artefacts due to certain factors. The impacts have been represented in a table below which illustrates how they affect artefacts and the degree of the impact, from high to low (see

Table 5). It is based on the level of breakage, movement, and disappearance of artefacts. In addition to this, a documented analysis of the aspects associated with archaeological sites will be presented. This could be the difference between finding artefacts on a ridgeline one day and finding that they have been redistributed to another location, such as a creek, the next day. What is expected from the archaeologist if this happens? Do they expand the site? Or change the site because it has moved?

Table 5

Factor impact table comparison

Factor	**Impacts**
Vehicle	High
Mowing	Low
Sheep	Medium
Cow	High
Goat	Medium
Deer	Medium
Kangaroo	Medium
Wind	Low
Rain	Medium
Rabbit	High
Slope	Low
Vegetation	Low

6.7.6. Importance

This study has confirmed that when creating avoidance buffers one has to take better consideration of other disturbances that are not factored in. From a CRM perspective, avoidance is a beneficial way of protecting a site because it deters the proponent from harming an already identified site (DECCW, 2010). However, this does not prevent other factors from harming a site. This study highlighted some key principles when considering the avoidance method and they are:

- Observation of any potential bioturbation
- Identification of the flora and fauna that can affect the artefacts
- Assessment of vehicle tracks adjoining the site the need for another assessment in 6 months to check the site integrity
- A cost-benefit evaluation of introducing a monitoring program to assess the integrity of the site
- The construction of fences to protect the site integrity

The following chapter will conclude this thesis and summarise the contents.

7. Conclusion

The introduction outlined the importance of site preservation and the causes of artefact disturbance in the New England Tablelands.

The literature review discussed some of the key articles on site and artefact disturbance. It concluded that over time the previous studies had focussed on specific causes of artefact disturbance such as weather, ploughing, livestock, ants, and human activity. None of the articles stated the importance of site extent boundaries or avoidance buffers to mitigate against site disturbance.

Following the literature review the methods chapter indicated the importance of the experimental method and how the study was conducted from set up to the monitoring processes. The limitations of the experiment were identified as well. The preliminary results section showed that the experiment at Laura Creek had worked and that disturbance to the mock sites would happen on a month by month basis. Artefacts large and small had already moved over a metre in a three day period, due to vehicle and cattle activity.

Chapter 4 described the key moments of the experiment and what was actually happening at Laura Creek, Barley Fields, the Deer Park, Kirby Farm, and Llangothlin. It included kangaroo disturbance, rabbit burrowing, vehicle destruction of the sites, and movement from cattle. The maximum movement recorded was 7 m and the minimum was 0 cm. Artefacts broke, disappeared, and moved over the six months.

After this, Chapter 5 included the results of the raw data from the six months of monitoring. Kirby Farm had a consistent amount of data for movement due to the least amount of artefacts going missing. Vehicles proved to be a significant cause of breakage, movement, and disappearance. Kangaroos were responsible for artefacts moving upslope. Rain submerged artefacts. There was a close correlation between use of vehicles and rainfall apparently due to the enjoyment some people get from driving four wheel drive vehicles over wet grounds with the unfortunate consequence of the destruction of many sites at Barley Fields. Rabbits at Llangothlin buried artefacts and caused some to disappear. When cattle were introduced to the area, movement on the 30° slope also happened. The greatest recorded surface movement over the monitoring period was 7 m which was staggering in such a short amount of time. Laura Creek had a combination of disturbances including cattle, vehicles, goats, and weather. Slope activity was common here as well as at Llangothlin.

The discussion chapter brought the data together and essentially elucidated the need for sites to be given extended boundaries and avoidance buffers for protection purposes. Monthly monitoring and formulae at different locations could help determine site boundaries and buffers. These measures would further protection of the site and potentially increase re-identification.

7.1. Future Research

A factor that had not been addressed in previous studies is identification of the seasons or when animals are more likely to harm an artefact, e.g. are rabbits less likely to disturb an artefact during winter months than during spring and or summer months? In addition, it is suggested that a sixth location should have been used to incorporate weather event reset monitoring into the experiment. Finally, predictive modelling and cultural heritage resource management strategies should be tested so that artefact scatters can be protected and avoided if necessary. Another method would be to manage such disturbances, and also predict their post impact locational distribution in the landscape. The rationale for further investigation is to improve CRM processes and emphasise the importance of preservation of the archaeological record. In addition more experiments need to be conducted especially for slope movement to see if animal, fluvial, and vehicle movement are the main contributors to artefact movement on a slope.

Based on results of the experimental part of the thesis, future studies of a similar nature should also consider using magnetic hematite and broken keys as they were found to be an adequate material. However, the monitoring should be more controlled than this study. It is recommended that artefacts positioned in different landscapes where more detailed monitoring can be undertaken; landscapes such as exposed sand dunes in South Australia, cyclone regions in Western Australia, and built up areas such as in Sydney, NSW. As observed in this study, unforeseen circumstances like erratic vehicle activity can have significant impacts.

If researchers could 3D print iron objects the exact shape, size, weight and density as a silcrete, quartz or chert stone artefact that would be ideal. Three dimensional printing of metal objects could be a better, albeit more expensive, alternative in future experiments.

Finally the methods listed in this thesis can help in developing future management plans by understanding what impacts are affecting stone tools in the New England Tablelands and by extrapolation to other temperate Australian areas. Better avoidance strategies can be created by understanding impacts on artefacts.

Archaeologists and heritage specialists need to incorporate larger site extent boundaries and avoidance buffers. As discussed, one can simply do this by determining where the site is and adding an extra 10 m to the site extent. This is not a buffer but an expansion of the original site. This should be trialled and tested over a six month period to determine what is happening at and to the site. Adding an extra buffer around it could be useful and that could be determined by using an equation similar in principle to that of the Baird (2004) maritime dredging study. In practice it may not be ideal unless it is tested. If a site is on a vehicle track, a buffer of 5 or even 100 m is not suitable to protect the site. It will be continually disturbed. If the site is within virgin ground then it is safe to say that any buffer can work depending on the circumstances. It would appear that in this study, artefacts on the flat or a slope can move up to 5 or 7 m in a six month period. A buffer needs to account for potential disturbances in and around the site so 20 m could be safe but if there is a high risk of vehicle activity putting a buffer in to protect the archaeology could be useless. That is why it is recommended that sites need to be tested and monitored to see if the boundaries and buffer are sufficient impact deterrents. By using a formula or other means to create site specific avoidance buffers such as arbitrary buffers, fences or guards, archaeologists can help preserve the integrity of archaeological sites, thereby increasing the possibility that those sites survive to enrich future generations.

8. Appendices (CD)

Monitoring photos have been placed in their designated folders ie: Experiment Setup, Barley Fields Setup, Barley Fields Monitoring 1 etc. Note: photo identification of disturbance for each individual artefact has not been provided in these appendices, if required please contact me for a specific photo log. In addition for all recording sheets these can also be provided upon request.

a) Photographs (Disc 1 & Disc 2)
b) Raw Data (Disc 2)
c) Sample of recording sheets (Disc 2)
d) Letter to Merced Holdings (Disc 2)

9. Bibliography

AAV. (2007). *Aboriginal Heritage Act*. Melbourne: AAV.

Aboriginal Heritage Information Management System. (2013, 29 August 2013). 2014, from http://www.environment.nsw.gov.au/licences/AboriginalHeritageInformationManagementSystem.htm

ABS. (2013, January 2013). Australia's Climate Retrieved 5th of June, 2013, from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1301.0~2012~Main%20Features~Australia's%20climate~143

Ammerman, A. J. (1985). Plow-Zone Experimens in Calabria, Italy. *Journal of Field Archaeology, 12*(1), 33-40.

Andrews, G. B., J. Lewis, J. (2000). Interpretation not record: the practice of archaeology *Antiquity, 74*, 525-530.

Baird. (2004). *Archaeological Damage from Offshore Dredging: Recommendations for Pre-Operational Surveys and Mitigation During Dredging to Avoid Impacts*. U.S. Department of the Interior Minerals Management Service

Beck, W. (2006). Aboriginal Archaeology. In A. Atkinson, J. S. Ryan, I. Davidson & A. Piper (Eds.), *High Lean Country: Land, people and memory in New England* (pp. 88-97). Crows Nest: Allen & Unwin Pty Ltd.

Beck, W., Haworth, R., & Appleton, J. (2015). Aboriginal resources change through time in New England upland wetlands,. *Archaeology in Oceania, 50*, 47-57. doi: DOI: 10.1002/arco.504

Bell, D. H., JT. & Haworth, RJ. . (2008). Montane lakes (Lagoons) of the New England Tablelands Bioregion. *Cunninghamia, 10*(3), 475-492.

Bell, M. (2011). Clean energy jobs in Regional NSW: A roadmap for the New England Tablelands (pp. 39).

Blackmore, S. (2015). *CSIRO Ginninderra Site Stage 2, Heritage Management Plan*. ERM Pty Ltd.

Blomfield, G. (1981). *Baal Belbora, the end of the dancing: the agony of the British invasion of the ancient people of Three Rivers, the Hastings, the Manning and the Macleay, in New South Wales*. Michigan: University of Michigan

BoM. (2013). Daily Weather Observations for Armidale, New South Wales 2013 Retrieved 19th of May, 2013, from http://www.bom.gov.au/climate/dwo/201305/html/IDCJDW2004.201305.shtml

Bowdler, S. (1981). Hunters in the Highlands: Aboriginal adaptations in the eastern Australian Uplands. *Archaeology in Oceania, 16*, 99-111.

Brunn, H., Harris, J. W. K., Isaac, G., Kaufulu, Z., Kroll, E., Schick, K., . . . & Behrensmeyer, A. K. (1980). An Early Pleistocene site in Northern Kenya. *World Archaeology, 12*, 109-136.

Burke, H., & Smith, C. (2004). *The Archaeologist's Field Handbook*. Crows Nest: Allen & Unwin.

Burr, P. (2013). Snow in Armidale NSW Retrieved 18th of May 2013, from http://weatherarmidale.com/snow.html

Butzer, K. W., & Helgren, D. M. (2005). Livestock, Land Cover, and Environmental History: The Tablelands of New South Wales, Australia 1820-1920. *Annals of the Association of American Geographers 95*(1), 80-111.

Cameron, D., White, P., Lampert, R., & Florek, S. (1990). Blowing in the Wind. Site Destruction and Site Creation at Hawker Lagoon, South Australia. *Australian Archaeology, 30*.

Catling, C. (2009). *Archaeology Step-by-Step: A practical guide to uncovering the past*. London: Anness Publishing Ltd.

Comber, J., & Smith, J. (2010). Aboriginal Cultural Heritage Assessment. Lake Illawarra Shared Cycleway (Shareway) (L. I. Authority, Trans.) (pp. 91). Croydon.

Cosgrove, R. (1989). Thirty Thousand Years of Human Colonization in Tasmania: New Pleistocene Dates. *Science, New Series, 243*(4899), 1706-1708.

Crow, P. (2004). *Trees and Forestry on Archaeological sites in the UK: A review Document* United Kingdom: Forest Research an agency of the Forestry Commision.

Davidson, I. (1982). Archaeology on the New England Tablelands: a preliminary report. *Armidale and District Historical Journal 25*, 43-56.

DECCW. (2010a). *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. NSW: National Parks and Wildlife Service.

DECCW. (2010b). *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales*. Sydney: Department of Environment, Climate Change and Water, NSW.

Dincauze, D. F. (2000). *Environmental Archaeology* Cambridge: Cambridge University Press.

DPI. (2012). *New England North West Strategic Regional Land Use Plan* NSW: NSW State Government.

. E-Trac Instruction Manual. (2008) (Vol. 4901-0065). Adelaide, SA, Australia: Minelab Electronics Pty Ltd.

Efremov, I. A. (1940). Taphonomy: new branch of paleontology. *Pan-American Geologist, 74*(2), 81-93.

El-Baz, F., Robinson, Cordula A. & Al-Saud, Turki S.M. (2007). Radar Images and Geoarchaeology of the Eastern Sahara. In J. E.-B. Wiseman, Farouk. (Ed.), *Remote Sensing in Archaeology* (pp. 47-69). Boston: Springer Science & Business Media LLC.

Engeman, R. M. C., Kathy J. & Felix, Rodney K Jr. & Avery, Michael L. . (2013). Feral swine disturbane at important archaeological sites. *Environmental Science Poluution Resources, 20*, 4093-4098.

Fanning, P. C., & Holdaway, S. J. (2002-2004). Artifact Visibility at Open Sites in Western New South Wales, Australia. *Journal of Field Archaeology, 29*(3/4), 255-271.

Field, J. H. (2006). Trampling through the Pleistocene: Does Taphonomy Matter at Cuddie Springs? *Australian Archaeology, 63*(December 2006).

Godwin, L. (1985). Archaeological Site Surveys on the Eastern Margin of the New England Tablelands. *Australian Archaeology, 17*(38), 38-47.

Godwin, L. (1990). *Inside Information Settlement and Alliance in the Late Holocene Northeastern NSW.* (Arts Ph.D.), University of New England.

Godwin, L. (1997). Little Big Men: alliance and schism in north-eastern NSW, during the late Holocene. In P. E. McConvell, N (Ed.), *Archaeology and Linguistics* (pp. 297-309). Oxford: Oxford University Press.

Haworth, R. (2013). [Geomorphology in New England Tablelands. Personal Communciation.].

Hewitt, G., & Allen, J. (2010). Site Disturbance and Archaeological Integrity: The Case of Bend Road, an Open Site in Melbourne Spanning Pre-LGM Pleistocene to Late Holocene Periods. *Australian Archaeology, 70*(June), 1-16.

Hiscock, P. (1985). The Need for a Taphonomic Perspective in Stone Artefact Analysis. *Anthropology and Sociology, University of Queensland*.

Holdaway, S., & Stern, N. (2004). *A Record in Stone: The study of Australia's Flaked Stone Artefacts*. Melbourne and Canberra: Museum Victroia and AIATSIS.

Huggett, J. (2015). *Preservation by record*. Word Press. Retrieved from https://introspectivedigitalarchaeology.wordpress.com/2015/05/25/preservation-by-record/

Isaac, G. (1977). Olorgesalle. *University of Chicago Press*.

Jeske, R. J. K., Lawrence A. . (2001). Canine Digging Behaviour and Archaeological Implications. *Journal of Field Archaeology, 28*(3/4), 383-394.

Johnson, D. L. (2009). *The Geology of Australia* Cambridge: Cambridge University Press.

Jones, e. a. (2007). *Caring for New Zealand Archaeological Sites*. Wellington, NZ: Science & Technical Publishing.

Jordan, M. (2006). Aborigines and Citizens. In J. S. R. A. Atkinson, I. Davidson and A. Piper (Ed.), *High Lean Country: Land, people and memory in New England* (pp. 122-134). Crows Nest: Allen & Unwin Pty Ltd.

Leonardt, S., Sheinshon, V., Florencia, R., & Tchilingurian, P. (2015). The memory of the landscape: Surface archaeological distributions in the Genoa Valley (Argentinean Patagonia). *Quaternary International, XXX*, 1-14. doi: http://dx.doi.org/10.1016/j.quaint.2015.11.131

Ling, D. L. (2015). Introduction to Statistics Using LibreOffice.org Calc Apache OpenOffice.org Calc and Gnumeric 5.3. from http://www.comfsm.fm/~dleeling/statistics/text5.html

Lyman, R. L. (2010). What Taphonomy Is, What it Isn't, and Why Taphonomists Should Care about the Difference. *Journal of Taphonomy 8*(1), 16.

May, J. (2012). *Gunnedah 132kV Transmission Line Archaeological Constraints Repot*. Archaeological ERM Pty Ltd.

McBryde, I. (1966). *An Archaeological survey of the New England region, New South Wales*. PhD Thesis. University of New England Armidale.

McBryde, I. (1974). *Aboriginal Prehistory in New England: An Archaeological Survey Northeastern New South Wales*. Sydney: Sydney University Press.

McFadgen, B., & Goff, J. (2003). *Earthquake uplift and erosion of archaeological site L26/1 at the mouth of the Heaphy River*. Wellington, New Zealand: DOC Science Publishing.

Midgley, E., Spennemann, D. H. R., & Johnston, H. (1998). The impact of visitors on Aboriginal sites in Mungo National Park. *Archaeology in Oceania, 33*, 221-231.

Milner, N. (2012). Destructive events and the impact of climate change on Stone Age coastal archaeology in North West Europe: past, present and future. *J Coast Conservation, 16*, 223-231.

Mulvaney, J., & Kamminga, J. (1999). *Prehistory of Australia*. Crows Nest: Allen & Unwin Pty Ltd.

Nugent, V. (2012). Quakes rock Armidale Retrieved 19th of July, 2013, from http://www.armidaleexpress.com.au/story/179993/quakes-rock-armidale/

Odell, G. H., & Cowan, F. (1987). Estimating Tillage Effects on Artifact Distribution. *American Antiquity, 52*(3).

OEH. (2011). New England Tableland Bioregion Retrieved 15th of May 2013, 2013, from http://www.environment.nsw.gov.au/bioregions/NewEnglandTablelandBioregion.htm

Ollier, C. D. (1982). Geomorphology and Tectonics of the Armidale Region. [eds Flood and Runnegar, B.]. *In New England geology*, 141-147.

Pargeter, J. (2011). Assessing the Macrofracture method for identifying Stone Age hunting weaponry. *Journal of Archaeological Science, 38*, 2882-2888.

Potts, A. (1970). Frost Action in Rocks: Some Experimental Data. *Transactions of the Institute of British Geographers, 49*(March), 109-124.

Rick, J. W. (1976). Downslope Movement and Archaeological Intrasite Spatial Analysis. *American Antiquity, 41*(2), 133-144.

Ridges, M. (2006). Regional Dynamics of Hunting and Gathering: An Australian Case Study Using Archaeological Predictive Modeling. In M. W. W. Mehrer, Konnie, L. (Ed.), *GIS and Archaeological Site Location Modelling* (pp. 123-143). Boca Raton: CRC Press Taylor & Franics Group.

Roberts, D. A. (2006). The Frontier. In A. Atkinson, J. S. Ryan, I. Davidson & A. Piper (Eds.), *High Lean Country: Land, people and memory in New England.* (pp. 98-110). Crows Nest: Allen & Unwin Pty Ltd.

Robins, R. R., Andrew. (2011). The antics of ants: ants as agents of bioturbation in a midden deposit in South-east Queensland. *Environmental Archaeology, 16*(2), 149-160.

Sampson, M. P. (2007, June 2007). Effects of Off-Highway Vehicles on Archaeological Sites in Red Rock Canyon Retrieved 27 of June 2013, 2013, from http://www.parks.ca.gov/?page_id=24576

Schiffer, M. B., Sullivan, A. P., & Klinger, T. C. (1978). The Design of Archaeological Surveys. *World Archaeology 10*(1), 1-28.

Smith, B., & Ballard, B. (2011). Rabbits Retrieved 10th of May, 2013, from http://www.uralla.nsw.gov.au/index.cfm?page_id=1073

Specht, J. (1985). Crabs as Disturbance Factors in Tropical Archaeological Sites. *Australian Archaeology, 21*, 11-18.

Speight, J. G. (2009). *Australian Soil Handbook and Land Survey* (Third ed.). Collingwood: CSIRO Publishing

Stein, J. K. (1983). Earthworm activity: A source of potential disturbance of archaeological sediments. *American Antiquity, 48*(2), 277-289.

Stening, T. (2014). *Aboriginal Archaeological Assessment, Lot 400 Strathyre Drive, Prestons*. Comber Consultants Pty Ltd. Sydney.

Sullivan, S., & Mackay, R. (Eds.). (2012). *Archaeological Conservation and Management*. China: Getty Conservation Institute.

Sutton, S. (1988). Results of A Survey for Aboriginal Sites in the City of Armidale Armidale: University of New England

Triggs, B. (2004). *Tracks, Scats and Other Traces*. Sydney: Oxford University Press Australia.

Vezgoff, P. (2010). *Arborist Assessment Report Lot 1 DP 214702 Cater Street Coledale NSW 2515*. Austinmer: Consulting Arborist Moore Trees.

What is Slag? (2006). Retrieved 01.10.2013, 2013, from http://www.asms.com.au/asms/common/what-is-slag.html

Wood, W. R., & Johnson, D. L. (1978). Disturbance processes in site formation. . *Advances in Archaeological Method and Theory, 1*, 315-381.