Rebecca_Macroberts_323820_Rebecca MacRoberts Dissertation.pdf

by Rebecca Macroberts

Title: A study of inter-analyst variability in the classification of stone-walled structures in southern Gauteng, South Africa.

Name: Rebecca MacRoberts

323820

Faculty: Science

School: Geography, Archaeology and Environmental Studies (GAES)

Division: Archaeology

Supervisor: Prof. Karim Sadr

Date: 19 October 2012

Abstract

The study of stone-walled structures from within the last 1000 years in southern Africa can help archaeologists to understand how the landscape was peopled. The size, spatial distribution and patterns can be representative of societal changes through time and space, so classifying these structures can be very beneficial to the research process. Google Earth and Geographic Information System (GIS) programmes can make the data capture process easier and more efficient, but when a number of different analysts are involved, there can be significant variability in their results. By comparing the classification data obtained by three analysts in the area "Joe 2" in southern Gauteng, it was possible to quantify the inter-analyst variability and also find out where and why it occurred. The quality of Google Earth imagery noticeably influenced how the analysts outlined and classified the stone-walled structures. This, along with the subjective decisions of the three analysts when it came to interpreting and classifying the structures, resulted in significantly high levels of inter-analyst variability. With more intensive training and better use of the resources available, inter-analyst variability can be drastically reduced so that research results and their subsequent interpretation are more reliable. As the problem faced by all fields of archaeology, it deserves better insight and understanding than is currently available.

Table of Contents

List of Figures and tables

Acknowledgements

Firstly, I would like to thank my supervisor, Prof. Karim Sadr for his help, support and constant positive attitude that made doing the work for this project much more enjoyable. I would also like to thank the two anonymous analysts, because without their time and effort this research would not have been possible. To my family members who helped to proofread, their assistance was invaluable and is greatly appreciated. Lastly, I would like to thank my classmates and friends, who kept me smiling and laughing through the continuous stress and panic that was my honours year..

Chapter 1: Introduction

A significant benchmark in African archaeology is the spread of the first farming communities southwards into sub-Saharan Africa. These people were quite different to the Stone Age groups they replaced in the sense that populations were larger and brought with them the skills to build large stone-walled villages, to mine metal, to make weapons and tools, to create pottery and produce food (Mason, 1962: 373). In many respects, the life ways of these communities are quite close to our own and certainly more familiar than anything in the Stone Age. For this reason, the early African farming communities make an interesting area of study for archaeologists in the continual struggle to understand what 'modernity' is and how it came to be.

Fortunately, there exists much more evidence of everyday life in the archaeological record for early farming communities than for any preceding phase of sub-Saharan prehistory. One such example is the remnants of stone-walled structures which vary in complexity from small, isolated circles to the impressive structure at Great Zimbabwe. The distribution of different stone-walled structures in their various sizes and patterns can provide useful information on the nature of their occupants in terms of the political and social organization of the inhabitants. The form of settlement units is largely dependent on kinship and social structure (Maggs, 1976) so it has been very beneficial to the field of archaeology to study them.

The first use of aerial photographs to study Iron Age sites took place at Mapungubwe and Zimbabwe in the 1930s, with later research conducted further south in the 1960s (Maggs, 1976). These studies will be discussed in detail later on in the literature review section. Aerial photography has been useful in the past for identifying large numbers of sites and their typological classifications, but with the constant improvement of technology come more efficient and accurate methods of conducting research. Stone-walled structures from the last Millennium in the southern part of Gauteng Province, South Africa have been the subject of research that makes use of technology such as Google Earth and Geographic Information System (GIS) software to plot, measure and compare the sites.

A number of studies have been done involving the classification of stone-walled structures. If this research is conducted by different researchers, then it is somewhat likely that variation in the results will occur. The inter-analyst variability may have consequences for the eventual conclusions drawn in areas such as average area, distance to nearest neighbour, elevation and number of each type of structure. For this reason, it becomes necessary to identify and quantify this variability. In measuring and comparing the statistics of the Stone-walled structures in a specific, predetermined area and comparing these results to those of two other studies of the same area, the inter-analyst variability can be evaluated. The statistical significance of the variation should reveal whether different analysts can capture data and classify it adequately, or if the variability is too great to be useful. In the latter case, it will be necessary to introduce mechanisms to dampen the effect of inter-analyst variability. Furthermore, it will be useful to create a better understanding of where and why inter-analyst variability may occur so that it may be minimized in future research. It must be noted that inter-analyst variability is not a problem unique to the study of stone-walled structures. In any archaeological field where the data capture and research in its various stages is to be conducted by a number of different researchers, it becomes necessary to measure the variability that occurs between analysts because of its potential impact on the study outcomes. This will be discussed at length in the literature review.

This study aims to understand the effect of inter-analyst variability on classifying stone-walled structures and on conclusions regarding settlement patterns of different types of stone-walled structures in southern Gauteng. This will be done by comparing three sets of data, classified by three separate analysts and measuring the significance of the variability that occurs in this data. This project has the potential to be part of a larger, on-going research topic on the inter-analyst variability occurring in classification in Iron Age archaeology, as well as any archaeological field where a number of analysts are involved in a single task with the likelihood of varying results.

1.2. Geographical Context

This study will be conducted in the area "Joe 2" which is found in southern Gauteng, spanning large areas of Vereeniging and Vanderbijlpark (Fig. 1.1). The southern Highveld region consists mainly of grassveld with some patches of bush and scrub-forest, summer rainfall and a relatively temperate climate (Vaal Triangle Info, 2012). These conditions are ideal for agriculture, but it seems that during the occupation of the early farming communities, wood was not available in sufficient quantities to be relied on for building and fuel (Maggs, 1976). This provides an explanation for the prevalence of stone-walling from within the last 1000 years on both sides of the Vaal River, across vast areas of Gauteng, the Free State and Mpumalanga. This intensive settlement and exploitation of the land provide plenty of research opportunities for archaeologists.

"Joe 2" covers an area of roughly 1700km² and contains somewhere between 80 and 140 stone-walled structures from within the last Millennium. The southeast corner of the polygon shares a border with the Vaal Dam, and its western edge is defined by the N1 highway. It extends southwards to the Vaal River and the northeast corner is bordered by the Suikerbosrand Provincial Nature Reserve. For the most part, this area is fairly flat as it is on the Highveld Plateau and elevation ranges from about 1500m to 1800m above sea level. The gentle slopes and small hills of the area were typically favoured for building stone-walled settlements within the last Millennium. This region has been of great interest to Iron Age archaeologists in the last 50 or so years, attracting researchers such as Mason (1968), Seddon (1968), Maggs (1976), Huffman (1986;2007) and Sadr and Rodier (2012) among others. Their particular interests in this area will be discussed at a later stage, in the literature review chapter.

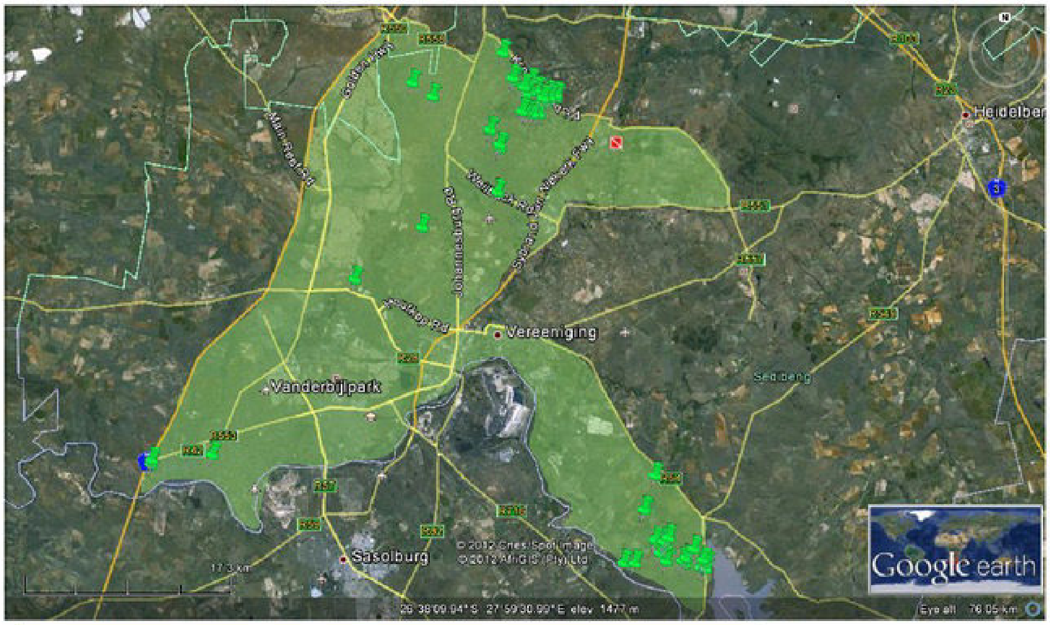

Figure 1.1. Map locating the study area "Joe 2" in southern Gauteng

1.3. Theoretical Basis

Bodies of data can never really be taken for granted without considering the factors and problems that occurred throughout the process to result in the end product. Archaeological data is used to lessen or eliminate gaps in knowledge, but it should always be used with caution. Binford (1977; 2001) argues that archaeologists need to carefully consider their subject matter or data before they can seek to understand the meaning behind it with bodies of knowledge from elsewhere. Binford's (1977) middle-range theory seeks to bridge the gap between high-order theory and lower range empirical data (Raab & Goodyear, 1984) which is important because the material elements of the latter are crucial to the ideas of the former. By ironing out the problems in data collection and usage, later inferences have a stronger and more accurate grounding (Kosso, 1991). Binford's (1977) middle-range theory is relevant in this study because the problems that occur in the data collection and measurement stage, i.e. the inter-analyst variability of stone-walled structure classification, are being analysed and quantified. The results intend to show whether or not the data capture and classification can be done adequately by different analysts, and just how significant the inter-analyst variability is. Thus, Binford's (1977) approach will provide guidance as to how these data problems can be measured and understood.

Chapter 2: Literature Review

The study of stone-walled structures in southern Gauteng has been a subject of great interest in South African archaeology. Different architectural types of stone-walled structures have been thought to be associated with different historically-recognised cultural groups. They have been researched with the intention of better understanding how the landscape had been peopled in prehistoric times (Huffman, 2007). Particular sizes and shapes of stone-walled structures have been linked to social, political and economic organization, usually involving a cattle-centred worldview and a dependency on agriculture and pastoralism (Maggs, 1976; Huffman, 1986; Hall, 1998; Boeyens, 2003). Morphological changes in these structures over time and space are understood to reflect social, political and economic changes, thus archaeologists are interested in classifying and studying them.

Linking the surviving material culture to the social groups who created and used it is a very difficult task for archaeologists, made more challenging by the limited archaeological material available. One approach, used recently by Boeyens (2003) is to use oral traditions to understand migration patterns and why people settled where they did. This is done by correlating stone-walled structures in certain areas to groups mentioned in oral traditions or written records, where available (Boeyens, 2003). The obvious problem with this approach is the unreliability of relatively recent oral records when applied to a much deeper time frame. A different angle taken by many archaeologists is to look at the physical shape of the structures themselves and how they change over time. By classifying stone-walled structures and comparing different types, it is possible to understand morphological changes over time and how they are driven by social circumstances.

Maggs (1976), Taylor (1979), Mason (1968) and Huffman (2007) all developed typologies for classifying stone-walled structures. Some, such as Huffman's (2007: 38) are a lot more culturally bound than others, assigning groups of people to structure patterns rather than grouping them just on shape. Taylor's (1979) typology was developed for stone-walled structures in the Vredefort Dome area, southwest of the study area in question. His system of classification is useful in this case because the range of variation in Joe 2 is similar to that in Taylor's (1979) study. It is worthwhile to use the labels because they do not assign origins or inhabitants to the various structure styles. Taylor's types are labelled Group I, Group II and Group III. Group 1 structures show some similarity to Maggs' Type N structures (1976) while Group II correlates somewhat with Maggs' Type Z and Huffman's Molokwane walling (2007: 38). Taylor's Group III structures are classified by Huffman (2007: 38) as the Klipsriviersberg Type. Mason (1968) developed a classification system for his aerial photography study in which sites were separated into five groups (Groups 1, 2, 3, 4a and 4b) although his criteria were slightly more particular than with the previously mentioned typologies. Mason later adjusted this typology (Mason, 1986) but the original version was still in use for the inter-analyst variability experiment he conducted (Mason, 1968).

During the 1960s and 1970s, the distribution of stone-walled structures across the eastern half of South Africa was measured and plotted through the use of aerial photography (Maggs, 1976; Mason, 1968; Seddon, 1968; Sadr & Rodier, 2012). Mason felt that the layout of settlements was a direct function of social organization (1968) and Seddon agreed that studying these spatial relationships would be useful in understanding prehistoric systems of communication (1968). Mason argued that in analysing settlements, there would be measurable variation in perceptual differences between the analysts (1968). Thus, he conducted a study with the help of six students in which the Iron Age settlement patterns from a large area of southern Gauteng were analysed via aerial photography. Mason noted that the workers were trained as a team but the site analysis was conducted on an individual basis (1968). The position and spatial relationship of the stone-walled structures was plotted while a ground excavation was simultaneously undertaken (Mason, 1968). This study was conducted because it was believed that the spatial relationship between the structures revealed important information about the activity that produced them, and the changes that could occur through time (Mason, 1968). Mason (1968) discovered that between the six workers who had analysed the structures, there was measurable variation in perceptual differences for all of them. While there was some degree of agreement, there was also obvious variation in the analysis of certain classes which, according to Mason (1968) could be mitigated with ground-truthing.

Seddon (1968) also studied the spatial relationships of stone-walled sites in order to better understand the systems of social interaction used by the original inhabitants through spatial layout, so that their lives may be archaeologically reconstructed. This study was done in the Olifantspoort Iron Age locality, through the use of aerial photography to locate and measure the settlements (Seddon, 1968). Each photograph covered roughly $9km^2$ and Seddon concluded that a possible 60-75% of structures could be picked up by aerial photographs, the reason being that most of them were concentrated on slopes, ridges and hilltops rather than flat plains or valleys (Seddon, 1968).

Fortunately, more recent technological advances have produced useful tools such as satellite imaging, Google Earth (GE) and Geographic Information Systems (GIS). These tools significantly reduce the margins of error in accuracy and resolution by making data clearer and more advanced, consequently making the data-capture process much more efficient and refined (Sadr & Rodier, 2012). Thus, it is possible to revisit survey areas and obtain more accurate data using new methods. MacQuilkan and Sadr (2010) conducted a comparative study of stone-walled structures using aerial photography, Google Earth and ground-truthing in order to ascertain how best to survey the sites. Google Earth had the benefit of historical imagery, in which different seasons and timeframes of the same area could be seen at the click of a button, whereas aerial photography may cover many decades but these images are not as easy to get hold of and are often only available in black and white (MacQuilkan & Sadr, 2010). The sites tended to show up better against dry grass with fewer trees, circumstances which are easier to find in Google Earth, using Historical Imagery to find the clearest image possible. This study showed that about 78% of the walls of the structures were visible in Google Earth, compared to 75% using aerial photography, so the newer technology proved its worth when it came to accuracy and availability (MacQuilkan & Sadr, 2010). Ground-truthing was used to verify the walls of stone-walled structures in this study and, as Mason (1968) acknowledged, ground surveys will yield different results to aerial ones but are not always feasible.

Sadr & Rodier (2012) have used the new technology to conduct research on the settlement patterns of the stone-walled structures in the Suikerbosrand Nature Reserve, southern Gauteng. In using Google Earth and GIS software, a higher quality of research can be achieved due to better resources and more complex analysis capabilities. Sadr and Rodier's (2012) sites were classified using Taylor's (1979) typology and subsequently the distribution of stone-walled structures in each group were measured in detail and compared to each other (Sadr & Rodier, 2012). This was done in order to better understand how changes in settlement patterns can reflect social, political and economic factors. The conclusions drawn, as with all research, rely quite heavily on the integrity and accuracy of the data when it is used for interpretation. For this reason, the role of analysts needs to be considered in a way that it has not been before.

The process of classifying archaeological data came under scrutiny by Sampson (1986) in the context of classifying Stone Age technology in southern Africa. He argued that typologies are the driving force behind the building of interpretive frameworks, and thus their use should be questioned. Sampson stated that "The need for calibration of analysts . . . should alert us to the slightly personal and subjective nature of typologies based on intuitive classification" (Sampson, 1986: 253). In line with this, Sadr and Rodier (2012) mention that archaeological typologies are often defined by norms and central tendencies rather than clear boundaries, which widens the margin of error when it comes to classifying data. This is crucial when one considers that the classification itself relies on the subjective decisions of the individual.

Inter-analyst variability has been considered in an archaeological context in diverse areas such as faunal remains studies (Abe *et al*, 2002) and the collection of metric data of materials such as tools, pots, beads etc. (Lyman & Van Pool, 2009). Abe *et al*. (2002) found that different analysts do not measure in the same way and prioritize or represent data in different ways, which is potentially a problem in all forms of archaeological analysis. Lyman and Van Pool (2009) found that both intra-analyst and inter-analyst variability were problematic and as such, typologies are often subject to observer fallibility. Wang (1990) and Iiames & Congalton (2006) have done research on the role of inter-analyst variability in remote sensing image classification, specifically on Landsat imaging. These studies were concerned with the classification of training sites, and the geographic consequences of training site variability. Errors or variation in the classification of certain features of Landsat images will influence how the remote sensing software recognises the features, and thus the end result can vary greatly (Wang, 1990; Iiames & Congalton, 2006). In these instances, variability has been identified and dealt with in different ways. Wang (1990) developed a problem-specific method of dealing with fuzzy or problematic data which involves improving the geographic representation of data and better estimation of classification perimeters. This method resulted in higher overall classification accuracy and a more positive outcome (Wang, 1990). Iiames and Congalton (2006) used a reference data set to measure the accuracy of their six analysts, as well as comparing the analysts' classification to each other and a percentage of agreement was used to measure variability. The researchers found noticeable inter-analyst variability that correlated with the scale of the image, the data itself had an impact but variability was also partially attributed to the limited experience of the analysts (Iiames & Congalton, 2006). This kind of research can provide valuable insight into how stone-walled structures are classified and studied.

If the stone-walled structures are classified by different analysts, then it stands to reason that a certain level of variation will occur in the results, both of the earlier aerial photography studies and later Google Earth and GIS projects. The accuracy issues of earlier research, including resolution quality, colour, manipulation of scale and manipulation of time frame, have been somewhat mitigated by more advanced technology in the past ten or so years. However, the problems of inter-analyst variability still need to be looked at in order to understand where and how they occur, as well as their eventual bearing on research conclusions. If the variability is significant, it could affect the results to the extent that conclusions become inadequate or invalid. This is a significant problem which extends to all fields of archaeology due to their reliance on classification systems, thus it urgently needs to be addressed by archaeologists.

Chapter 3: Method

This project began by using Google Earth to look at the specific area "Joe 2" in the Southern Gauteng region, South Africa, known to have a relatively high number of stone-walled structures (SWS). The SWS were outlined following the perimeter walls. Subsequently, the 100+ SWS were classified according to the existing typologies used by Mike Taylor (1979) and Sadr & Rodier (2012). Following this, the data was then imported into GIS and the software was used to measure specific dimensions of the sites in each SWS group in terms of size, number and spatial layout. The specific details of how this was done will be presented later on in the "Technique" section.

Once all of this data had been gathered, the data of two other studies of the same area was looked at. These studies were from the same area in which the data was obtained and compiled by two others, and the results were compared within the categories of area, number, elevation and distance to the nearest neighbour of the same type. These results were compared numerically using statistics and the variation was quantified to obtain a significance value of the variation between the results of this project and the results of the other studies. The sites of the three analysts were also compared visually in Google Earth to compare where and potentially how variability might occur in the classification stage.

The limitations on this project are that predetermined criteria exists only for three groups of SWS, not for sites that analysts feel should be classified outside these categories. Also, I did not perform all of the detailed statistics on my own without the help of outside sources as I do not have a statistics background. I used the advice of an expert to determine which statistical processes to run, as well as online statistics programmes to obtain the information I required, and then I ran the stats. In addition, the classification of the SWS was restricted to the predetermined geographical area "Joe 2" and the results reflected will only be valid from within this area. Finally, only the data from three analysts was used, so until further research in this field has been conducted, it is impossible to say whether variability would be reflected differently if a larger sample size of data is used.

3.1. Classification

Mike Taylor's (1979) typology, developed for stone-walled structures in the Vredefort Dome area was also used for this study. The common, most recognised types were Group I, Group II and Group III. Group I sites are usually the least complex in nature (Fig. 3.1), typically consisting of clear circular or oval outer walling with one or more smaller inner enclosures (Taylor, 1979). Group II structures (Fig.3.2) are quite different, consisting of a series of inward-facing c-shaped or scalloped walls which make up the outer perimeter and a centred group of inner enclosures (Taylor, 1979). In Group III structures (Fig. 3.3), the outer wall does not stand out clearly from the complex, interweaving inner walls. The perimeter wall is made up of curved and scalloped sections and the inner enclosures are not necessarily centred (Taylor, 1979; Sadr & Rodier, 2012). At the analysts' discretion, it was also possible to create a Group IV category as Sadr and Rodier (2012) did, or even an Unknown category for sites that did not seem to fit into the existing typology.

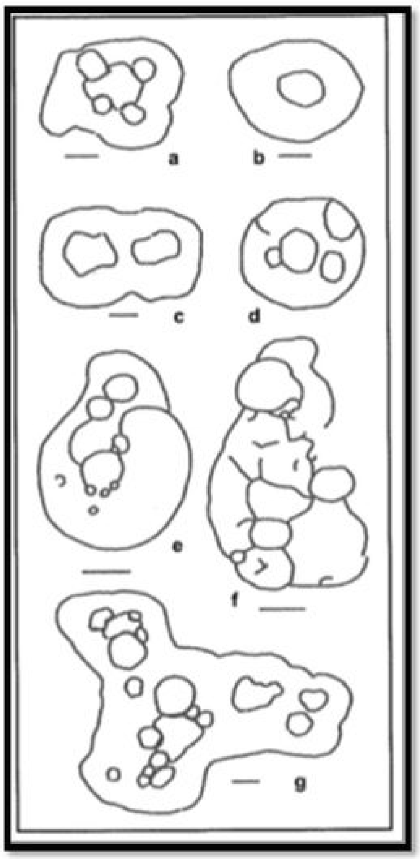

Figure 3.1. Group I Structures. Scale bars represent 20m. Diagram from Sadr & Rodier (2012)

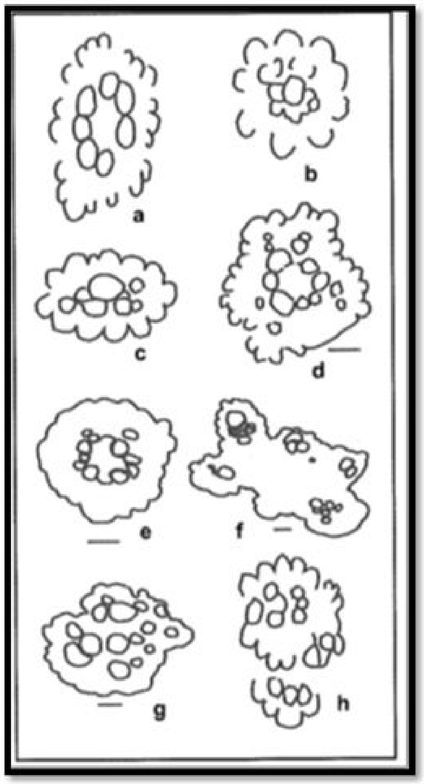

Figure 3.2. Group II structures. Scale bars represent 20m. Diagram from Sadr & Rodier (2012)

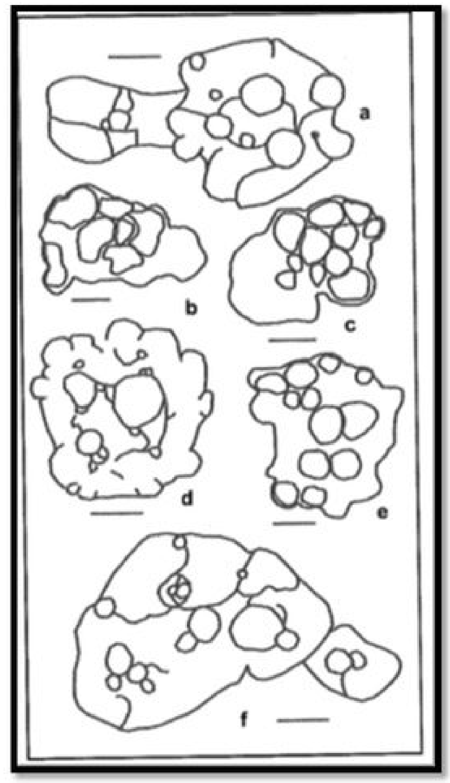

Figure 3.3. Group III structures. Scale bars represent 20m. Diagram from Sadr & Rodier (2012).

3.2. Technique

Within the study region "Joe 2", stone-walled structures had already been flagged in Google Earth (Version 6.2). Before classification, however, it was necessary to do a cursory sweep of the area to check for structures which may have been overlooked or unclear. An estimated 100 stone-walled structures are present in "Joe 2". For each of these, polygons were demarcated over the outer enclosing walls of the structures. To make later analysis more clear, I made the polygons of each type a different colour: yellow for Group 1, red for Group 2 and blue for Group 3. A placemark was dropped on each site, necessary for later spatial analysis, and these placemarks were also grouped and colour coordinated. The Google Earth

“Historical Imagery” feature was used to look through different time frames and seasons in order to find the clearest image of each structure. This is important because the vegetation can play a significant role in how the sites appear on Google Earth. For instance, SWS will show up more clearly in a dry season when the ground is brown in colour or burnt, but in summer they may be difficult to identify as they are overwhelmed by the surrounding green vegetation. Using ‘Historical Imagery allows the analysts to observe each site over a range of different seasons and years and ideally use the best image to classify the site. The structures were divided into Groups I, II, III and IV according to their overall appearance and how they fit into Taylor (1979) and Sadr & Rodier’s (2012) typology. Additional classes were created by each analyst if it was deemed necessary.

The polygons were then imported into Quantum GIS 1.7.4, the Wroclaw Geographic Information Systems software. Here they were converted into ESRI shapefiles and projected correctly using UTM 35S so that they could be analysed. They were measured, using software features such as ‘Analysis Tools’ and ‘Data Management Tools’, in terms of the following categories: the number of each type, the average area of each type, average altitude and the average distance to neighbouring sites of the same type. For this last category, additional plugins including the ‘Point Sampling Tool’ were used. Once all of this information had been gathered, the data from two other studies from within the same area was measured in the same way and looked at. The values from all of the above-mentioned categories were compared numerically using standard descriptive and comparative statistic. This provides a quantitative value of the inter-analyst variability. Additionally, the structures, as classified by the three analysts, were overlaid and compared visually in Google Earth. This was done to better understand the how and why behind any inter-analyst variability that may occur.

The versions of software for Google Earth and Quantum GIS may be influential on the data capture process as much as the decisions of the analysts themselves. Image quality, image angle, resolution and programme tools update and change over time. This could account for some of the variability and needs to be taken into consideration throughout the entire process. Wang (1990) and Iiames & Congalton (2006) have done studies on the variation that can occur in remote sensing classification processes, and it would appear that sometimes bad or "fuzzy" data simply cannot be avoided. This data has the potential to falsify training sites in the classification of Landsat imagery and alter results, so similar problems may occur in Google Earth and GIS data. Bad image quality can result in classification errors or discrepancies, regardless of who is doing the classifying. Because of this, not all difference in results can be attributed to inter-analyst variability, but in fact other kinds of variability need to be taken into account. In spite of this, even in the case of bad data the analyst may have to make a subjective decision on how a structure should be classified, whether or not it fits into existing categories or perhaps to disregard it altogether. Thus a significant portion of discrepancies in the end results could be accounted for by inter-analyst variability.

It is expected that some level of inter-analyst variability will be found in this kind of study. Indeed, it would be strange if all sites end up being classified in exactly the same way. The question is then directed towards how much variability is acceptable, and at what level will it adversely affect the results and subsequent conclusions? For the purpose of this study, more than 10% variability in the measured categories will be considered significant. As such, significant variability needs to be addressed and mitigated where possible because of its potential to corrupt data and the interpretation thereof.

Chapter 4: Results

4.1. Calculated Results

4.1.1. Number of Structures.

First and foremost, it must be noted that the same number of structures were not identified by all three analysts. The analysts were given the same original shapefiles which showed the extent of "Joe 2" and 53 placemarks which flagged the location of individual or groups of structures. These original placemarks are the green pins in Fig. 1.1. It was found that, in total, 94 stone-walled structures were identified by the analyst 'R' while the analyst 'M' identified 118 structures and 'A' identified 111. The distribution of these structures across classification groups is demonstrated by Fig. 4.1. By averaging out these figures, it can be assumed that there are roughly 107 stone-walled structures in "Joe 2". Since one of the analysts obtained a structure count that differed from the average by more than 10%, it is already clear that the inter-analyst variability is having an impact. It is immediately apparent that for all three analysts, the largest proportion of stone-walled structures was classified as Group I, with a total of 46 structures identified by 'R', 63 structures identified by 'M' and 57 structures identified by 'A'. However, there is much inconsistency in every other category (Fig. 4.1). 'R' identified 20 Group II structures in "Joe 2" while 'M' classified five structures as Group II and 'A' only had one Group II structure.

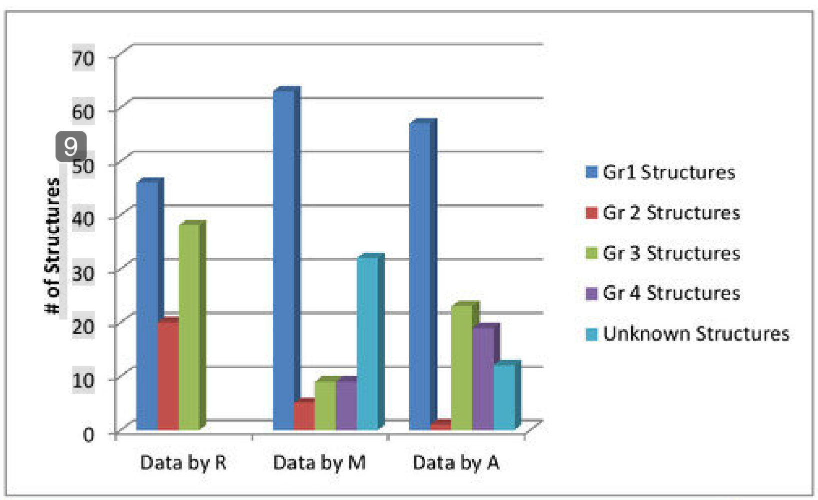

Figure 4.1. Graph showing number of structures identified by each analyst.

In Group III, 'R' identified 38 stone-walled structures while 'M' had nine structures and 'A' had 23 structures.

Two out of the three analysts created additional categories above and beyond Taylors (1979) typology. While both of these analysts labelled their categories 'Group IV' and 'Unknown', the criteria for classifying structures in these groups would not have been the same. This will be addressed further in the Discussion chapter. 'M's Group IV contained a total of nine structures while 'A' classified 19 structures in this group. The Unknown Group contained the second highest proportion of structures for 'M' with a total of 32, while 'A' put 12 structures into this category. In general, the numbers of structures for most of the categories seem to correlate more closely between 'A' and 'M', the reasons for which will be explained in the Discussion section.

4.1.2. Area Data

The results of the area calculations for most of the groups of structures show some variation between the analysts. Of greatest interest are the mean area values for each type by each analyst, as minimum and maximum values can be adversely affected by structures which are abnormally large or small. CV in Tables 4.1. – 4.5. represents the statistical critical value, or the margin of error when multiplied by the standard deviation value. In Group I, 'M' had the largest mean area but also a maximum area that was at least four times larger than that of the other analysts, which would influence the mean. In Table 4.1, the mean area values of Group I by 'R' and 'A' are not dissimilar. Taking into account the figures from all three analysts, the mean area for a Group I structure can be estimated to be about 2024.2 m^2. As two of the analysts differ from this by much more than 10%, there is considerable variability in results.

Table 4.1.: Group I area data

	Group I by R	Group I by M	Group I by A
Mean area (m^2)	1569.5	2624.1	1878.9
Min area (m^2)	154.8	126.7	116.3
Max area (m^2)	5353.6	32784.2	8467.2
Std deviation	1114.2	4255.4	1464.5
CV	0.7	1.6	0.8

Group II shows even more variation in the area calculations of stone-walled structures by each analyst. 'A' had just one Group II structure, but it was at least six times larger than the average Group II structure by the other two analysts (Table 4.2). 'R' has the smallest Group II structures in terms of mean, minimum and maximum and overall, results are inconsistent. It is clear that the results obtained by the three analysts differ by much more than 10% so in this case, the inter-analyst variability is definitely significant.

Table 4.2: Group II area data

	Group II by R	Group II by M	Group II by A
Mean area (m^2)	2291.8	4248.6	27371.5
Min area (m^2)	893.5	1053	27371.5
Max area (m^2)	11313.5	12581.8	27371.5
Std deviation	2209.7	4280.6	0
CV	0.97	1	0

In Group III, there were noticeable similarities between the data of 'A' and 'R' (Table 4.3) with very close values for both the mean and maximum area. 'M', on the other hand, had much smaller Group III structures (Table 4.3) both for mean and maximum values. It should also be noted that 'M' had far fewer structures in this category than the other two analysts (Fig. 4.1). Averaging out the mean values of all three analysts gives an area of 4443.2 m^2 and although 'A' and 'R' are within 10% of each other, 'M's measurements are quite far off the average. Thus, Group III displays a significant level of inter-analyst variability.

Table 4.3: Group III area data

	Group III by R	Group III by M	Group III by A
Mean area (m^2)	5212.9	2539.7	5577
Min area (m^2)	1392.5	674.3	966.2
Max area (m^2)	24585.2	3888.3	33267
Std deviation	4163.4		6701
CV	0.8	0.4	1.2

The category Group IV, created by two of the three analysts, turned up much variation in area measurements too. The mean area of the structures in this category, as classified by

'M' is much larger than those classified by 'A' (Table 4.4). The minimum area for both analysts is very similar, but it is clear that overall, the two analysts had different ideas of what the size of Group IV structures should be. With a difference of nearly 50% between these two analysts for their mean area values, the variability that occurs in Group IV stone-walled structures is definitely significant.

Table 4.4: Group IV area data

	Group IV by M	Group IV by A
Mean area (m^2)	1272.3	651.4
Min area (m^2)	149.9	138.1
Max area (m^2)	3584.9	1790.9
Std deviation	1156.7	435.1
CV	0.9	0.7

The Unknown category was also created by two of the analysts, 'M' and 'A'. There is a very large difference in the maximum area in this group, with 'M's results more than five times higher than 'A's (Table 4.5). This could be the result of one or two abnormally large sites, but 'M's mean area is also noticeably higher than 'A's indicating larger stone-walled structures in general. The mean area for 'M's Unknown structures was nearly twice the size of those classified by 'A', so this category also displays significant levels of inter-analyst variability.

Table 4.5: Unknown area data

	Unknown by M	Unknown by A
Mean area (m^2)	2661.4	1421
Min area (m^2)	132.6	515.2
Max area (m^2)	28182.2	5565.8
Std deviation	5194.9	1390.7
CV	1.9	0.98

4.1.3. Nearest Neighbour Data

The statistical analysis of nearest neighbour was done to ascertain how close stone-walled structures of each type are to others of the same type. This aspect is relevant because spatial distribution is crucial to understanding stone-walled structures in terms of how they move and evolve over time. Thus, if errors are made through inter-analyst variability, or for any other reason, this will affect spatial distribution patterns and the interpretation thereof. The nearest neighbour index is used to determine whether units tend towards being clustered or more dispersed, calculated by dividing the observed mean distance between units by the expected distance. Expected distance is the average distance between neighbours in a hypothetical random distribution, when the number of units and total area covered is known (Clark & Evans, 1954). Therefore, if the nearest neighbour index is greater than one, then there is a trend towards dispersion but if it is less than one, the pattern exhibits clustering.

The Group I structures show the least variability and the low nearest neighbour indexes of all three analysts show that the units were tending towards being more densely clustered (Table 4.6). 'A' had the least observed mean distance and also the lowest nearest neighbour index, indicating that their Group Is tended to exist in fairly close proximity to one another. Although further apart, the values for 'M' and 'R' indicate that their Group I structures were also generally clustered. Group II stone-walled structures showed quite a different pattern among the three analysts. While 'R's Group II structures also showed consistent clustering, 'M's nearest neighbour index showed that Group II structures were very widely dispersed (Table 4.7). This is backed up by the fact that 'M' has an observed mean distance which is nearly six times greater than 'R' for the same category of structures. To make the variability even greater, the third analyst 'A' only identified one Group II structure, so there is no spatial relationship data.

Table 4.6: Group I nearest neighbour data

	Group I by R	Group I by M	Group I by A
# of structures	46	63	57
NN observed mean dist	1549.1	1346.3	941.6
NN expected mean dist	3374.1	3386.4	2944.5
Nearest neighbour index	0.46	0.4	0.3

Table 4.7: Group II nearest neighbour data

	Group II by R	Group II by M	Group II by A
# of structures	20	5	1
NN observed mean dist (m)	2006	11653.7	N/A
NN expected mean dist (m)	4814.9	6560.8	N/A
Nearest neighbour index	0.42	1.8	N/A

Clear differences between the analysts' data once again in Group III. The analysts 'R' and 'A' have nearest neighbour index values of 0.3 and 0.5 respectively, which are very close and are indicative of clustered structures (Table 4.8). The observed mean distance for these two analysts is very similar, but 'M's data reflected a very different outcome. With an observed mean distance 25 times greater than the other analysts, it is no surprise that the nearest neighbour index for 'M' is very high and means that Group III structures are very dispersed.

Table 4.8: Group III nearest neighbour data

	Group III by R	Group III by M	Group III by A
# of Structures	38	9	23
NN observed mean dist (m)	1066.9	45362	1818.2
NN expected mean dist (m)	3193.8	9351.4	4009.5
Nearest neighbour index	0.3	4.9	0.5

Group IV structures also show noticeable differences in spatial distribution. 'M's observed mean distance is very small but the nearest neighbour index shows that the structures may not be obviously clustered (Table 4.9). In contrast, 'A's observed mean distance is much greater but according to the nearest neighbour index, the stone-walled structures are more clustered. Lastly, the Unknown category results reflect that both of the analysts who created this group tended towards assigning the structures in clusters. They did, however, have very different results for the observed mean distance (Table 4.10) which seems to have been balance out by the number of stone-walled structures that they each had. 'A' had fewer structures and on average a larger distance between them, so the nearest neighbour index implies that they were clustered but not very densely. As for 'M', there were a lot more structures in this category and less space between them, so according to the nearest neighbour index the structures were quite densely clustered.

Table 4.9: Group IV nearest neighbour data

	Group IV by M	Group IV by A
# of structures	9	19
NN observed mean dist (m)	275.3	3731.5
NN expected mean dist (m)	264.7	5206
Nearest neighbour index	1	0.7

Table 4.10: Unknown nearest neighbour data

	Unknown by M	Unknown by A
# of structures	32	12
NN observed mean dist (m)	1414.9	4271.2
NN expected mean dist (m)	4469.2	6268.2
Nearest neighbour index	0.3	0.7

4.1.4. Elevation Data

The elevation data ranged between 1528m and 1573m above sea level. As Fig. 4.2 shows, there are no obvious patterns in elevation for any groups. With a range of just 50m, the data did not seem to reveal very clear variation in any of the categories for all of the analysts.

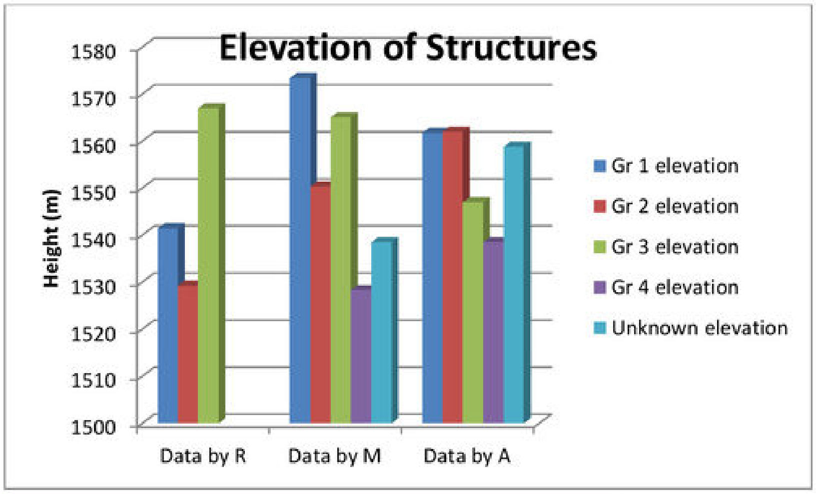

Figure 4.2. Average elevation of stone-walled structures

4.2. Visual Analysis Results

In order to better understand the calculated results given above, it became necessary to revisit the analysts' data in Google Earth. This was done essentially to see what they saw and to understand why they classified stone-walled structures the way that they did. The polygons from all three analysts, in all typological categories, were colour coded, made semi-transparent and overlaid so that patterns and differences in classification would stand out clearly. Table 4.11 indicates the colours assigned to each polygon class when they were compared in Google Earth, and should be used for the interpretation of Fig.4.3 - Fig.4.8.

Table 4.11: Colour code for visual analysis of polygons

SWS Group	Structures by R	Structures by M	Structures by A
Group 1	Yellow	White	Dark Blue
Group 2	Red	Lavender	Dark Brown
Group 3	Blue	Green	Red
Group 4	N/A	Brown	Dark Green
Unknown	N/A	Orange	Yellowish-orange

4.2.1. Areas of Overlap

The most noticeable similarities occurred in the classification of Group I structures. As has been noted earlier, Group I made up the highest proportion of structures for all three analysts (Fig. 4.1) but it is clear that there was also a high proportion of agreement on what a Group I structure looked like. Fig.4.3 illustrates an example of all three analysts classifying the same structure as a Group I. Using Table 4.11, it is clear that a single structure was assigned to Group I by all of the analysts, a circumstance that was not uncommon in Group I. In most cases where there was not unanimous agreement between the analysts, 'R' and 'A' would classify a structure as Group I while 'M' would assign it to the category of Unknown. One may notice that there is a clear vertical shift in the outlines of the polygons

(Fig. 4.3), as defined by the different analysts and the specific reasons for this shift will be discussed in detail at a later stage.

After Group I, Group III had the most noticeable agreement, an example of which is in Fig. 4.4. All three analysts have classified this stone-walled structure as Group III although their physical outlines of the polygons did not match up perfectly. As with Group I, Group III structures tended to be agreed upon most often by 'A' and 'R' while 'M' tended to classify the same stone-walled structures as either Group I or Unknown. The last area with very noticeable overlap is on stone-walled structures which were classified as Group II by 'R' and as Group IV or Unknown by 'A' and 'M' (Fig. 4.5). There was virtually no total agreement by all analysts for Group II structures and, interestingly enough, almost half of the 20 structures classified as Group II by 'R' were not classified at all by the other two analysts.

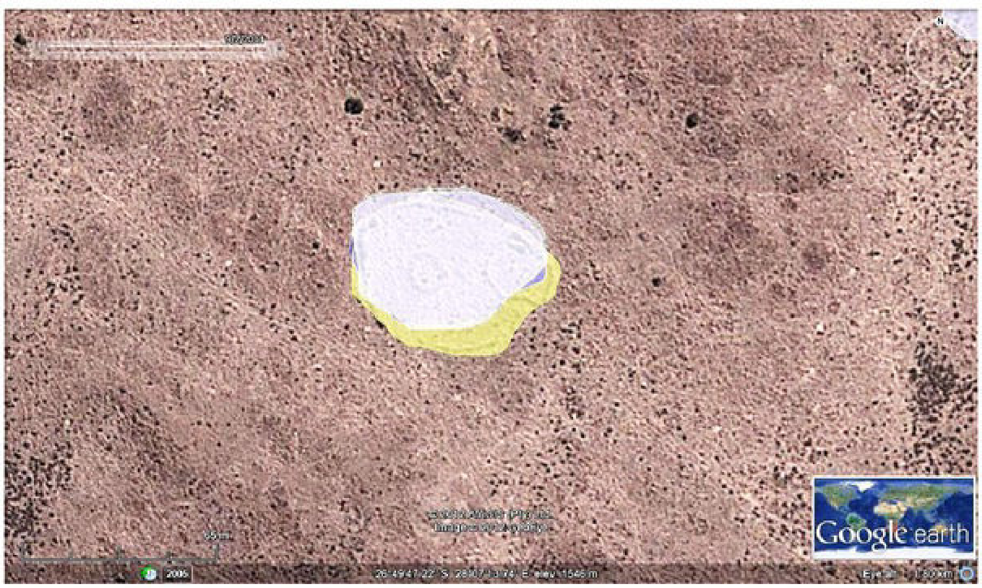

Figure 4.3. Group I agreement by all three analysts

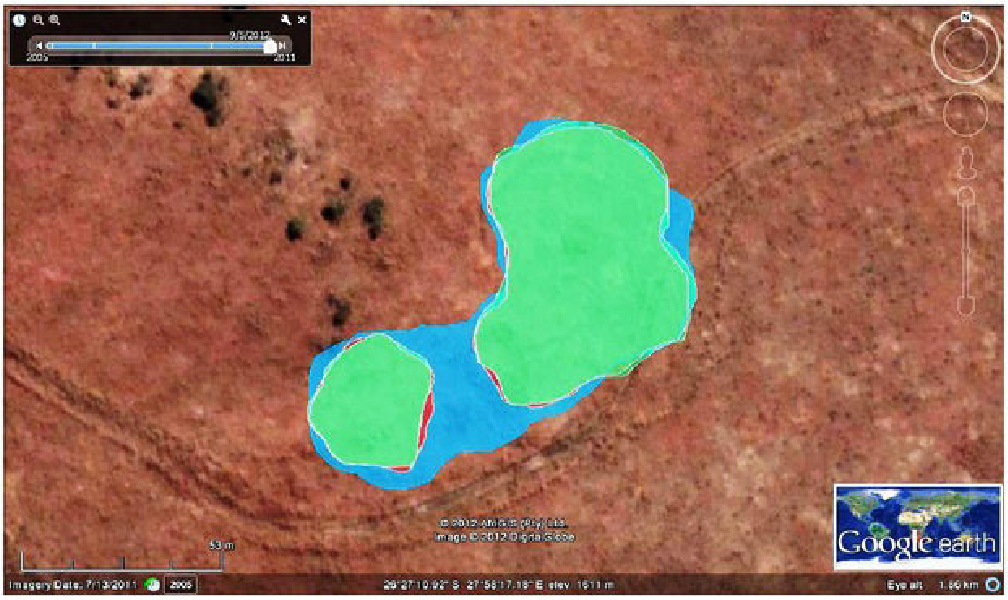

Figure 4.4. Group III agreement by all three analysts

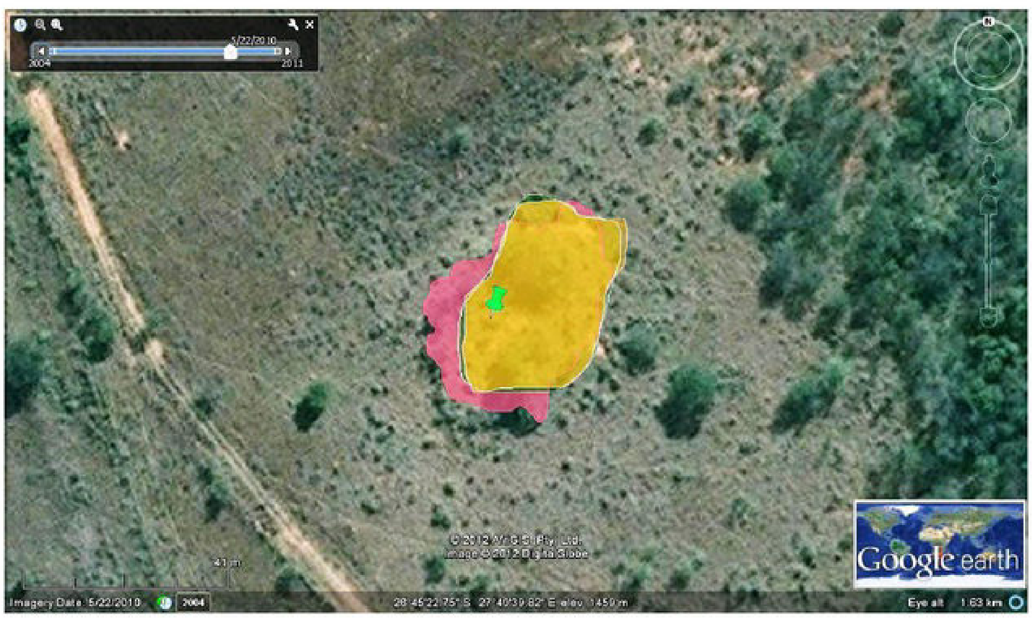

Figure 4.5. Group II/Unknown disagreement

4.2.2 Typological vs. Shape agreement

Another recurring pattern that was observed was that very often two out of three analysts agreed on the classification of the stone-walled structures and two out of three analysts agreed on the physical outline of the structures, but these two aspects did not necessarily correlate. 'A' and 'M' agreed on the physical outline of the polygon very closely in almost every case, but usually assigned the structures to different categories. 'A' and 'R', on the other hand, tended to assign structures to the same categories in spite of outlining the perimeters of the structures differently. This is demonstrated in the example of Fig. 4.6 where both 'R' and 'A' have classified the structure as Group III (Table 4.11) although their outlines of the stone-walled structure differ considerably. At the same time, 'A' and 'M' have nearly identical outlines but 'M' is the only analyst to classify this particular structure as Group I. This pattern was also observed in cases where two analysts determined structures to be Group I although their outlines did not match, while the third analyst would have an outline that matched one of the others and assign the structure to Group IV or Unknown.

A slight variation of this pattern occurred, albeit rarely, when all three analysts agreed on the typology of a structure but all outlined it very differently. An example of this is given in Fig. 4.7 where the three analysts have identified a stone-walled structure as belonging to Group I, yet all of their outlines are drastically different.

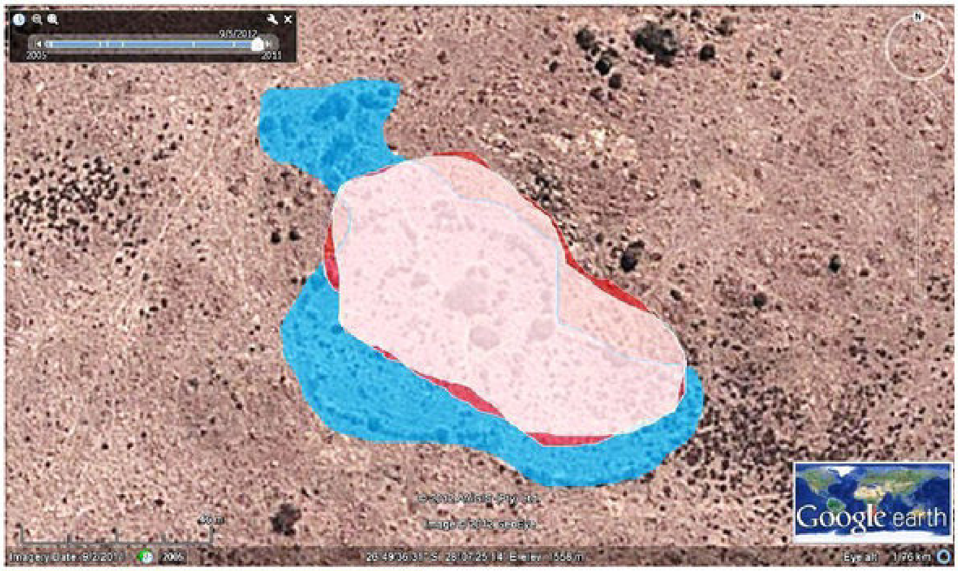

Figure 4.6. Typology vs. shape agreement

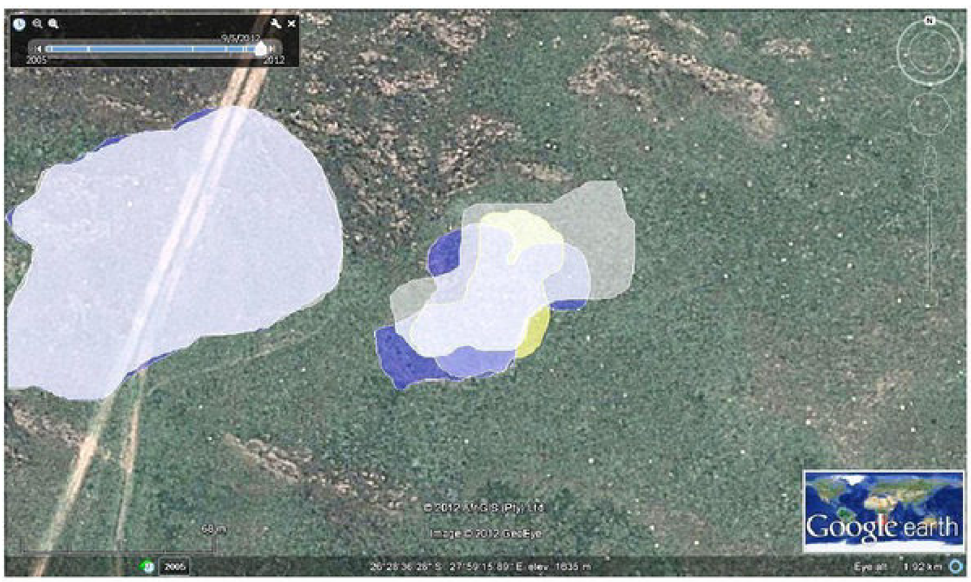

Figure 4.7. Typological agreement; shape disagreement

4.2.3 Single Large vs. Several Small structures

The last obvious pattern emerged in discrepancies of stone-walled structures being outlined as either a single (or a few) large structure(s) or many smaller structures in a cluster. This had a knock-on effect on how they were classified as a larger structure could be interpreted as more complex than a number of smaller, more simple structures. This was quite common in structures that were classified by one analyst as Group III but separated into a number of Group I structures by the other two analysts. Fig. 4.8 shows an example of such a circumstance where 'A' and 'M' identified three separate Group I structures but 'R' identified this same structure as a single Group III structure. This pattern also extended to stone-walled structures which had been classified the same way by all three analysts but the shape of the structure was either seen as a single larger unit or a cluster of smaller units of the same type. An example of one of these cases can be seen in Fig. 4.4 where all analysts classified the structures as Group III, but only one analyst incorporated all of the stone-walling into a single unit.

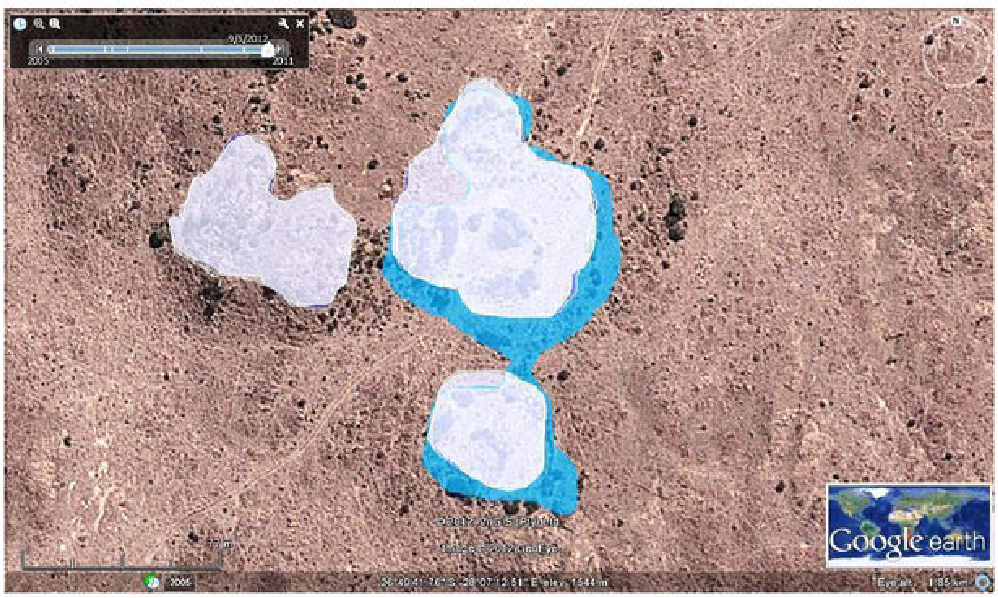

Figure 4.8. Single large unit or many smaller ones

In summary, the results reflect the presence of inter-analyst variability in all fields with the exception of elevation. Group I displays the least variability out of all the classified groups and similarities are present for area, spatial distribution and physical location of the structures among all three analysts. Group III calculated data shows similar patterns for the analysts 'A' and 'R' while 'M' tended to reflect quite different area and spatial relationship patterns. The visual data for Group III often showed very close correlation in the physical outlines of the structures for 'A' and 'M' but typologically, there was more agreement between 'A' and 'R'. An incredible amount of variability was found between the analysts in Group II in terms of number of structures, size and spatial distribution. This variability continued in the visual analysis where structures were often classified as both Group II and Group IV or Unknown by the different analysts. The created categories of Group IV and Unknown were only created by two out of the three analysts and these categories varied significantly in all fields of both the calculated and visual data. This variability will be explored in more detail in the following chapter. Possible reasons will be given to explain the variability and suggestions will be made on how it can be addressed.

Chapter 5: Discussion

The results given in Chapter 4 all lean towards indicating that inter-analyst is present in the classification of stone-walled structures. The next step is to figure out how and why these differences occur as well as what can be done to mitigate them. Because the variation differed between structure groups, they will be discussed here separately. Common themes will also be addressed in terms of what may have influenced the variability and suggestions will be made for how this can be lessened.

5.1. Group I Structures

Out of all the classification groups, Group I tended to have significantly less variability than the others. This category made up the highest proportion of structures for all of the analysts and even the individual counts for sites in this group were relatively similar. The consistency in Group I structures for all analysts seems to imply that this category was somehow clearer or easier to classify. Looking at the area data for Group I, there is definitely variability between the analysts although it is not at the extreme level of some of the other categories. On the whole, Group I stone-walled structures are quite small in comparison to the other types and this trend was common for all three analysts. In terms of spatial distribution, Group I structures were on average more clustered than those in the other groups as the nearest neighbour indexes for all three analysts were typically very low.

When the visual data was looked at, a theme that emerged very quickly was that Group I structures experienced overlap by the three analysts much more than the other structure types. The physical shape of the structures tended to be outlined in the same way by all analysts or at least very closely with only slight variations. The implication of this result is that, for Group I structures at least, the analysts were seeing the same features in the stone-walling and thus classifying the structures in the same way. One possible explanation for this is that Group I structures, by nature, have a relatively simple shape with their distinct outer wall and single or few inner enclosures (Taylor, 1979) and so potentially, they are just much easier to see and classify for the analysts. The less complicated a stone-walled structure is, the easier it will be to make out its features and assign it to a typological category, thus it would be expected that there a higher level of agreement would exist between the analysts for Group I structures.

5.2 Group II Structures

A significant amount of variability was found in the classification of Group II structures. Most noticeable was the actual number of structures classified as this type by each of the analysts. Ranging from 20 to one, it is clear that the analysts had different ideas when it came to Group II structures. The area data reflects clear differences between the analysts 'R' and 'M' but what really stands out is the single, massive unit that was classified as a Group II structure by 'A'. It is obvious from this data alone that the three analysts had very different ideas on what a typical Group II structure looks like. Spatial relationship patterns also varied significantly among the analysts. The analyst 'R' found clear evidence of a clustered pattern among Group II structures, but 'M's five structures were very widely dispersed throughout "Joe 2".

Analysis of the visual data of Group II structures confirmed that the analysts had little in common when it came to the classification of these structures. There wasn't a single structure that all three analysts classified as Group II and in fact, half of the structures assigned to this category by the analyst 'R' were not marked or classified at all by 'A' and 'M' which implies that for some reason, two analysts missed these structures entirely. Furthermore, many of the structures classified as Group II by 'R' were classified as Group IV or Unknown by the other two analysts. This meant that the patterns in the stone-walling did not seem to fit into the existing categories of Taylor's typology (1979) and were significantly different or unclear enough to warrant the creation of new categories. The results prove that Group II structures were a lot more challenging to see or classify for the analysts than Group I structures were. Group II structures are quite complex to look at (Taylor, 1979) and so could be more confusing to classify, which could account for some of the inter-analyst variability observed. There is, however, another very influential factor at play which will be discussed shortly.

5.3. Group III Structures

This category showed some consistency in classification, although not quite as much as in Group I. The data for the analysts 'A' and 'R' tended to have the most similarities while 'M' showed more variability. 'M' had far fewer Group III stone-walled structures than the other two analysts did, but also had noticeably different area data. Two of the analysts had relatively similar area data but the mean area of 'M's Group III structures are about half the size. This pattern is just as evident in the nearest neighbour results where 'R' and 'A' found quite clear clustering in this category but the data of the third analyst reflected quite the opposite and structures were very widely dispersed. From this evidence, it can be assumed that two of the analysts had quite similar ideas of what they were looking for when classifying Group III structures while the third analyst seemed to have slightly different criteria for classification. Although all three analysts received exactly the same training prior to classifying the structures and all three used Taylor's (1979) typology as a basis, it is very clear that when it came to practical application, they used their knowledge differently.

A clue to why these differences occur can be found in the visual analysis of the Group III stone-walled structures. As it was mentioned in the results section, there was a tendency towards typological agreement between the analysts 'R' and 'A' for a high proportion of Group III structures. However, at the same time, there was almost perfect agreement on the shape of the structures between 'A' and 'M' while the shape of 'R's structures tended to look quite different. The implication of this unexpected outcome is that two of the analysts, 'M' and 'A' seem to be looking at the exact same thing and thus are able to outline the structures in exactly the same way, for the most part. Nevertheless, when it came to interpreting the shape of the polygons and the details of the stone-walling and assigning the structures to a typological group, there was more in common between 'A' and 'R' and their classification often matched.

5.4. Group IV/ Unknown Structures

These two categories were both created in addition to Taylor's (1979) typology by the analysts 'A' and 'M' but it is unlikely that they would have used the same criteria for putting structures into these groups. It is also not clear if this category uses the same criteria as the Group IV created by Sadr & Rodier (2012) for either of the two analysts. For this reason, comparing the data of these categories should be done with caution although their very existence is clear evidence of inter-analyst variability. Group IV could either be created for structures that just do not seem to fit into the three existing categories, or they could all have a distinguishing feature in common that sets them apart from Groups I, II and III. Similarly, the group Unknown could have been created by the analysts for structures that did not typically fit into the existing typology or it could be for structures where the image was not clear enough for the structures to confidently be placed in Groups I, II, III or IV.

Group IV and the Unknown group combined make up a significant proportion of the total number of structures for both analysts – 28% for 'A' and 35% for 'M'. If the structures were assigned to these categories because they weren't clear enough to be put into the existing groups, then there could have been a significant problem with the images that the analysts were looking at. The area data for both of these categories indicates that structure sizes were very inconsistent. 'M's mean area for structures in both Group IV and Unknown were much lower than for the structures classified in these groups by 'A', indicating that there was definitely variability in how structures were assigned to this group. This variability continues into the nearest neighbour data where the analysts' results reveal different things about spatial relationships. Looking at 'M's Group IV nearest neighbour index, one could conclude that the stone-walled structures were relatively dispersed, but 'A's results imply that they were, in fact, noticeably clustered. Furthermore, although both analysts' nearest neighbour indices show that Unknown structures were clustered, they are to varying degrees.

The visual analysis of the stone-walled structures in Group IV and the Unknown group revealed that they very often overlapped with the structures classified as Group II by the analyst 'R'. A possible explanation for this is that the Google Earth imagery being used was not of sufficient quality to accurately make out the details of the stone-walling, thus the analysts could not confidently assign the structures to an existing category. The fact that such a high proportion of structures have been placed in Group IV and the Unknown group by two of the analysts is a clear indicator that something in the data or training was either unclear or confusing to the analysts. This resulted in noticeable inter-analyst variability.

5.5. General Observations and Possible Causes

The results of the elevation data revealed very little variation both between the analysts and between the different categories of stone-walled structures (Fig. 4.2). However, this is not necessarily an indicator that the analysts agreed when it came to the height of the structures. It is more likely that the region of "Joe 2" is actually very flat and lacks variety in elevation levels.

One consistent pattern that was observed in the visual analysis of the classified stone-walled structures could have been very influential on the variability found in the area data. When it came to the physical outlines of the polygons before they were even classified, the analysts had noticeably different approaches. Some of the analysts opted for outlining the structures in a more generalised way while others adhered to the details of the outer walls much more closely. An example of this can be seen in Fig. 5.2., where the structure has been classified as Group III by 'A' and 'R' but classified as a Group I by 'M'. The outline of the structure by 'R' is much more contoured and follows the specific details of the structure more closely than the other two outlines. While the basic shape of the structure is matched quite well by all three analysts, 'A' and 'M' tend to generalize the shape more than following the exact contours of the stone-walling. The reason why this is problematic is because, in the long run, this could actually be quite influential on the structure measurements such as area and length of outer wall. This inter-analyst variability has the potential to adversely affect the spatial data of stone-walled structures and hence the interpretation of the spatial data could be influenced.

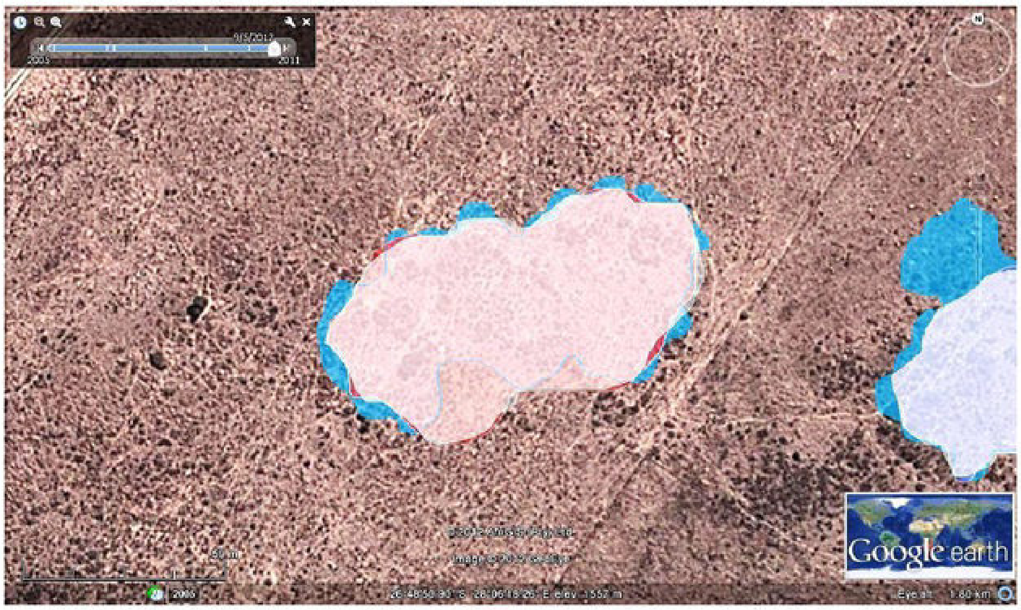

Figure 5.1. Generalized shapes vs. precise outlines

A very important pattern that emerged again and again in the visual analysis of the stone-walled structures was the physical overlap in the polygons created by the analysts 'A' and 'M' for all categories of structures. This did not coincide with a typological overlap, as the data of 'A' and 'R' often did, but it is still quite clear that two of the analysts were seeing the structures in a particular way in Google Earth and their subsequent interpretation and classification was different. Furthermore, there was often a distinct vertical shift in the polygons when the data from all three analysts was overlaid, resulting in the polygons for 'A' and 'M' being very closely aligned most of the time while 'R's polygons were slightly shifted.

This is particularly evident in Fig. 4.3. and the pattern clearly points towards the fact that two of the analysts were looking at a slightly different set of imagery.

The Google Earth historical imagery feature is very useful for finding the optimum time frame for viewing stone-walled structures. They typically show up best during dry seasons where they are not obscured by long, green grass or when the veld has recently been burnt and the structures show up clearly against the earth. The region of "Joe 2" has been photographed by satellite a number of times between 2004 and 2012 so there is a range of options available for viewing the structures. The images are taken at different times of the year and so they show different phases of vegetation growth. The sets of imagery which seem to be the clearest and best for seeing stone-walled structures are the ones taken in dry seasons in 2006 and 2011, although the quality of the images is slightly inconsistent throughout "Joe 2". Ideally, the analysts should look at every structure through the full range of available Google Earth images in order to classify from the clearest image, but this is very time consuming and is not always necessary.

The visual comparison of all three analysts' data proves that both 'A' and 'M' tended to use the 2011 imagery while 'R' tended to classify more in the 2006 set of imagery. This is very important because although these two timeframes make the stone-walled structures stand out a lot better than the other available imagery, they still differ in terms of resolution, vegetation and clarity. In many areas of "Joe 2", the 2006 imagery is actually noticeably sharper and the details of the structures are more clearly visible. This provides an explanation for the high proportion of Group IV and Unknown structures classified by 'A' and 'M', because if the imagery was not sharp enough it would be very difficult to say with certainty that structures belonged in either Group II or Group III. Thus, it would be safer to create new categories for structures that were not very clear or did not neatly fit into the existing typology. The discrepancy in image quality can also account for the vertical shift observed between the polygons of the different analysts and also for the many structures that were classified as a single large unit or several smaller ones by the different analysts. This is because poorer image quality would make it difficult to distinguish connecting walls between parts of a structure from nondescript rocky ground. The best way for analysts to overcome these unclear or confusing structures is to look through a wider range of available imagery so that they are able to pick out potentially important details of the structures that may otherwise be overlooked.

Problems with image quality can account for a very large proportion of the inter-analyst variability that has been observed in the results. It is not entirely to blame though. In cases where the physical outlines of the structures coincided very closely for the analysts but they still classified them differently, it seems that the interpretation of the structure is the issue. The analysts were most likely looking at the same image of a structure if they outlined it in exactly the same way, but they still might have had different ideas of what each structure type should look like. The three analysts received the same basic training individually, but still seem to interpret many of the structures differently. Perhaps it is necessary that they receive more intensive training and supervised practice in classification before conducting the practical work, as this would hopefully control and reduce the high levels of inter-analyst variability.

Conclusion

Significant inter-analyst variability is highly problematic for archaeological research and indeed any kind of research that relies on information that has been gathered by a number of different individuals. It is possible that three analysts are not enough to conclusively prove the accuracy of data, and just because two agree on the classification of a structure or its shape, this does not necessarily make it correct. Mason (1968) and Iiames & Congalton (2006) used six analysts for their respective studies and compared the results, so perhaps a larger data set could reveal different patterns or improve the accuracy of conclusions. More extensive training or supervision of analysts could help to improve the accuracy of the data they obtain, or in the very least make sure that they are on a similar track to one another. Differing quality of imagery was a very influential factor on the inter-analyst variability of this study, but it can easily be overcome by the analysts making better use of the various resources they have available to them. Inter-analyst variability has the potential to negatively impact research and its outcomes, but with better training and more attention to detail, it can probably be reduced and mitigated quite easily. Using multiple analysts to get work done is time and energy efficient, as long as it is done in the correct way and measures are taken to minimalize any potential inter-analyst variability that could negatively impact results.

References

Abe, Y. Marean, C.W, Nilssen, P.J, Assefa, Z and Stone, E. C. 2002. The Analysis of Cutmarks on Archaeofauna: A Review and Critique of Quantification. *American Antiquity* 67(4): 643-663.

Binford, L. 1977. General Introduction. In: Binford, L (ed.) 1977. *For Theory Building in Archaeology*: 1-10. Academic Press, New York.

Binford, L. 2001. Where do research problems come from? *American Antiquity* 66(4): 669-678.

Boeyens, J.C.A. 2003. The Late Iron Age sequence in the Marico and early Tswana history. *The South African Archaeological Bulletin* 58 (178), 63-78.

Clark, P.J & Evans, F.C. 1954. Distance to nearest neighbour as a measure of spatial relationships in populations. *Ecology* 35(4), 445-453.

Hall, S. 1998. A consideration of gender relations in the Late Iron Age 'Sotho' sequence of the western highveld, South Africa. In: Kent, S. (ed.) Gender in prehistory: 235-258. London: Altamira Press.

Huffman, T.N. 1986. Iron Age settlement patterns and the origins of class distinction in southern Africa. *Advances in World Archaeology* 5, 291-338.

Huffman, T.N. 1996. Archaeological evidence for climatic change during the last 2000 years in southern Africa. Quaternary International 33: 55-60.

Huffman, T.N. 2007. *Handbook of the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa*. KZN Press, Pietermaritzberg.

Iiames, J & Congalton, R.G. 2006. *A Comparision of Inter-Analyst Differences in the Classification of a Landsat ETM+ Scene in South-Central Virginia*. ASPRS 2006 Annual Conference, Reno, Nevada (1-5 May 2006).

Kosso, P. 1991. Method in Archaeology: Middle Range Theory as Hermeneutics. *American Antiquity* 56(4): 621-627.

Lyman, R. L & Van Pool, T.L. 2009. Metric data in archaeology: A study of intra-analyst and inter-analyst variability. *American Antiquity* 74(3): 485-504.

MacQuilkan, P & Sadr, K. 2010. Remote sensing of archaeological ruins: a comparison. *PositionIT* Nov/Dec 2010: 50-51.

Maggs, T.O.C. 1976. *Iron Age Communities of the Southern Highveld*. Council of the Natal Museum, Pietermaritzberg.

Mason, R.J. 1962. *The Prehistory of the Transvaal: a record of human activity*. Witwatersrand University Press, Johannesburg.

Mason, R.J. 1968. Transvaal and Natal Iron Age settlement revealed by aerial photography and excavation. *African Studies* 27 (4), 167-180.

Mason, R. 1986. *Origins of black people of Johannesburg and the southern western central Transvaal, AD 350-1880*. Occasional Paper No. 16 of the Archaeological Research Unit, Johannesburg: Witwatersrand University Press.

.Raab, L.M & Goodyear, A.C. 1984. Middle Range Theory in Archaeology: A critical review of origins and applications. *American Antiquity* 49(2): 255-268.

Sadr, K., Rodier, X. 2012. Google Earth, GIS and stone-walled structures in southern Gauteng, South Africa. *Journal of Archaeological Science* (2012).

Sampson, C.G. 1986. On the classification of Stone Age prehistory in southern Africa. In: Singer, R. & Lundy, J.K (Eds.) *Variation, Culture and Evolution in African Populations: Papers in honour of DR Hertha de Villiers*. Witwatersrand University Press, Johannesburg, pp. 249-259.

Taylor, M. 1979. *Late Iron Age Settlements on the Northern Edge of the Vredefort Dome*. M.A. Dissertation, University of the Witwatersrand, Johannesburg.

Vaal Triangle Info, 2005. *Climate information on the Vaal* accessed from www.vaaltriangleinfo.co.za in August 2012.

Wang, F. 1990. Fuzzy Supervised Classification in Remote Sensing Images. *IEEE Transactions on Geoscience and Remote Sensing* 28(2): 194-201.

Rebecca_Macroberts_323820_Rebecca MacRoberts Dissertation.pdf

ORIGINALITY REPORT

1 %	0 %	1 %	0 %
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Sadr, K.. "Google Earth, GIS and stone-walled structures in southern Gauteng… *Publication*	1%
2	A. J. Storer. "The fate of an intentional introduction of Formica lugubris to Nort… *Publication*	< 1%
3	www.juliantrubin.com *Internet Source*	< 1%
4	Submitted to Northern Consortium UK *Student Paper*	< 1%
5	Submitted to The Hague University *Student Paper*	< 1%
6	nationalserviceresources.org *Internet Source*	< 1%
7	Tim Maggs. "Iron age patterns and Sotho history on the southern Highveld: So… *Publication*	< 1%
8	Peter Chigozie NWILO. "An Assessment and Mapping of Gully Erosion Haza… *Publication*	< 1%
9	csmr.ca.sandia.gov *Internet Source*	< 1%
10	oak.ucc.nau.edu *Internet Source*	< 1%
11	Horkoss, S.. "Influence of the clinker SO"3 on the cement characteristics", Ce… *Publication*	< 1%

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	< 5 WORDS
EXCLUDE BIBLIOGRAPHY	ON		