A SPATIAL ANALYSIS OF STONE CIRCLES

IN SOUTHWESTERN

IRELAND

by

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ABSTRACT

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There is a tendency for the stone circles of southwest Ireland to be categorized by archaeologists as either Five-stone circles or Multiple-stone circles based on the number of stones used to define their circumferences. This categorization does not adequately describe the associations that exist between the size and location of stone circles and their elevation, nearest neighbor distance, nearest coastal distance and intervisibility. Spatial analyses allow stone circles to be considered distinctive in other ways besides the number of stones used to define their circumferences. This research demonstrates that the area of a stone circle is often more closely associated with these variables than is the number of stones used to define their circumference. Intervisibility among stone circles is shown to be a significant factor in the location of Five-stone circles. Five-stone circles are observed to be non-randomly distributed throughout the region with respect to their intervisibility, while other stone circles do not suggest intentional positioning with respect to their visibility from other stone circles. This may indicate an important aspect of the social interactions which took place at these sites. A cultural distinction is suggested based on these variables between social groups associated with the building and use of Five-stone circles and social groups that built and used other stone circles in the region.

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CHAPTER 1

HISTORICAL SURVEY OF MEGALITH STUDIES

1.1 Early Ideas: Superstition and the Church

Megaliths, ancient stone monuments throughout Western Europe, have fascinated and mystified scholars and the general public for centuries. The term "megalith" was originally used to designate any ancient architecture composed of large, multi-ton stones. This would include single standing stones, certain tombs and stone circles. Aubrey Burl (2000:8) has described stone circles in simple terms. "Megalithic rings can be defined as approximate circles of spaced standing stones." Today large structures composed of many small stones piled up as a memorial or landmark, such as cairns, are also considered megaliths by researchers. Now known to date to the period ca. 3300 BC – 900 BC (Burl 2000:5), these prehistoric structures have occasioned many theories regarding their origin. During ancient times superstitions fueled notions of giants, fairies and gods. Traditional folklore beliefs shaped by popular imagination have provided some of the earliest explanations for megaliths, as these impressive structures were thought to be too large to have been built by mere humans.

During the first millennium of the Christian era, megaliths were understandably viewed by the Church as a threat. The connection between paganism (a term used here to describe religious beliefs and practices outside Christianity) and stone monuments often prompted the Church to condemn the sacrilegious rituals believed to have been performed in earlier times. During the 4th century St. Martin of Tours traveled through Gaul destroying pagan shrines made of wood and stone (Jones and Pennick 1995:97; Burl 1999:11). The Councils of Arles in AD 452 and Tours in AD 567 condemned the stone structures and encouraged their destruction (ibid). Massive stones are not easily destroyed, however, and monuments were often re-used as a means of converting people's beliefs and practices from pagan to Christian ritual. By modifying a pagan stone structure through stone carving, rearranging a few stones to resemble the Christian cross, or incorporating the megalithic monuments into church structures, megaliths were brought into compliance with Christian beliefs and symbology (Jones and Pennick 1995:103).

In AD 448, St. Patrick established Christianity in Ireland as the official religion, and he is said to have instructed his followers to build a church wherever standing stones were found (Burl 1999:16). During the 6th century, pagan rituals were still being performed at megalithic sites such as the barrow cemetery, Hill of Tara in Co. Meath. Known as the place from which the kings of Ireland were crowned, Tara appears to have been considered a very spiritual and powerful location in pre-Celtic Ireland (Jones and Pennick 1995:100; McCaffrey and Eaton 2002:61). In AD 554, the Christian monk Ruadhan of Lothra is said to have cursed Tara upon learning it was still being venerated by non-Christians for its use in pagan rituals, and the last pagan king of Ireland is thought to have been Diarmat McCerbaill, who sanctioned pagan ceremonies until his death in AD 565 (ibid). Pope Gregory the Great wrote to Abbot Mellitus in AD 607 with instructions that missionaries in Britain were to convert pagan buildings for

Christian use instead of destroying them (Hutton 1991:271). Bede, the 8^{th} century historian of Christianity in Britain, refers to pagan practices in his *Ecclesiastical History*, and notes that the greatest sacred occasion among the pagans is the winter solstice, Modranicht (Mother Night), which marked the beginning of the new year (Hutton 1991:272). As early Christianity took hold throughout the British Isles, traditional beliefs were integrated into Church doctrine. For the simple peasant, megalithic structures were intertwined with supernatural beliefs of heaven and hell. With a little imagination and support from the Church, megaliths were sometimes viewed as the petrified remnants of pagan sinners who broke Church law. As the first millennium of the Christian era neared an end, the Church found that it could not entirely stamp out the pre-Christian rituals associated with megaliths, and so continued to incorporate pagan rituals into Church doctrine. Brighde, the Irish goddess of sun, warmth and fire, became St. Bridget (Jones and Pennick 1995:101). Beltane, the great festival celebrating the beginning of the summer half of the year, was blessed by the Church and celebrated with May Day processions (ibid). Despite the integration of folklore beliefs into Church doctrine, pagan practices and superstitious beliefs continued and would persist into modern times. Even today various modern Druid groups gather at Stonehenge to celebrate the summer solstice sunrise.

Throughout the Dark Ages, magic and giants were favored in popular imagination as the builders of megalithic monuments. In medieval Britain, megalithic monuments were objects of local interest, and literate priests would occasionally chronicle the folktales associated with the structures (Trigger 1989:31). In *History of* *the Kings of Britain*, c. 1136, the clergyman Geoffrey of Monmouth associates Stonehenge with Arthurian legend and refers to the circular monument as the giant's ring that Merlin moved from Mount Killarans in Ireland to Salisbury Plain in England (Wood 1978:5; Trigger 1989:45; Burl 1999:12). The 13th century English monk Ralph of Coggeshall recorded the discovery of mammoth bones on the Essex coast as the bones of a giant man (Piggott 1976:4). As late as the 15th century it was commonly believed that giants had existed in ancient times as a result of the occasional discovery of the bones of extinct animals. It seems that it was easier to believe in extinct giant humans than in large extinct animals during this period. Belief in witchcraft was also becoming more popular. The stone circle site called Long Meg and Her Daughters, in northern England, was of such a shape and configuration that it was explained as witches frozen in stone (Hadingham 1975:178; Burl 1999:35).

The Renaissance of the mid-15th century stimulated an interest among the social elite and religious leadership in collecting antiquities. In 1462, Pope Pius II passed a law to preserve ancient buildings (Trigger 1989:36). During the papacies of Popes Paul II (1464-1471) and Alexander VII (1492-1503) the Church sponsored systematic searches for objects that had aesthetic value. There was little concern for understanding the context of the objects or their history since the only reliable knowledge about the past was derived from the historical records of Greece and Rome, and from the Bible (Trigger 1989:31). "The repeopling of the entire world after the flood formed a divinely constituted and inescapable frame of reference within which all remote antiquity had to be constrained" (Piggott 1976:4). A chronology of the world based on the Bible did not allow very much time for prehistory, and most scholars agreed that the world was less than six thousand years old. Jewish rabbinatical calculations from the Hebrew Massoretic text indicated the world began 3740 years before the Christian era (Stiebing 2000:68). The Roman Catholic calculations were based on the Latin Vulgate Bible and placed creation in 5199 BC (ibid). The Protestants accepted the calculations of Archbishop James Ussher of Armagh who in 1650 placed the creation date on Sunday, October 23, 4004 BC. A short time later Dr. John Lightfoot, Vice-Chancellor of Cambridge University, was able to refine Ussher's time of creation to 9 o'clock in the morning (Daniel and Renfrew 1988:10).

1.2 Antiquarianism: A "backward-looking curiositie"

Down through history, explanations of antiquity have always been made in terms of what is known about the past from historical records and artifacts. As late as the 19th century, scholars sought to explain ancient monuments within the context of their possible association with people mentioned in historical accounts. Thus, the study of antiquities was constrained by the belief that the world had been created around 4000 BC. Information from Greek and Roman literary sources on the nature of the earliest people in Britain and Western Europe led antiquarians to the Celts, described by the Greeks as *Keltoi*. The Celts are not thought of as one homogeneous people but rather as having been composed of many different tribes that spoke a similar language. Initially occupying central and west-central Europe, they eventually expanded into Italy during the 5th century BC and contributed to the downfall of Etruscan civilization (Herm 1975:5, Laing 1979:7). In 387 BC, the Roman legions were overcome by the Celts at the battle of the Allia (Herm 1975:14, Laing 1979:7). It was not until 295 BC that the Romans gained the upper hand militarily (Laing 1979:7). The Celts were finally pushed out of northern Italy in 225 BC at the battle of Telamon (Herm 1975:14, Laing 1979:7). Italy was only one target of the Celts, however, and by 335 BC they had reached northern Greece (Herm 1975:33). Posidonius, a Greek scholar who traveled through Gaul during the 2nd century BC, provides written evidence in his *Histories* for the Celtic tribes in Gaul and north of the Alps (Hadingham 1975:168). By 270 BC, they established the territory of Galatia near Ankara, Turkey (Laing 1979:8). In Christian times, the Celts in this region were known as Galatians and still spoke a recognizable Celtic language (Herm 1975:40, Laing 1979:8, Daniel and Renfrew 1988:73). Eventually, the Romans dominated the Celts in most of Britain, and by the 3rd century BC the Celtic world had begun to shrink (Herity and Eogan 1977:224, Laing 1979:8). Julius Caesar mentions the Celts in his *Gallic Wars* as he recounts the Roman military campaigns from 58 – 51 BC against the Celtic inhabitants of Western Europe (Wood 1978:199, Trigger 1989:148).

The Celtic tribes are thought to have moved into Britain in two major waves. Based on linguistic research, the first movement is thought to have taken place between 2000 – 1200 BC (Herm 1975:204). Another major migration of Celts occurred during the 7th century BC based on artifacts in Britain that correspond to the Celtic La Tène culture of western and central Europe (Herm 1975:122, Laing 1979:5). Part of Celtic society was made up of a priestly class, the Druids, who are thought to have advised tribal leaders and officiated at religious rituals (McCaffrey 2002:76). Druids are mentioned in Pliny the Elder's *Natural History* in AD 77 and he, like Julius Caesar, remarks that the original source of Druidism was Britain (Hadingham 1975:170). While there is no evidence that the Celts constructed the megaliths of Western Europe, a prehistory of Druidic origin allowed antiquarians to explain the past with historical documentation within the constraints placed upon them by religious doctrine (Wood 1978:5).

In Western Europe, the Renaissance gave rise to antiquarian studies as scholars sought to understand ancient civilizations through classical literature and archaeology. With the 16th century came more empirical reasoning and the idea that megaliths were the work of men. In Britain, the prehistoric megaliths were a favorite focus of interest and were being described in a scholarly fashion while their origins were the subject of learned debate within societies such as the College of Antiquaries (1586) (Trigger 1989:47), the Royal Society of London (1660) and the Society of Antiquaries of London (1707) (Daniel and Renfrew 1988:7; Trigger 1989:61). Michele Mercati (1541-1593), Superintendent of the Vatican Botanical Gardens and advisor to several popes, recorded in his book of natural history, *Metallotheca*, that primitive stone implements were manmade and not supernatural (Daniel 1981:10). Continued interest in megaliths prompted King James I (1566-1625) to commission an architect, Inigo Jones, to provide the first authoritative study of Stonehenge. Seen as too beautiful and elaborate to have been built by barbaric Druids, he declared it to be a Roman temple (Daniel and Renfrew 1988:13). Other scholars of the time suggested that Stonehenge was the work of Danes, Phoenicians or Saxons (Daniel and Renfrew 1988:13; Trigger 1989:48).

In 1586, William Camden (1551-1623), the Headmaster of Westminster School in London, wrote *Britannia*, a topographical and historical survey of all of Britain and the first general guide to the antiquities of the island. Translated from Latin to English in 1657, this work addressed those who criticized the study of antiquities as a "back-looking curiositie" stating, "in the study of Antiquity there is sweet food of the mind well befitting such as are of honest and noble dispositions" (Daniel 1981:10). In *Britannia*, Camden recorded both the folktales surrounding megalithic monuments and valuable descriptive information. The stones making up the Rollright Stones, for example, were popularly believed to have been the Danish king Rollo, his five knights and army who were metamorphosed into stone by a witch (Burl 1999:10). Camden also provided a more objective assessment of the megalithic monument and gave basic and accurate information upon which antiquarians could build more reasonable theories. He documented for perhaps the first time that the stone ring was circular and had been built by humans:

> …a great monument of Antiquity; a number of vastly great stones placed in a circular figure, which the Country-people call *Rolle-rich-stones*, and have a fond tradition, that they were once men thus turn'd into stones. They are irregular and of unequal height, and by the decays of time are grown ragged and very much impair'd (Camden 1695:254). What the occasion of this Monument might be, is not hinted to by any inscription upon the Stones, nor by any other marks about them: which seems to make it probable at least that it was not erected in memory of any persons that were bury'd there.
>
> (Camden 1695:268)

1.3 Scientific Antiquarianism: "We speak of facts not theory"

Antiquarian reasoning continued to be influenced by Christian theology that proclaimed megaliths to be supernatural and often the results of divine punishment for profanations on the Sabbath. But as antiquarians adopted a more descriptive scientific methodology of observation, classification and experiment, archaeologically useful descriptions became more common. Glyn Daniel and Colin Renfrew (1988:14) described the period as one in which "Everything had to belong to something and to something clearly named and historical." In addition to describing megalithic structures, an effort was being made to understand how large stones might have been moved and how monuments had been constructed in ancient times (Trigger 1989:64). Later in this period, an increased interest in ancestral heritage developed as the nature of one's origins became a matter of national pride. Antiquarians were not immune to this trend and sought to enhance their countries' prestige and national identity through association with ancient monuments. In Britain, the roots of what was to become archaeology can be found in the work of such 17^{th} and 18^{th} century antiquarians as John Aubrey (1626-1697) and William Stukeley (1687-1765).

John Aubrey recorded excavations and provided measurements of megaliths which were published in his *Monumenta Brittanica* in 1693. He also developed a classification of megalithic monuments, earthworks and barrows based on objective, observable criteria. Stone circles, for example, became a class of megalithic monument based on their morphological features. Earthworks such as Roman camps were described as squarer in form and were distinguishable from the more rounded Danish camps (Daniel 1981:56). Aubrey's investigations of Stonehenge in 1666 and other stone circles in areas not known to have been occupied by Romans helped establish a period for the construction of "pagan temples" as pre-Roman and offered the possibility that they were temples of the Druids (Burl 1999:16). The discovery of American Indians during this time also helped influence antiquarian thought and Aubrey's interest in Druids may have been enhanced by comparative ethnography of the aboriginal inhabitants of America. Aubrey described the Druids in 1659 as "2 or 3 degrees, I suppose, less savage than the Americans" (Piggott 1976:9). By "Americans" he was referring to the barbaric behavior of North American Indians on European settlers in New England at the time. In any event, his work inspired a revival of interest in Druids as the builders of stone circles (Trigger 1989:148).

Drawing on Aubrey's work, later British antiquaries writing for Gibson's 1695 edition of *Camden's Britannia* set out classifications for groupings of megaliths. These include the megalithic monuments in Scotland and the Orkneys as "great stones set in a circle" for henge monuments and "obelisks" for the single standing stones (Camden 1695:955). In Wales, Edward Lhwyd defined stone circles as a class within the general megalithic group, and classified single chambered tombs based on their size and capstone with the larger, free-standing monuments called *kromlech* and the smaller stone cist graves termed *kist-vaen* (Camden 1695:620, 628). In France, Legrand D'Aussy undertook classification of Breton megaliths, and by mixing the local language with antiquarian terminology, single standing stones became *menhirs* while chamber-tombs became *dolmens* (Daniel 1981:56).

William Stukeley was an antiquarian with a vivid imagination and an eye for detail. Greatly influenced by Aubrey, he was one of the first to investigate sites by means of excavation and documentation. He noted that geometrical crop marks that English farmers had noticed in various areas of the country since medieval times were not supernatural but were outlines of buried structural foundations (Piggott 1985:51). He recognized that Roman roads were built around ancient burial barrows at Silbury Hill, while Roman roads elsewhere often cut through the barrows. Thus he was able to establish relative dates for these sites, suggesting a pre-Roman occupation (Trigger 1989:64). His work at Stonehenge also resulted in an early understanding of the stones' astronomical alignments with respect to the summer and winter solstices (Burl 1999:130), as well as the suggestion that the builders of Stonehenge may have used a system of measurement during construction, the 20.8 inch "Druid cubit" (Hadingham 1975:80; Burl 1999:20). Stukeley was fascinated by all things Druidic and was convinced that all prehistoric monuments were temples of the ancient Britons, and were Druidic in origin (Piggott 1976:70-72; Trigger 1989:65; Burl 1999:19). This fascination with priestly Druids affected him profoundly and may have contributed to his ordination into the Church of England clergy in 1729 (Piggott 1976:116). Through his archaeological investigations Stukeley sought to explain the Druids as the founders of the Christian faith, "of Abraham's religion entirely" and interpreted megalithic monuments as ancient universal symbols of early Christian orthodoxy and Druids as having "a knowledge of the plurality of the persons in the Deity" (Piggott 1976:72).

His fieldwork at Stonehenge and Avebury, published in the 1740s, is considered an unusual mix of science, religion and Romanticism (ibid).

During the late 18th century, Druids fit comfortably into antiquarian notions of a world created around 4000 BC and a Druidic origin for megalithic structures was commonly accepted. A decline of British interest in megalith studies in general and their excavation in particular was replaced by an interest in the excavation of ancient graves for artifacts which might reveal how their early ancestors had lived (Trigger 1989:66). Trigger reports that more than 750 Anglo-Saxon burial mounds in southeastern England were excavated from 1757 – 1773 by the Rev. Bryan Faussett and another 379 barrows were excavated in Wiltshire by Richard Colt Hoare (ibid). This work resulted in the definition of five types of barrows. In his classification, long barrows were distinguished from circular barrows. Circular barrows were further subdivided into bowl, bell, Druid (disc) and pond barrows (Daniel 1981:65). Hoare sought to distinguish his more scientific approach from the dilettantish approach of earlier antiquarians. In his book, *Ancient Wiltshire*, he writes, “We speak from facts not theory. I shall not seek among the fanciful regions of Romance an origin of our Wiltshire barrows” (Daniel and Renfrew 1988:9). His observation of stratigraphy allowed primary and secondary interments to be distinguished, and graves containing stone artifacts were considered to be older than graves containing metal artifacts. Other antiquarians were still willing to argue, however, that the graves did not necessarily represent social groups of a different time period but perhaps belonged to different social classes within a group. The socially disadvantaged class may have used stone tools while an upper class enjoyed the benefits of metal tools (Trigger 1989:67).

1.4 Archaeological Theories of Megalithic Culture

The first half of the 19^{th} century was marked by important discoveries in Egypt including Champollion's decipherment of Egyptian hieroglyphs in 1822, which resulted in a fairly accurate chronology of civilization in the eastern Mediterranean. This provided a reference point for European prehistorians eager to establish a chronology for European cultures by linking the development of prehistoric societies of western Europe to the civilizations of the eastern Mediterranean. This assumption, along with a second, that similarities between cultures was the result of the degree to which the cultures had been in contact with each other, formed the basis of popular culture-historical and diffusionist approaches in 19^{th} century archaeology.

In 1816, a young Danish scholar, Christian Jurgensen Thomsen (1786-1865), was asked to organize an exhibit of artifacts for the National Museum of Antiquity in Copenhagen. His efforts to arrange the large collection of artifacts chronologically resulted in the development of the Three-Age System based on the idea that prehistoric people in Europe passed through successive stages of technological development reflected in the production of stone, bronze and iron tools (Trigger 1989:78). Before man used metals, he had used stone. As metals were discovered, copper was used first, followed by bronze and then iron (Daniel and Renfrew 1988:38). There had been earlier ideas about tool chronology but they were based largely on speculation. Yet as Trigger notes, "despite a growing number of supporters, the Three-Age theory remained as speculative and unproved as it had been in the days of Lucretius." (Trigger 1989:61)

Thomsen's Three-Age System was a simple idea supported by scientific evidence that gave chronological depth to prehistory. His organized approach to the massive collection of artifacts included the use of shape and decoration as stylistic criteria which helped establish a chronological sequence for Danish prehistory. In *Ledetraad til Nordisk Oldkyndighed*, published in 1836, Thomsen proposed a developmental sequence of five stages: Early Stone Age, Later Stone Age, Bronze Age, Early Iron Age and Later Iron Age (Rodden 1981:51; Trigger 1989:76). Thomsen also used the principle of seriation which uses percentages of artifact types within a particular assemblage relative to another assemblage, to support the validity of his relative dating system. In this way, all the characteristics of individual artifacts were used, including material, style, decoration and context of discovery, to form a coherent pattern of variation (ibid). With the development of Thomsen's Three-Age System it became clear that stone megaliths had been built many centuries before the Iron Age Druids (Patton 1993:69).

Throughout the 19th century, European archaeologists sought to trace the geographic distribution of archaeological discoveries throughout the Stone, Bronze and Iron Ages. In 1864, the French archaeologist Alexandre Bertrand argued that megalithic monuments in western Europe were all built by one culture that had spread from north to south (Trigger 1989:155). In 1870, Gabriel de Mortillet interpreted La Tène artifacts from northern Italy as evidence of a Celtic invasion into the area (ibid). In 1890, Sir

Arthur Evans identified and associated Celtic urns from southeastern England with the Belgae of northeastern Gaul, who, according to the Romans, had invaded Britain in the 1st century BC (ibid). Trigger further notes that in 1898, the Danish archaeologist Sophus Muller (1846-1934) argued that although single graves and megalithic burials of the Danish Neolithic were partly contemporary, the artifacts associated with them were different enough to represent distinct peoples (ibid).

In the late 19th century, a growing nationalism encouraged the idea that every nation was united by its own biological heritage. Human behavior was seen as biologically determined and largely lacking in creativity. The cultural change seen in the archaeological record was attributed to the diffusion of ideas from one group to another or to migrations that led to replacement of one people and culture by another (O'Kelly 1989:247; Trigger 1989:150). Taking an evolutionary approach, Sir William M. Flinders Petrie (1853-1942) was a British archaeologist and Egyptologist who explained almost all cultural change in terms of mass migrations or the arrival of small groups who brought about cultural change by mixing culturally and biologically with the existing population. "Petrie saw no possibility of significant cultural change without accompanying biological change" (Trigger 1989:154). At the other end of the spectrum was the Australian archaeologist, Grafton Elliot Smith (1871-1937), who theorized that all cultural development had originated in Egypt. He believed that the development of events such as agriculture and monumental architecture had occurred in a unique environment and was unlikely ever to have happened elsewhere. Thus, all cultural ideas had diffused outward from Egypt and had been passed on from one cultural region to the next. Some scholars were influenced by the hyper-diffusionist ideas of Elliot Smith and argued that megalithic monuments in western Europe might be a degenerate form of the Egyptian pyramid (Daniel and Renfrew 1988:86; Trigger 1989:152; Patton 1993:5). By the 1920s, the archaeological record was sufficiently understood to discredit hyper-diffusion explanations for megalithic monuments and world prehistory in general (Trigger 1989:405). Neolithic tombs and monuments were seen as the result of the spread of megalithic builders or their ideas. A less extreme view of diffusion suggested that European megaliths were a coastal phenomenon built by Iberian colonists traveling by sea and settling along the shores of western France, Britain, Ireland and Scandinavia. The Iberian monuments, it was thought, had originated in the Aegean (Renfrew 1960:193).

V. Gordon Childe (1892-1957), in his 1925 *Dawn of European Civilization* did much to legitimize a modified diffusionist approach in subsequent decades. His functionalist view of material culture argued that the historical significance of artifacts could be better ascertained by considering the economic role they played in prehistoric cultures. Childe thought that artifacts such as pottery, ornaments and burial rituals were ethnic traits that reflected local tastes and were relatively resistant to change. They were useful, therefore, for identifying specific ethnic groups. Childe regarded tomb architecture along the Mediterranean and Atlantic coasts and the land routes connecting these coasts as suggestive of diffusion of culture by “maritime intercourse” (Childe 1958:213). Regarding megaliths, Childe described the most intriguing tombs to be those built of “extravagantly large stones,” but also noted that their construction seemed to be conditioned by the local geology in as much as they followed the same plans as tombs built of smaller stones (ibid.). He states, "It is in fact only detailed agreements in seemingly arbitrary peculiarities of plan and in accessories, such as posthole slabs and forecourts, that justify the interpretation of megalithic tombs as evidences of the diffusion of ideas" (Childe 1958:219). Childe believed that artifacts of more utilitarian value, such as tools and weapons, were more likely to diffuse rapidly from one group to another and were useful in assigning different cultures to the same period and in establishing cultural chronologies. He believed these technological traits in prehistoric societies had diffused to Europe from their place of origin in the Near East (Trigger 1989:170). Childe also advanced the study of settlement patterns in the 1930s and 1940s through the use of archaeological surveys, not merely as a means of locating sites to excavate, but as a source of information about the past. He interpreted the Neolithic village at Skara Brae in the Orkneys (Childe 1931) with reference to 19^{th} century social organization of rural homes in the Scottish Highlands. In 1940, Childe conducted a survey of megalithic monuments on the island of Rousay in the Orkneys to correlate their spatial distribution in the landscape with arable land, and used the number of monuments to estimate the size of the population on the island during the Neolithic (Childe 1942).

Childe's examination of the artifactual evidence in southern Britain resulted in the identification of four cultural periods prior to 1400 BC (Childe 1940:11). Artifacts of the Windmill Hill and Causewayed Camps period, the oldest Neolithic culture, suggested to him that immigrants from Europe "brought, fully formed, the oldest

Neolithic culture recognizable in the archaeological record" (Childe 1940:34). Further, when the sites were plotted on a map, Childe saw the distribution of Mesolithic and Windmill Hill settlements to be in sharp contrast to each other, suggesting that the earlier inhabitants of Britain were joined by later settlers who brought with them the Neolithic culture of agriculture and animal breeding that originated in Egypt. He states, "The Western culture itself can be traced not only to South France and Spain, but even to Egypt" (Childe 1940:41). Childe interpreted megalithic monuments as an ethnic trait representing a 'megalithic religion' that reflected local ritual preferences among the various settlement groups (Childe 1940:46). Variation in the style and construction of megaliths is to be expected as the builders were seen as "families coming by sea from different quarters and settling down among native populations to whom they taught their own peculiar version of the faith" (Childe 1940:53). Childe's conclusion about the use of megalithic monuments to define a Western European culture can be summarized:

> There is no megalithic culture, defined by equipment and ornaments, common to all megalithic tombs, and therefore no megalithic people whose mass migrations could have diffused tombs and equipment too. In each area of Europe the grave-goods belong to local types, equally represented in non-megalithic or pre-megalithic contexts.
> (1940:52)

Likewise, Glyn Daniel (1959) argued that megalithic tombs and temples are not the same around the world and that the use of large stones in different parts of the world in architecture that had little else in common might well have arisen independently and was not likely the result of wandering Egyptians. Like Childe, he thought it pointless to infer megalithic people or race since "there is no necessary cultural or chronological or functional link between all megalithic monuments" (Daniel 1959:124). He believed that megaliths could have originated independently in several different places in Europe alone and that megalithic monuments were "obviously developed in the world at different times by different people for different purposes" (ibid). Daniel's conclusion about the origins and nature of megalithic tombs is that their spread in western Europe was driven by the diffusion of ideas made possible by trade and metal prospecting being carried out by diverse people with strong religious beliefs and complex funerary practices:

> It should now be clear to all serious and unbiased students of megaliths that these structures of great stones came into existence in many separate societies: Malta, the toe of Italy, Bulgaria, Almeria, the Algarve of Portugal, Brittany, the northern European plain of NW Germany and Denmark, southern Britain and Scotland. Whether to these nine areas we should add Ireland is a matter for discussion.
> (1978:268)

The development of radiocarbon dating in the late 1940s by Willard Libby and subsequently, tree-ring calibration, helped establish a more accurate chronology of prehistory in the decades that followed. Calibrated radiocarbon dates pushed the megaliths of Brittany back to ca. 4500 BC and in Ireland back to ca. 3000 BC, whereas the earliest tombs in the Aegean in the Mesara of Crete date to ca.2500 BC (Daniel and Renfrew 1988:180). It became apparent that Irish megaliths were built around the same time as Iberian monuments from which they were supposedly derived, and some megaliths in Brittany were found to be much earlier than any in the Mediterranean, with the earliest monuments dating to the first quarter of the 5th millennium BC (Patton 1993:5, 16). With the increasingly clear assumption that similar monuments could appear independently in different areas of the world it became necessary to explain cultural change in terms other than the diffusion of people and ideas exclusively.

In distinction to diffusionist arguments, recent scholars have emphasized megalithic tombs as social centers, arguing that tombs often function as territorial markers in segmentary societies (Fleming 1973:189; Kinnes 1975:26; Chapman 1981:72; Renfrew 1976:208; 1983:8; Thomas 1987:417). For example, Renfrew argued that megaliths were territorial markers built in response to population pressure near the coast (Renfrew 1976:211). The Atlantic coastline was viewed as an area of relatively high population density made up of Mesolithic communities prior to the introduction of agriculture due to the relatively rich resources available from the sea and land. With the spread of agriculture, the ocean became a barrier to expansion of Neolithic communities. As population density increased in coastal areas, pressure for land ownership resulted in the need to identify territories. Megalithic monuments associated with funerary rituals such as tombs and graves were used to venerate ancestors publicly and proclaim a period of occupancy long enough to justify ownership of the surrounding land. In this way, similar monuments could be explained as appearing in various parts of western Europe not because of the diffusion of people or ideas, but because of similar social processes (agriculture) that resulted in similar social functions (territoriality) and made use of similar monumental architecture (megaliths) (Renfrew 1976).

The introduction of territoriality as a possible factor in explaining the incidence of megaliths requires us to consider how space is used for various kinds of activities. If one concedes that there is archaeological information in spatial relationships among things as well as within the things themselves, then the relationships of space around the archaeological data becomes an important feature of study within the discipline of archaeology. The history of spatial archaeology can be traced back at least to the end of the 19th century in Europe where relationships were recognized between archaeological sites and geography, and settlement patterns were considered to be conditioned by the landscape (Williams-Freeman 1881, Guest 1883, Ratzel 1896). From these beginnings, methods were developed that combined distribution maps of archaeological and geographical information seeking to document social change in large regions over several millennia (Crawford 1912, Fleure 1921, Fox 1922, Childe 1934, Hogg 1943).

While British spatial archaeology emphasized the geographic aspects of artifact distribution maps, American archaeologists emphasized the anthropological aspects dealing with social origin and settlement patterns. Julian Steward's (1937, 1938) studies of prehistoric regional and community patterns in the American Southwest stimulated interest in locating and mapping archaeological sites for the purpose of studying settlement patterns within an environmental context (Phillips et al.1951:5; Willey 1953:371; Watson 1956:117; Parsons 1972:140). New analytical approaches also were developed to explain and categorize spatial relationships of archaeological data as it related to cultural change (Hill 1966; Binford 1972; Wilmsen 1975; Hodder and Orton 1976: Clarke 1977; Vita-Finzi 1978). These studies emphasized the sociological, economic and ecological aspects of cultural change rather than the spatial information itself.

If indeed megalithic monuments functioned as territorial markers, then new ways of analyzing the landscape around the monuments are necessary to understand how prehistoric territorial size and boundaries may have been established. One of the most useful techniques in spatial analysis is Central Place Theory (CPT), developed by German geographer Walter Christaller as a means of understanding the spacing and function of settlement patterns (Christaller 1933). CPT assumes that generalizations can be made about settlement patterns based on the functional interdependence between a settlement and its surrounding area (King 1984). Under ideal conditions, Christaller proposed that central places of the same size and nature are equidistant from one another and surrounded by secondary centers with their own smaller satellites (Baskin 1967:16). The premise is that a town forms the center of a region based on the goods and services that it provides to occupants of the surrounding area. The size of this area of influence is defined as "the farthest distance the dispersed population is willing to go in order to buy a good offered at a place – a central place" (Baskin 1967:22). Christaller's formulation was of a polygonal pattern of market areas and a hierarchy of central places (Figure 1.1). Researchers suggest that Christaller's model can be useful in studying ancient sites based in the same theory of distribution in a uniform landscape (Figure 1.2).

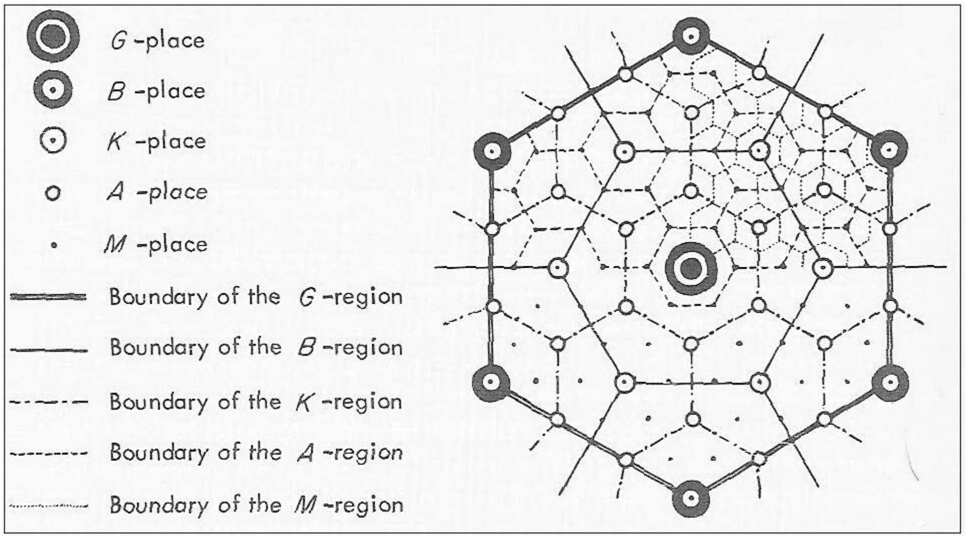

Figure 1.1 Marketing regions in a system of central places.
(Baskin 1967:66,translated from Christaller 1933, *Die Zentralen Ort In Suddeutschland*)

"In a flat landscape, with no rivers or variations in resources, a central place (town or city) will dominate a hexagonal territory, with secondary centers (villages or hamlets) spaced at regular intervals around it" (Renfrew and Bahn 2000:179).

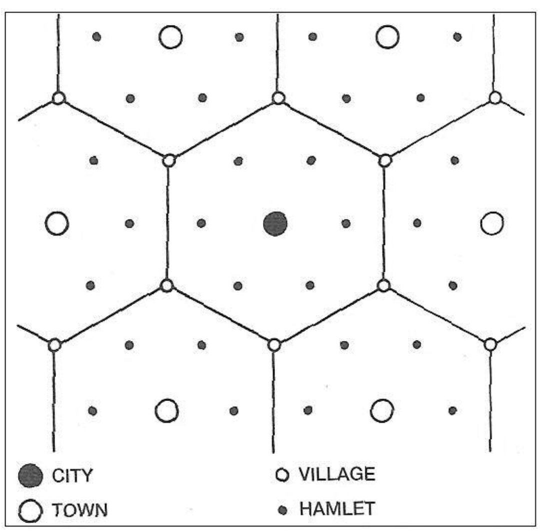

Figure 1.2 Central Place Theory. (Renfrew and Bahn 2000:179)

Today, various terms for the polygon include Thiessen polygon, Dirichlet tessellation and Voronoi diagram (Clarke 1972:774; 1977:289). In its simplest form, the hypothetical territory around a central place is constructed by drawing straight lines between pairs of neighboring sites; at the mid-point along each of these lines, a second series of lines are drawn at right angles to the first. As the lines are connected the Thiessen polygons are created (Figure 1.3). In Childe's *Social Evolution*, he suggests that in the case of contemporaneous settlements, a line drawn halfway between them would indicate the size of their respective territories (Childe 1951:56).

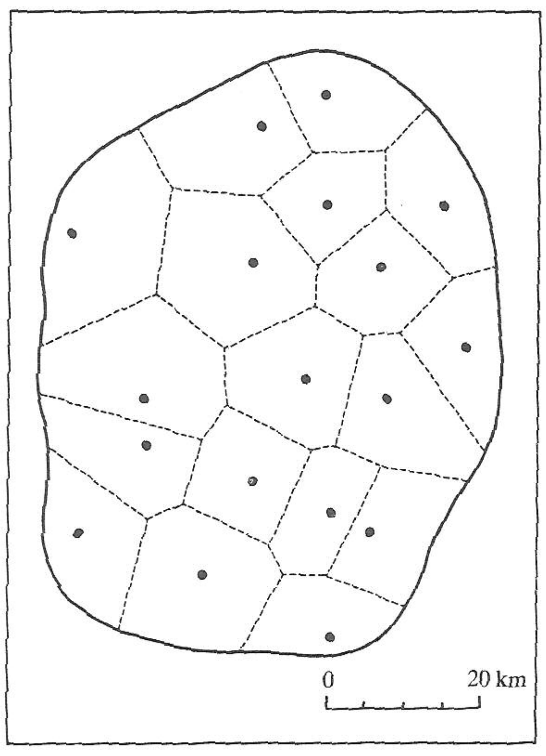

Figure 1.3 Thiessen Polygons. Idealized territorial structure of early civilizations,showing the territories and centers. (Renfrew 1984:95)

David Clarke also called attention to the potential of locational models to help interpret the complex spatial organization of archaeological data and emphasized the study of sites as patterned systems territorially distributed over landscapes as “spatial manifestations of activity patterns” (Clarke 1972:7). Renfrew used Thiessen polygons in his study of Neolithic barrows and the development of chiefdoms in Wessex, England (Renfrew 1973:545). In Renfrew’s *Investigations in Orkney*, Donald Davidson uses visibility diagrams in a locational study of cairns on the island of Rousay (Davidson 1979:13). Claudio Vita-Finzi devised techniques for studying the area around a site that would have been exploited by occupants of the site. Site Catchment Analysis and Site Exploitation Territory are methods for determining the resource proportions within a territory from which conclusions can be drawn regarding the nature and function of a settlement within the territory (Vita-Finzi 1978:25). Other more sophisticated models in environmental archaeology weight Thiessen polygons based on variables such as access to the coast, topography and the distribution of natural resources. For example, Renfrew’s XTENT model overcomes some of the limitations of CPT and Thiessen polygons by taking into account the possible hierarchies of sites based on size and distance among them (Renfrew 1984:58).

Interesting studies using spatial analysis to determine social and ritual organization in prehistoric societies include Darvill’s (1979) investigation of megalithic tombs in Ireland. By using Thiessen polygons and nearest neighbor analysis, Darvill shows different grave types to have different spatial distributions that may be related to social change in Ireland (Darvill 1979:321). Nearest neighbor analysis (Figure 1.4) is a useful tool developed by Philip Clark and Francis Evans who were primarily interested in patterns of distribution of plant populations but found their approach equally applicable to animal populations (Clark and Evans 1954:445). “The measure of spacing which we propose is a measure of the manner and degree to which the distribution of individuals in a population on a given area departs from that of a random distribution” (Clark and Evans 1954:446).

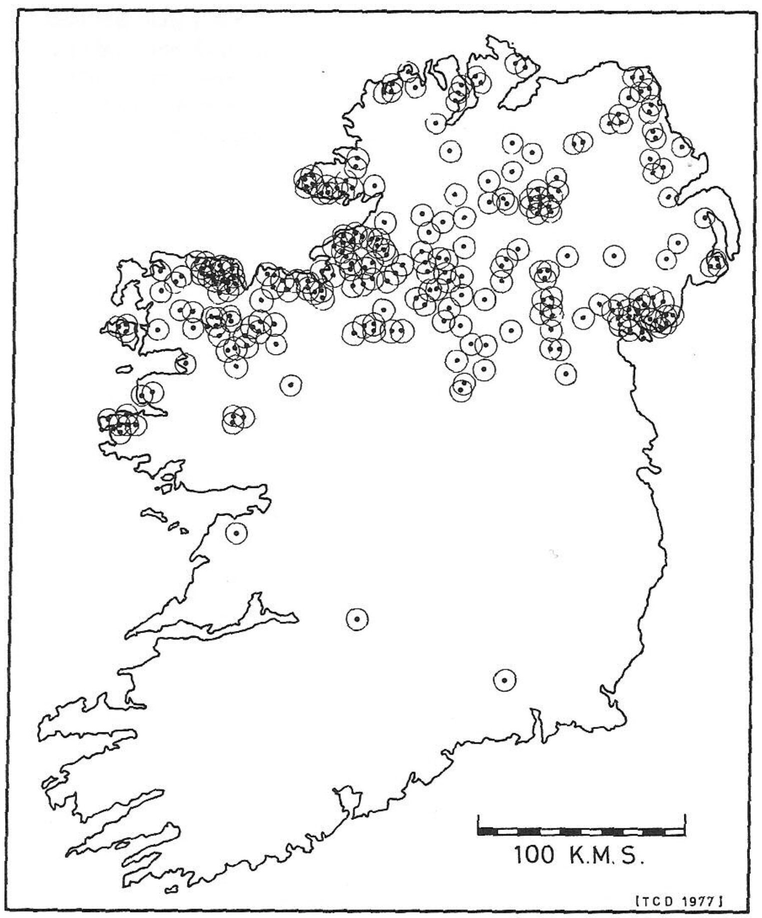

Figure 1.4 Court cairns with mean nearest neighbor circles imposed on the distribution. (Darvill 1979:313)

Nearest neighbor analysis is a measure of spatial randomness that uses the mean nearest neighbor distance in a population of points to calculate the degree of departure of the observed distribution from an expected random distribution (Hodder and Orton 1976:38, 246). Darvill argues that different spatial distributions of graves are a function of changes in the ritual patterning and hierarchical organization that occurred during the transition from segmentary societies to chiefdoms in the middle and late Neolithic (Darvill 1979:325).

1.5 Problems of Definition

Unclear definitions are an impediment to a clear understanding of prehistoric megalithic monumentality. Thus far the issues of what constitutes a prehistoric megalith, and for the purposes of this paper what constitutes a stone circle, have been largely generalized to include structures composed of either a small number of large stones or a large number of small stones. A more detailed discussion of megaliths, however, requires a brief review of the various definitions and classifications related to the term 'megalith.' Historically, attempts to classify megaliths have referred to perceived function or morphology.

V. Gordon Childe provides a reasonable starting point for a review of terminology associated with megalithic monuments. In Childe's *Dawn of European Civilization*, megalithic tombs are referred to as "just artificial caves" (1958:219), and he finds it convenient to distinguish "by quite arbitrary classifications" two main types of tombs: *passage graves* consisting of a chamber with a distinct passage that is lower and narrower than the chamber, and *gallery graves* where the chamber itself is long and narrow and entry is through a passage-less portal. In *Prehistoric Communities of the British Isles* (1940), Childe mistakenly notes, "The megalithic 'circle' always surrounds some sort of cairn, which in well-preserved examples appears as a ring of boulders bordered inside and out by a kerb of big set stones" (Childe 1940:100). In *A Short Introduction to Archaeology* (Childe 1956), orthostats are defined as big stone blocks set on end. When this sort of orthostatic construction is used for tombs, it is termed "megalithic." Childe continues, "Though etymologically this word [megalith] refers to the bigness of the stones, it is conventionally confined to sepulchral monuments" (Childe 1956:58). Regarding tombs, Childe states the "megalithic tombs have been traditionally divided on the basis of plan into dolmens, passage graves and gallery graves or long stone cists" (Childe 1956:64). Dolmens are described in *Dawn of European Civilization* as any megalithic tomb constructed of between three and six orthostats, generally with a small rectangular or polygonal chamber but without an entrance passage. Daniel (1960:214) reports that in France all megalithic tombs are called 'dolmens', while in England 'dolmen' refers to a single rectangular or polygonal chamber.

In *The Megalith Builders of Western Europe* (1959), Glyn Daniel attempts to define what is meant by megalithic architecture in western Europe and creates a useful typology. "There is a sense in which all these monuments in western Europe – there must, at a guess be between forty and fifty thousand of them in western Europe – can be grouped together and labeled megalithic, and that they all employ very large stones, or megaliths, in their construction" (Daniel 1959:14). He defines megalithic architecture in western Europe as monuments constructed of large, roughly dressed slabs of stone with "either the single large slab or the large slab as walling stone with another large slab resting on two or more large walling stones as a capstone – a sort of house of cards architecture" (Daniel 1959:18). He describes a characteristic of megalithic architecture as "namely the fact that the great stones used are rarely dressed to straight edges and faces: they are rough, rude stones" (Daniel 1959:14). Daniel distinguishes the megaliths of Western Europe from the "cyclopean" architecture of the eastern Mediterranean where stone slabs are placed one on top of another and the stone work is chisel-dressed.

Daniel states that in archaeology "it is customary to restrict the term megalithic monument to certain specific types of construction employing these large stones – chamber tombs, rows, single standing stones, and enclosures – which were, in the main, constructed between 2000 and 1500 B.C." (Daniel 1959:15). He then proceeds, however, to combine the categories of 'row' and 'enclosure' to create three separate types of prehistoric megalithic monument in western Europe: chambered tombs; single standing stones; and grouped standing stones. The chamber tomb is defined as a room usually large enough to walk into, which he distinguishes from "large stone cists" (from the Welsh word *cistaen* meaning "a box of stone") which is usually a slab-lined grave holding a single burial and set in the ground with a covering stone slab (ibid). Daniel concedes that intermediate forms exist, however, which may blur the distinction between cists and small chambers. He notes that the word *dolmen*, found in late 18th century French archaeological literature and derived from the Breton word *tolmen*, or table stone, is also used as a general descriptive term for megalithic tombs (Daniel

1959:46). In Wales, the word *cromlech* is used much as dolmen is used in France. Confusingly, in France the word *cromlech* means stone circle. (Daniel 1959:47).

The second type of megalithic monument in Daniel's classification system is the single standing stones, often referred to as *menhirs*, from the Welsh *maen* (stone) and *hir* (long). It is unclear what factors distinguish single standing stones from Daniel's third type of monument, the grouped standing stones. There is the assumption that some common association of single standing stones can be inferred based on their distance to one another which suggests for example, that two stones five meters apart are part of the same construction process and should be grouped together as a site, while stones twenty meters apart are assumed to be unrelated. The utility of the classification system may be further called into question when one notes the proximity and apparent close association between some menhirs and chamber tombs, as well as the occasional chamber tomb found within the circumference of a grouped circle of stones which may be located near standing stones.

Daniel's third megalith type, the grouped standing stones, includes all other monuments that are excluded from the previous two groups, and are, as he says, "difficult to particularize" (Daniel 1959:16). These include the generally circular groupings of megalithic stone which may be found in association with a concentric earthen bank and ditch, referred to as a 'henge.' Indeed, the existence of a henge without stones seems sufficient to justify the label megalith. For example, Stonehenge I, the earliest stage of Stonehenge, dated around 2750 BC, consisted only of a concentric earthen bank and ditch and preceded the erection of stones by over half a millennium

(Hadingham 1975:41; Manley 1989:82). Daniel creates a typology that makes a functional distinction in arguing that while chambers are tombs, most non-chambered megalithic monuments are temples, "non-domestic and non-sepulchral sites of a ritual or sacred nature" (Daniel 1959:17). While this may be a useful basis for discussion of megaliths in western Europe, Daniel contends that this typology should not imply that funerary rituals may not have been practiced in association with chamber tombs, or that treatment of the dead may not have occurred at single or grouped standing stones.

Only a few of the approximately 1300 stone circles in the British Isles have been excavated. Burl's county gazetteer of stone circles in Britain, Ireland and Brittany (Burl 2000:393) lists 342 stone circles in Ireland of which only thirty-six (10.5%) have been excavated. Fewer still reveal evidence of human cremation or burial. Only eight of ninety-three (8.6%) stone circles identified by Sean O'Nuallain (1984:7) in southwest Ireland encircle a burial. Referred to by O'Nuallain as boulder-burials, these dolmens each consist of a large cover stone resting on three smaller support stones located inside the circle (Figure 1.5). None of the burials have been excavated. Three of the ninety-three stone circles (Bohonagh, Reanascreena South and Drombeg) have internal pits which revealed small amounts of cremated bone (ibid). Based on the paucity of burial evidence, it may be that while megalithic rings may have included a funerary function, the primary entombment of human remains seems to have occurred outside of stone circles. The problem of accurately dating stone circles and establishing a chronological sequence has thus far been hampered by the lack of excavations in general and also the lack of datable material found in association with stone circles. One cannot assume that artifactual evidence found inside a stone circle is contemporaneous with the circle itself. Datable material is to be considered more representative of the age of the circle when it is found directly under a stone than merely in the area of the circle. Much work remains for future archaeologists interested in excavating and dating stone circles.

Figure 1.5 Kenmare stone circle with interior dolmen. © Richard Mudhar, 2000. (http://www.anima.demon.co.uk/sites/v907707.html)

We now know that 'megalithic circles' do not always surround a cairn, as Childe believed in the 1940s, nor do we restrict use of the word 'megalithic' to sepulchral monuments. Stone circles fall within Daniel's (1959) megalithic typology as enclosures created by grouped standing stones that do not contain a chamber and need not contain human remains within their perimeters. Thus, it seems appropriate to use a functional typology to distinguish megaliths into three general types: domestic shelters, sepulchral monuments and ritual enclosures that are non-domestic and non-chambered. It also should be noted that in Daniel's *The Prehistoric Chamber Tombs of France* (1960), stone circles are mentioned only in remarks distinguishing them from megalithic tombs. For example, the site Er-Lannic is described as "Not a megalithic tomb but two juxtaposed stone-circles partly submerged" (Daniel 1960:269). Further distinguishing the enclosure category seems best achieved through a typology based on morphology and composition. Following Daniel's functional typology and further delimiting the terms 'enclosure' and 'grouped standing stones' by heuristic morphology, this paper deals with the stone circle as a non-chambered and non-domestic megalithic monument which delimits space through the placement of large stones in a generally circular arrangement.

1.6 Contemporary Theories

Contemporary views regarding the origins of megaliths have shifted away from Childe's modified diffusion theory to the possibility that megalithic monuments may have been invented independently by different people in different stages as part of the natural cultural evolution of man (Daniel and Renfrew 1988:92). Given a basic tomb type as a simple translation of an earthen grave, impressive funerary architecture using stones could have developed independently in a great many areas. Regarding the lack of cultural unity regarding megaliths, Renfrew states:

> We all now realize that the megaliths were not a unitary phenomenon, and that the very use of the term 'megalith' to class together such a disparate variety of monuments, of several independent origins, is to impose a classification which owes more to our own assumptions than to any inherent unity in the material.
>
> (1983:8)

There is sufficient variation in the physical characteristics of megalithic monuments to suggest that there is more than one cultural origin for monumental stone architecture during this period (de Valera 1979; O'Kelly 1989; Woodman 1978;

Renfrew 1983). Colin Renfrew suggests that the study of megalithic architecture should take a regional approach given the broad variation in megalithic monumentality although he emphasizes that “the construction of these monuments represents *a serious, coherent, indeed patterned activity*” (his italics) (Renfrew 1983:9). He is more cautious in ascribing a primary funerary practice to chambered megaliths, described by Daniel as chambered tombs. “The evidence is clear that many of them relate to the disposal of the dead, but we need not assume that this was their primary purpose” (Renfrew 1983:9). Renfrew maintains that the primary purpose of megaliths was as territorial markers to broadcast a group’s claim to land and critical resources. He uses a heuristic, functional typology of social space by defining basic activities which he suggests took place in a prehistoric segmentary society. One can consider *locality* space as “the everyday spatial behaviour of the inhabitants of a particular locality,” such as a homestead or village (Renfrew 1983:10). *Kinship* space can be described as an area defined by residence rules. *Political* space is defined by the territorial aspects of the exercise of power. *Ritual* space refers to the way in which land is divided and used for ritual activities, and *burial* space defines the spatial aspects of handling the dead and the burial process (ibid). Renfrew emphasizes that these spaces are not exclusively defined, but may overlap. For example, residence rules may be expected to define kinship space within a settlement defined as locality space. Also, ritual and burial space may overlap since the physical depository of human remains need not occur within the same space as a death ritual. There is evidence that human cremations within stone circles may have been just one stage in a funerary practice that moved the remaining bones to another location for permanent entombment. Given that a general distinction can be inferred between settlement space and burial space, if we accept the assumption that social spaces are used for specific activities, then the relationship between these spaces may be informative regarding the organization of society and the ecological and resource constraints operating on it (Renfrew 1983:10).

Since the 1980s, emphasis on the functional aspects of megalithic monuments has been challenged by approaches seeking to discover cultural meaning in the archaeological record. This postprocessual approach suggests that if culture is essentially communicative, then material culture should be comparable to a text composed of symbols and an understandable structure. A postprocessual study of megaliths as cultural symbols focuses on decoding their meaning from various characteristics such as morphology and settings (Hodder 1984; Thomas and Whittle 1986) or the funerary organization of human remains (Shanks and Tilley 1982; Tilley 1984). For example, Hodder identifies structural similarities between Early Neolithic long mounds and houses, and argues that the tombs are symbolic transformations of houses (Hodder 1984:53). Shanks and Tilley interpret disarticulated human remains from chambers in Scandinavian megaliths to suggest that the way "human remains were placed within tombs formed part and parcel of the reproduction of power relations" (Shanks and Tilley 1982:151). While processual archaeologists are often concerned with the social function of megaliths, other approaches emphasize the dynamics of inequality within human societies. Elsewhere, Barbara Bender (1985) relates megalithic monuments to the role of religion in society. She interprets passage graves with restricted access in Brittany as evidence of the control of the ritual space by elites who occupied the sacred space to the exclusion of others. As a new type of monument, the gallery grave, developed in later centuries with a more open structure, shows little evidence in terms of grave goods to suggest social differentiation. Bender interprets this change in ritual monumentality as a transformation away from a power structure based on control of ritual practice (Bender1985:38).

1.7 Environmental Archaeology

For the purpose of this thesis I suggest a general definition of environmental archaeology as the study of the material traces of past peoples within the context of their social interactions in the broader natural environment. It is about how people lived in the past, the environment they faced, the resources it provided and the strategies by which people made a living in the worlds around them. A distinguishing feature between environmental archaeology and more site-based approaches is the emphasis placed on the relationships between the archaeological data and the larger surrounding environment in ways that allow social inferences to be made about past cultures. "The essence of the more recent versions of this theory rest on the proposition that archaeological remains are spatially patterned as the result of the patterned behaviour of the members of an extinct society, thus the spatial structure is potentially informative about the way the society organized itself" (Clarke 1977:18). In addition to studying an archaeological site, therefore, the surrounding landscape is also considered an important factor in understanding the context of the site data.

The scale of spatial relationships between human activity and the landscape can be examined at various levels of resolution. On the micro level, spatial archaeology may confine itself to the artifactual evidence within a single structure such as a house, room or grave. Clarke (1977:11) has suggested that at this scale personal rather than economic factors of location dominate the social structure. At a somewhat broader level, communal space such as domestic quarters, ceremonial centers and cemeteries can be spatially analyzed and may display a greater influence of economic factors on location than at the more personal micro level (ibid). At a macro level, the space between sites can provide information regarding the effect of time and distance on energy expenditure in acquiring resources. At this scale economic factors can be expected to dominate the more personal factors in determining location. By viewing the site and landscape together, the boundaries of an area of investigation create a more complete picture of activity by social groups within and between site exploitation territories (ibid). Since excavation of large areas is often impractical, landscape archaeologists often focus on the visible surface features to piece together how people interacted with their environment.

Advances in survey techniques such as aerial and satellite imaging now permit the rapid and accurate analysis of wide areas of land as well as the discovery of new archaeological sites of interest. Among the more stimulating studies in environmental archaeology is a cumulative viewshed (line-of-sight) analysis for site intervisibility conducted by David Wheatley in 1995. By using geographic information systems (GIS) and statistical software, inferences were made about the relationships among sites in the

English landscape based on intervisibility. Wheatley examined the spatial relationship between Neolithic funerary monuments known as long barrows in two regions of southern England. The geographical groupings of barrows have frequently been interpreted as evidence of discrete political groups. Renfrew, for example, has suggested that the barrows are family tombs and represent the existence of chiefdoms characterized by a hierarchical clan society (Renfrew 1973:556). Both regions, one surrounding the later site of Stonehenge and the other just north, including the later monuments of Avebury and Silbury Hill, share a geography of chalk uplands and are located within 20km of each other. The groups are on a scale suggesting that regular travel was likely within each area involving walking distances of about 10km over moderate chalkland terrain (Wheatley 1995:174).

Two types of barrow are known to exist in the area. Earthen barrows generally consist of chalk and turf in rectangular or trapezoidal mounds with flanking ditches. Stone chambered barrows consist of elongated mounds containing stone chambers and often have stone facades at the larger end. Both types of barrow occur in the Avebury region, while only the earthen mounds occur in the Stonehenge region. Discussions of these two regions (Devereux 1991, Thomas 1993) have emphasized the role of monument visibility and intervisibility in the interpretation of social hierarchy. Wheatley's analysis suggests that the choice of location for constructing barrows in the Stonehenge area is a function of intervisibility with other barrows while placement of barrows in the Avebury region is not statistically significant with respect to intervisibility. Of this spatial relationship Wheatley says, "it seems distinctly possible that visual references to other barrows may have constituted part of the mechanism by which social structures were reproduced and renegotiated" (Wheatley 1995:178). This information may provide insight into the function of barrows as well as a context for construction of later tombs.

Over the years, archaeologists interested in the megaliths of western Europe seem to have given more attention to funerary monuments than to stone circles. It is understandable since graves, tombs and burial cists are more likely to hold human remains and grave goods that can be analyzed and interpreted in a familiar context. Inferences can then be made about cultural behaviors such as social hierarchy, economy, belief systems and kinship rules. Stone circles are seldom found to have a close and primary association with funerary practices and so are sometimes overlooked by archaeologists more interested in the "bones" than in the "stones." This may be due in part to the difficulty of relating space on either side of stones which appear to delimit space to the stones themselves. While one might be tempted to think it obvious, a primary burial site within a stone circle may be no more integral to the original purpose of the monument than a grave located a few meters outside the circle. Additionally, difficulties associated with reliably dating the time of construction of stone circles make any connection with cultural remains equivocal. Therein lies the mystery of stone circles. Hopefully, careful excavation of stone circles in the future will help reveal their original purpose. It seems obvious from the amount of effort involved in constructing stone circles that they played a significant role in the lives of early humans in Ireland.

Spatial analyses of stone circles on a macro level can provide information regarding their role in early Irish society.

The goal of the present study is to examine the spatial relationships among stone circles in the southern Irish counties of Cork and Kerry. Spatial analyses techniques utilizing Thiessen polygons, nearest neighbor analysis and site intervisibility are used to determine if patterns in site location exist which allow social inferences to be made about the people who built them.

CHAPTER 2

LANDSCAPE OF IRELAND

2.1 Introduction

Ireland is an island of ancient rocks. It is located in the north Atlantic on the westernmost margins of northern Europe. Separated by the Irish Sea from parts of northern Britain by as little as 15 miles, Ireland is less than half the size of Britain, which is positioned between it and the continental mainland. The natural landscape of Ireland is the result of geological, biological and climatic processes that took place over millions of years independently of humans. Understanding the landscape prior to man's arrival in Ireland is integral to appreciating how and why arriving people modified the environment to suit their needs. Today's cultural landscape is the result of millennia of human activity upon a changing natural landscape, and it complicates efforts to understand man's relationship with the environment during the early stages of human settlement in Ireland. Thus, one challenge of environmental archaeology is to attempt to reconstruct the natural landscape as early humans found it in order to derive some understanding of the cultural behavior that changed the landscape and gave rise to such features as megalithic architecture during the Neolithic and Bronze Age in Ireland.

2.2 Pre-Pleistocene Ireland

Ireland is geologically similar to the highlands of Scotland, with the majority of rocks dating from the Palaeolozoic era, 570 - 230 million years ago (Aalen 1978:9) (Figure 2.1). Ireland's physiography is the result of geological folding and faulting which has left three-quarters of the country, largely the Central Lowland, less than 500 feet (152.5m) above sea level and 95% less than 1000 feet (305m) above sea level (Aalen 1978:10). Caledonian folding during the Devonian-Silurian period, approximately 400 million years ago has given Ireland a noticeable northeast-southwest grain. In southern Ireland, tectonic folding from 300 million years ago has resulted in an east-west orientation of ridges and valleys separating the Old Red Sandstone mountains of the south from the lower Carboniferous land to the north (Holland 1981:194). The Central Lowland, composed of Carboniferous limestone and underlying Old Red Sandstone, is the dominant physical feature of Ireland, covering an area of 8000 sq. miles at an elevation mostly between 60 and 120 meters (ibid). Around the margins of the island, detached upland areas of quartzite and granite provide a perimeter with corridors from the Central Lowland to the sea through the Moy, Slaney, Barrow, Nore and Suir Valleys. Only in the Boyne Valley, north of Dublin, is the upland perimeter absent, allowing the interior lowlands to reach the east coast. These valleys form the traditional avenues of communication between the coast and lowland interior. The upland areas are composed of four geographically distinct regions: the Caledonian highlands of the northwest, the Caledonian structures in the east, the Armorican hills and valleys of the south, and the Cenozoic basaltic region in the northeast (ibid). Together with the Central Lowland, the

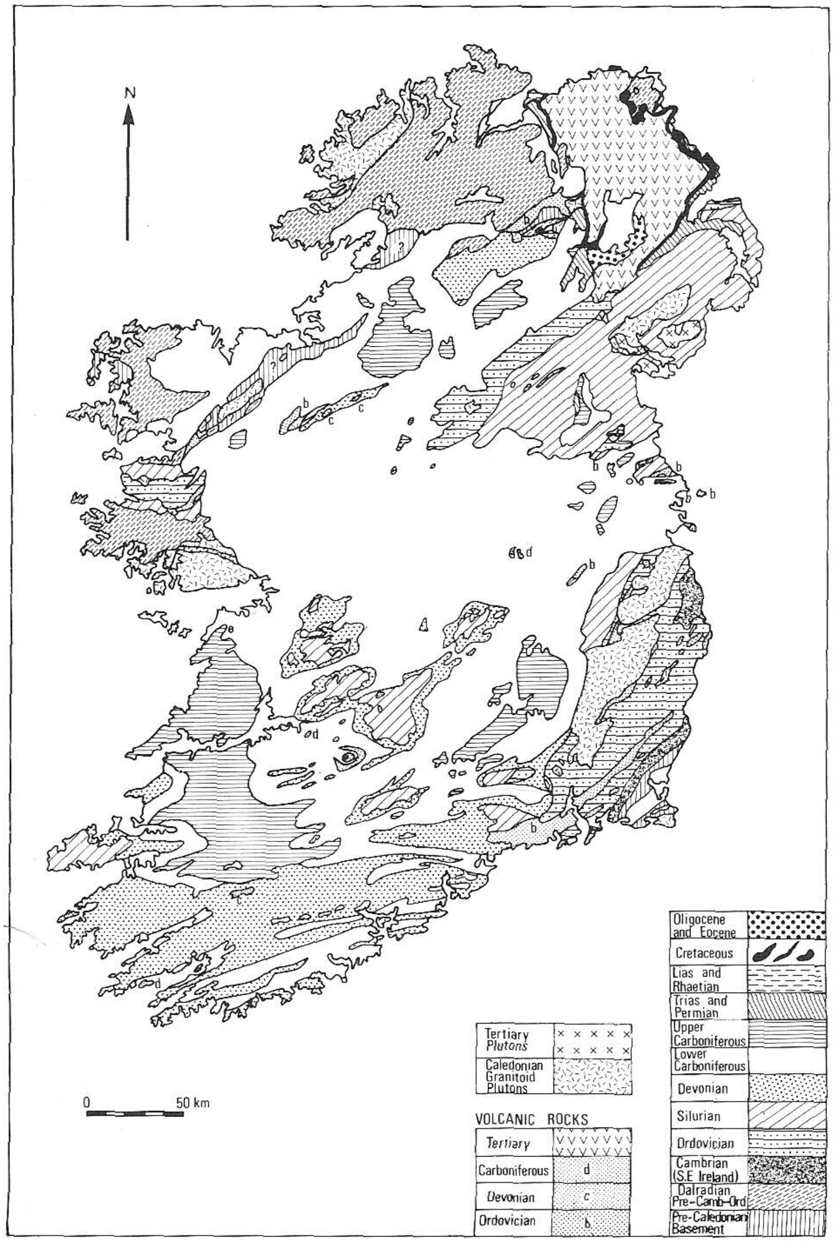

Figure 2.1 Geological map of Ireland (Holland 1981:3).

country is divided into five major physiographic regions. The resulting geology has left Ireland with a wealth of minerals. Gold is found within the granite of the Leinster Mountains which extend from Dublin Bay down the east coast to Waterford. Silver deposits exist in the south-central regions of Tipperary, and copper in the Wicklow Mountains on the east coast and in the southwestern regions of Counties Kerry and Cork (Herity and Eogan 1977:1).

The soil is the product of glacial action during the Pleistocene when ice sheets several hundred meters thick ground the central region into a broad plain (ibid). The soil is variable in composition, ranging from irregular deposits of till (boulder clay) to water-sorted sand and gravels (Aalen 1978:20). This drift cover is distributed unevenly, reaching a thickness of over 60m in the eastern Central Lowland but thinning out in the west where outcrops of solid rock occur. On the western and northern edges of the Central Lowland the drift forms rounded, tightly packed hillocks, called drumlins, surrounded by lakes and bog patches in the lower hollows (ibid). Over time the persistent moist climate, irregular terrain and poor drainage of the drift deposits has resulted in extensive areas of peat bog growth in the Central Lowland and along the western regions of Ireland (Aalen 1978:23). The growth and decay of peat combines with the underlying clay soil to produce an acidic peaty gley that is the most widespread and fertile soil type in the country (Aalen 1978:27). Rocky surfaces predominate in the upland areas and are the result of abrasion by the glacial ice combined with wind and weather, which has removed fertile soil from land at higher elevations (Aalen 1978:23). The deposition of drift soil in the lowlands often extends up the sides of glaciated valleys to elevations of from 180 to 240 meters and determines the altitudinal limits of land suitable for farming (ibid).

The history of the natural vegetation of Ireland is revealed largely through the analysis of fossil pollen and radiocarbon dating. In Ireland, wind-blown pollen grains are well preserved in anaerobic conditions within the strata produced from grassy tundra during the Late Glacial period (ca.10,000 – 9,000 BC) and peat bogs that became established in the Central Lowland around 8500 BC. These peat bogs have grown steadily from that time to the present. As the bogs decay and accumulate into thicker layers, a pollen record of vegetational changes is preserved, allowing a history of vegetation and climate to be determined (Aalen 1978:28).

2.3 The Ice Age in Ireland

Over the last 200,000 years Ireland is thought to have experienced two major glaciations, the Munsterian and Midlandian, which correspond to the Riss and Würm glaciations in the Alps (Aalen 1978:17). During the Munsterian glaciation, about 200,000 to 130,000 years ago, most of the island was covered by ice except for areas in the west and southwest (Holland 1981:244). During the second glaciation, about 70,000 to 10,000 years ago, ice covered the northern and central parts of the country as well as the southern highlands of Kerry and west Cork, but left an ice-free corridor zone of tundra extending from Dingle peninsula in the west to Wexford in the east (Figure 2.2). Thus, parts of southern Ireland remained unglaciated during portions of the final stages of the Pleistocene (ibid). The last glacial ice began to melt away about 12,000 years ago, leaving the surface topography much as it is today, although the coastline profiles have changed periodically due to post-glacial sea level changes caused by the melting ice sheets (Aalen 1978:20). The ice sheets deposited most of the productive soils on the

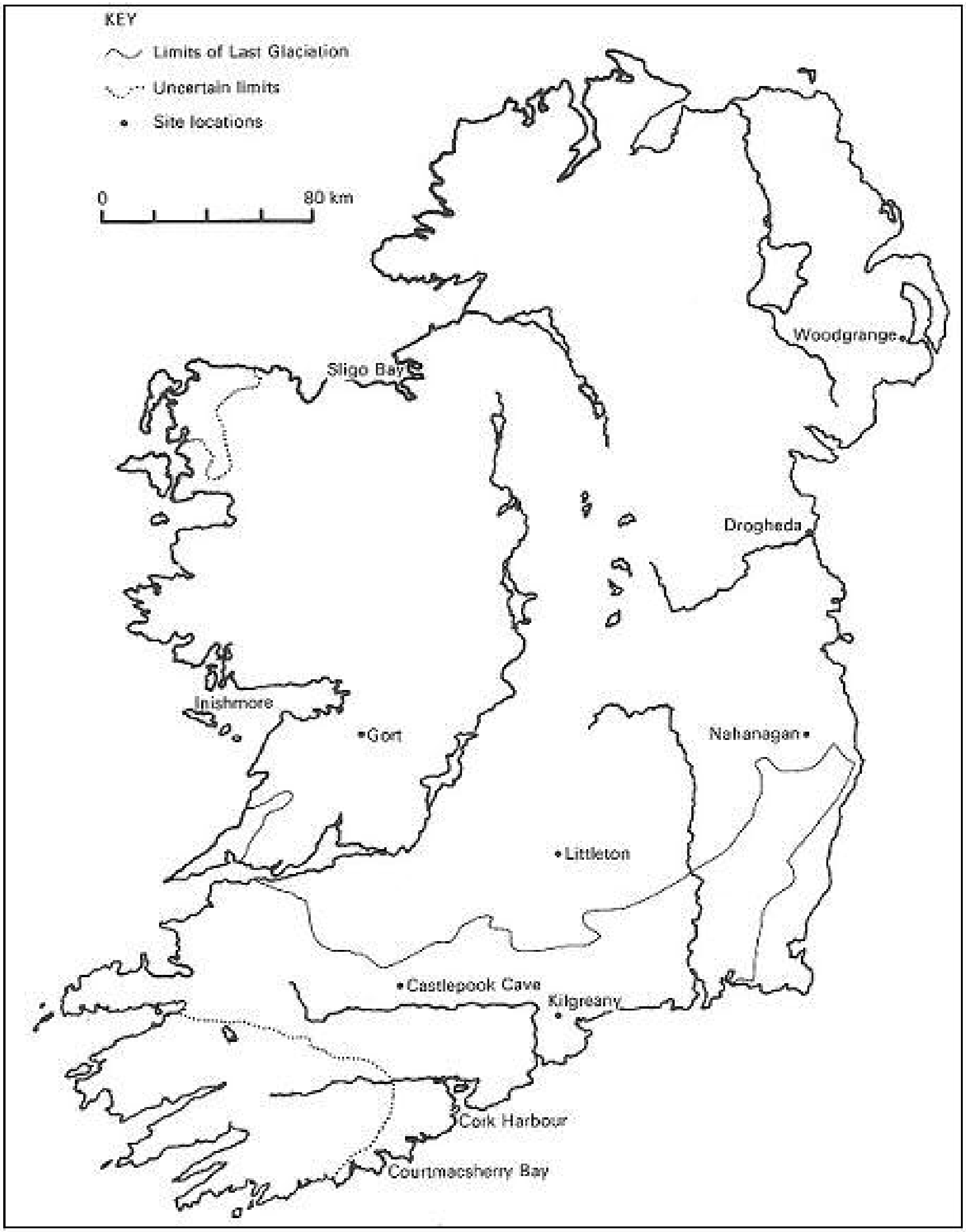

Figure 2.2 Glacial limits. (O'Kelly 1989:4)

limestone Central Lowland plain, which allowed peat bog growth and has influenced the landscape and patterns of land use by man (ibid).

The flora of Ireland was largely eliminated during the last Ice Age although plant species in the unglaciated southern regions of the country may have survived (Aalen 1978:29). During the glacial period the sea level was several hundred feet lower than present due to the vast quantities of water that were locked up in the ice sheets. It is probable that during this period Ireland was connected by land bridge to Britain, and Britain to the European continent (ibid). Around 10,000 – 9,000 BC, during the Late Glacial Period, lowland areas in Western Europe, Britain and Ireland were covered by open tundra vegetation that established itself as the ice retreated (Aalen 1978:30). Animals found it possible to move across these temporary land bridges from the continent. In Ireland, the tundra vegetation supported reindeer, brown bear, mammoth, Irish hare, lemmings and Artic fox (Herity and Eogan 1977:16). As climate ameliorated, an increasing variety and volume of flora became established, including sub-arctic heath, dwarf willow, dwarf birch, crowberry and juniper. Large herbivores attracted to the vegetation included reindeer, giant Irish deer, bison, wild cattle, wild boar and horse (Evans 1975:86, Aalen 1978:31, O'Kelly 1989:13). While evidence indicates that Paleolithic hunting groups were following migratory herds of large herbivores in western Europe and Britain during this time, there is no unequivocal evidence that Paleolithic man reached Ireland (Herity and Eogan 1977:17, Aalen 1978:31, O'Kelly 1989:5). The island's insular nature and remoteness from the continental mainland would likely have diminished the probability of large-scale immigration by hunting groups (Aalen 1978:31). It is not until the Boreal period (ca. 7500 – 5500 BC), when deciduous forests, lakes and lowland swamps evolve, that evidence suggests a suitable habitat for man (Evans 1975:79, Aalen 1978:31, Mitchell 1981:259, O'Kelly 1989:13).

For several millennia following the Pleistocene, sea levels rose in response to melting ice sheets, and by about 5000 BC most land bridges between Ireland and Britain would have been submerged. By then coastlines would have been similar to their present outline (Aalen 1978:29). The Mesolithic period, beginning around 6000 BC, marks the first evidence of humans in Ireland (Aalen 1978:40). While the fauna of Ireland might have been isolated by rising sea levels, humans would have continued to move onto the island by boat (O'Kelly 1989:10). It seems likely that the environment at the time would have been suitable to humans, whose way of life involved hunting, fishing and gathering (Herity and Eogan 1977, Aalen 1978, O'Kelly 1989).

2.4 Evidence of Humans

One of the earliest archaeological sites in Ireland is Mount Sandel (Upper) located on a ridge overlooking the River Bann in northern Ireland. Based on the work of Peter Woodman (1978, 1985), the site revealed posthole remnants of roughly circular huts about six meters in diameter, each with a central hearth. This site has been interpreted as a substantial base camp that might have been occupied most of the year (O'Kelly 1989:22). Flintknapping areas with microliths and flake axes were identified, along with burnt hazelnut shells, seeds and the bones of pig, hare, birds and fish. Radiocarbon dates ranged from 8960±70 BP to 8440±65 BP (O'Kelly 1989:22). Other early Mesolithic sites include Mount Sandel (Lower) (8370±200 BP); Castleroe, on the west bank of the River Bann, dating to the first half of the 8th millennium BP; and Lough Boora in the central plains of Co. Offaly, with dates similar to Mount Sandel in the north. O'Kelly suggests that early Mesolithic people might have been widely dispersed throughout a large portion of Ireland, perhaps entering the island along the northeastern coast from Britain (O'Kelly 1989:24). It seems probable that by this time, if not earlier, the Irish Sea and English Channel may have been seen not as an obstacle to travel, but rather as a travel route to be exploited. It is likely that Mesolithic people made short sea voyages in primitive craft such as skin-clad coracles and curraghs (Yesner 1980:730, Edwards and Mithen 1995:348). As O'Kelly states, "It seems unlikely that the neighbouring land-masses were unknown to the coastal dwellers on each side of the dividing waters" (1989:30).

The available evidence of the earliest Mesolithic settlements indicates they are all located in the northeastern area of Ireland (Figure 2.3), making it probable that Mesolithic man's first entrance into Ireland might have been from Scotland (Aalen 1978:42, 46). Their mode of existence was based on a hunting and gatherering economy, and they appear to have spread throughout the northern half of Ireland, possibly making use of the flint resources there (Aalen 1978:44). There is no evidence, however, that their nomadic lifestyle included the use of megalithic structures of the kind now found throughout the island. The final stages of the Mesolithic hunter-gatherer lifestyle survived until about 3000 BC. Evidence suggests that the Neolithic way of life based on farming and animal husbandry was already established in Ireland during the fourth millennium BC (O'Kelly 1989:27). In southwestern Ireland, at

Ferriter's Cove on the Dingle peninsula, the discovery of a planoconvex flint knife near several small shell middens is considered an indicator of Neolithic activity (O'Kelly 1989:28). Subsequent excavation at Ferriter's Cove revealed no evidence of pottery or domesticated animals associated with the Neolithic, but did reveal several blade types

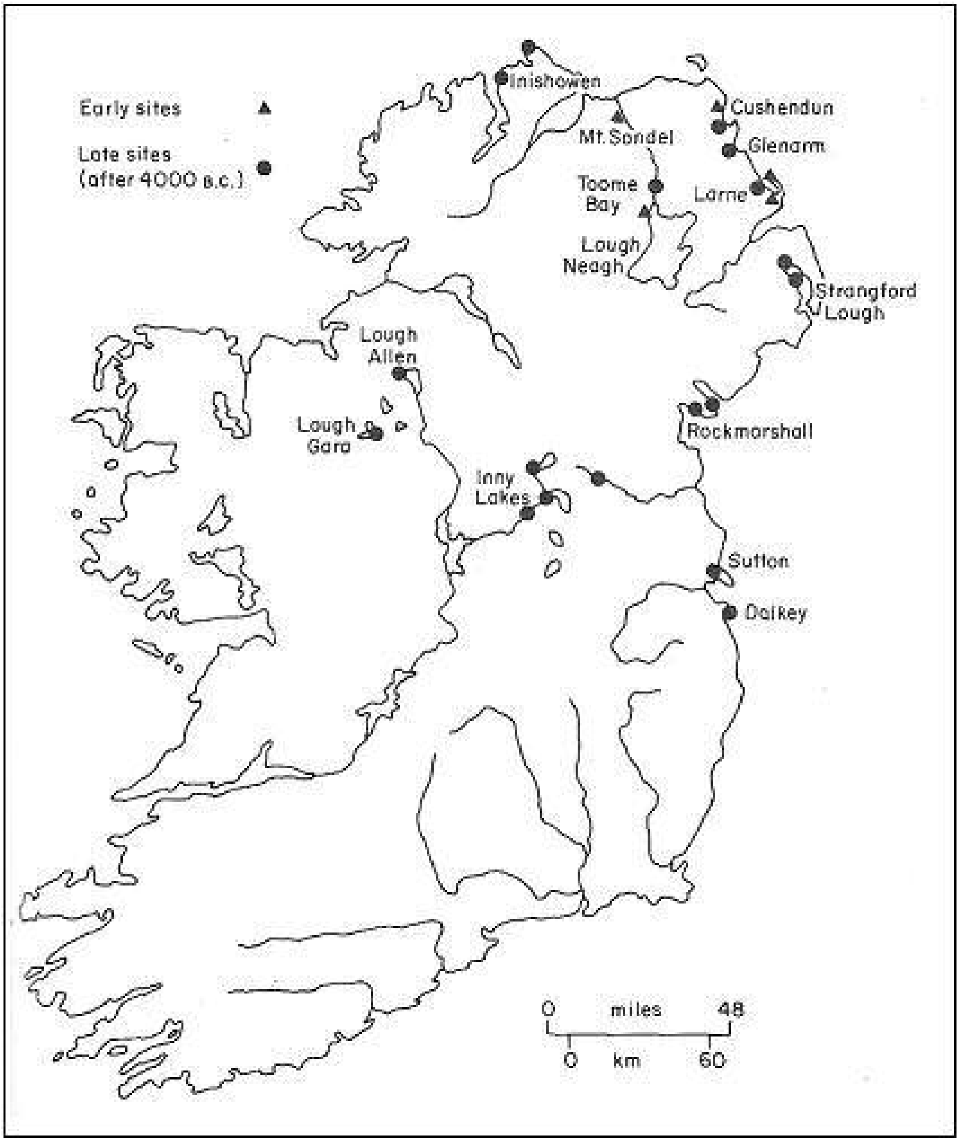

Figure 2.3 Distribution of major Mesolithic sites. (Aalen 1978:43)

considered representative of a late Mesolithic blade industry (ibid). Radiocarbon dates ranging from 5620±80 BP to 5190±110 BP suggest the site may be transitional between the Mesolithic and Neolithic (O'Kelly 1989:29). O'Kelly suggests that Ferriter's Cove represents a coastal site of well-adapted hunter-gatherer groups living concurrently with other communities who had already adopted a lifestyle based on farming. In Ireland, the transition from Mesolithic hunter-gatherer to Neolithic farmer appears to have taken place gradually over an extended period (Aalen 1978:47). While some archaeologists may view this transition as so drastic that only an invasion can account for the change, others believe that the transition to the Neolithic in Ireland was a slow process resulting from peaceful overseas contacts between large numbers of culturally diverse immigrants (O'Kelly 1989:29). Clearly, at some point a transition in economy occurred from hunting and gathering to animal domestication and farming, and this transition seems to have taken place over 500 years or more. Evans (1975:109) notes the possibility that early Neolithic communities may have existed with an economy based entirely on domesticated cattle, making the transition from Mesolithic herd-hunting even less distinct in the archaeological record.

Considerable evidence of the transition to farming is suggested from pollen profiles and vegetation analyses that support the idea that the clearing of forested land by fire was integral to the development of agriculture and animal husbandry (Evans 1975:113, Aalen 1978:47, Herity and Eogan 1977:24, O'Kelly 1989:33). The use of fire by Mesolithic hunter-gatherers to stampede a herd or create a clearing to attract grazing animals should not be ruled out, however. If this was practiced, the effect of fire on vegetation may have been significant and perhaps out of proportion to the intended use of the fire as well as to the size of the human population using it (Smith 1970:81, Evans 1975:114, Manley 1989:28). Evidence of deforestation alone probably should not be relied upon to define accurately a transition phase between the Mesolithic and Neolithic. It might also be unwarranted to emphasize a link between the building of megaliths and land clearing that characterizes the Neolithic period. Aalen (1978:49) suggests that Irish megalithic tombs dated to the late fourth millennium BC appear to pre-date the first Neolithic land clearances. Reasonably assuming that Mesolithic nomads are not the originators of megalithic monuments, Aalen suggests that the earliest Neolithic settlers in Ireland might have brought with them burial customs involving mortuary monuments of timber, which led to the use of stone as a need for permanent monuments developed. The variation in megaliths throughout Ireland also suggests a diversity of origins from Britain and the Continent. "But the existence of distinct megalithic building styles in Ireland with, to a significant degree, complementary geographical distributions, could be taken to imply the existence of diverse immigrant streams possessing, on arrival, their own well developed megalithic traditions, and, if that is the case, it suggests a separate origin for any pre-megalithic farmers who may have existed" (Aalen 1978:49). During this early period of agriculture and animal domestication, people migrated from Britain and the Continent into Ireland, bringing with them cereals, cattle, sheep and goats, none of which are native to Ireland (O'Kelly 1989:117). The earliest indisputable evidence of farming communities in Ireland dates to the mid-4th millennium BP and comes from several sites in the north

(Evans 1975:108). At Ballynagilly, Co. Tyrone, the foundation of a house with hearth and pottery was uncovered and dated ca.3800 – 3700 BC (ApSimon 1969). At Ringneill Quay, Co. Down, bones of domesticated cattle, sheep and pig were found in a midden (Stephens and Collins 1960). The process by which land was cleared for more permanent farming settlements, however, need not overly concern us in this research. It is sufficient to understand that during this transition to a sedentary lifestyle with permanent settlements megalithic architecture is thought to have arisen (Aalen 1978:47). What is important is that the sedentary lifestyle of farming that replaced hunting and gathering provided the opportunity for one or more cultures to incorporate megalithic structures such as stone circles into their social organization.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The distribution map has long provided the foundation upon which most archaeological studies have built their theories concerning trade, diffusion, culture and chronology (Hodder and Orton 1976:1). "For the past thirty or forty years archaeological distribution maps have been one of the main weapons in the armoury of the prehistorians" (Clark 1957:153). The increased use of spatial analysis in archaeology over the last thirty years has come from the desire to use more detailed and systematic methods in the examination of archaeological data, and of widely available computers and software capable of handling large amounts of spatial data. With the application of statistical analyses, a bias inherent in the visual interpretation of mapped data is reduced. Ideas of random and regular spacing can be more rigorously tested, and correlations among spatial data can be resolved with greater statistical probability. For example, if circles are drawn around points on a map that represents settlement sites, these buffer zones can suggest spheres of interaction in an otherwise apparently random collection of sites. Clusters of these buffer zones might then be investigated as possible centers of greater population and activity with implications relating to trade, diffusion, social hierarchy, belief systems and other aspects of cultural evolution.

The nature of human behavior and a hypothesis of non-randomness in spatial patterns are fundamental to this research. Most, if not all, of the data that archaeologists recover are spatial in nature. Most, if not all, of human behavior is non-random (Hodder and Orton 1976:9). We should thus expect spatial patterns resulting from human behavior to be non-random and detectable (Clarke 1977:9). Spatial patterns created by humans are expected to be non-random because we know that individual behavior is not random but is influenced by many physical, biological and social factors. Non-random behavior is not always apparent, however, in spatial patterns. Groups of individuals behaving in accordance with those factors that influence them can produce an aggregate pattern that may theoretically be similar to patterns produced by random processes (Hodder and Orton 1976:9). Care should be taken, therefore, when testing theories about spatial data as they relate to human behavior. Another concern with the use of spatial analysis is that of inferring social process from spatial form. The benefit of spatial analysis in archaeology is its ability to define more objectively the probabilities of behavior based on the data. Thus, while interpretations of behavior may continue to be subjective, analysis of data based on statistical probabilities can help produce more objective results from which to draw behavioral interpretations.

Spatial patterns can be produced by a variety of different factors, and tests can be applied to statistically differentiate among those factors, or variables (Hodder and Orton 1976:8). For example, if a mapped area is subdivided into equal cells and superimposed over points representing archaeological sites, a certain level of randomness becomes predictive. On a basic level, empty cells might predict where an undiscovered site is more likely to be found, or where a destroyed site previously existed. Spatial analysis does have limits, however. It is impossible to identify and test all possible variables that may be significant in a process. In this study, I make no claim to identifying all the possible factors influencing the decisions that resulted in the construction of stone circles in their particular locations.

Uses of spatial analysis in archaeology have expanded beyond theories of central place (Christaller 1933) and nearest neighbor measurements of plant populations (Clark and Evans 1954). Increased emphasis on spatial analysis can be found in modeling approaches (Clarke 1968, 1972, 1978; Hodder and Orton 1976; Johnson 1977); theories of territoriality on Orkney (Renfrew 1973, 1984); location analysis of settlements in prehistoric Maya (Green 1973) and modern Argentina (Upton 1986); nearest neighbor analysis relating to human behavior (Pinder et al. 1979); and site catchment analysis (Vita-Finzi 1978). More recent approaches using geographic information systems (Kintigh and Ammerman 1982; Kvamme 1990; Ebert 1992; Wheatley and Gillings 2002) include monument intervisibility on the Croatian island of Hvar (Gaffney and Stancic 1991); territoriality on the Easter Islands (Renfrew 1984); and investigations of Celtic road systems (Madry and Rakos 1996). Spatial studies conducted in the British Isles have examined locational models of Romano-British settlements (Hodder (1972); Bronze age monument visibility on the island of Mull, Scotland (Fisher et al. 1997); territoriality in the Orkneys (Renfrew 1979); the distributional effect of cairns and graves on social organization in neolithic Ireland

(Darvill 1979); and intervisibility among English long barrows (Wheatley 1995) and hillforts (Lock and Harris 1996).

My approach in this research is two-fold. An initial examination is made of the generally accepted categorizations of stone circles into two groups, five-stone and multiple-stone (all others). Secondly, my research examines the probabilities that stone circles were intentionally situated with respect to their visibility to other stone circle sites of similar form. A determination of the statistical probability of a preference for line-of-sight intervisibility among the stone circles in southwest Ireland is explored. A tendency toward or against line-of-sight visibility might have had social implications for small groups of settlers who occupied land for pastoral and agricultural use during the Neolithic and Bronze Age.

The approach involves descriptive and inferential statistics of the available data. It is beyond the scope of this paper to give a comprehensive introduction to basic statistical theory, and it is hoped that the interested reader will consult one of the many textbooks on the subject if additional information is desired. The sample data are examined statistically to suggest whether or not stone circles in southwest Ireland should be considered representative of a single statistical population based on spatial distribution, morphology, association to other megaliths, excavation finds, elevation, nearest coastal distance and nearest neighbor distance to other stone circles. Thiessen polygons and weighted buffers are used to visualize theoretical regions of influence surrounding sites. Tests of spatial association between clusters of sites suggested by O'Nuallain (1984) are also performed. Finally, following Wheatley's approach (1995), cumulative viewshed analysis is used to examine line-of-sight intervisibility and suggest a possible relationship among the builders of the stone circles.

The stone circles in southwest Ireland have been well studied and documented by O'Nuallain (1984), Burl (1995, 1999, 2000) and others. Their distribution in a small region of the island provides an opportunity to examine spatial associations with regard to several variables. In choosing the stone circles of southwest Ireland for analysis, the assumption is made that these sites represent a non-random cluster that is situated in the landscape based on a number of factors. In investigating whether intervisibility among sites was one of these factors, an assumption of contemporaneity is made that must be addressed. Few reliable dates have been obtained for the construction of stone circles, although a period from 3300 BC to 900 BC has been noted by Burl (2000:5). It is apparent that over this period of time people likely changed and cultures evolved in ways that may have been reflected in changes to the style and structure of stone circles. Regarding the megaliths of western Europe, Colin Renfrew has written, "Chronological problems will persist, whenever spatial distributions are studied, until the far-off day when every monument under consideration can securely be dated by means of radiocarbon" (Renfrew 1982:17). More interesting than establishing a chronology of construction, perhaps, is the detection and understanding of cultural change over time. Statistical analysis of spatial patterns that exist among groups of stone circles can help reveal cultural change with a certain degree of probability. Thus, spatial analysis of stone circles can be useful in understanding human behavior and cultural evolution. In this research, several approaches are used, including nearest neighbor analysis and cumulative viewshed analysis of intervisibility, to reveal interesting characteristics concerning stone circles as indicators of cultural change in southwest Ireland.

3.2 Site Characteristics

3.2.1 Site Data

Appendix A provides a list of the Five-stone circles from O'Nuallain (1984:6) and six other sites considered within the Five-stone group (Burl 2000:398-401). Included are the location coordinates; an estimate of the interior area in square meters derived from the diameter as reported in O'Nuallain (1984) and Burl (2000); the elevation (m.a.s.l.) obtained from a digital elevation map (DEM) using the geographic information system ArcMap; the distance from each site to its nearest five-stone neighbor; the distance from each site to the coast; and the number of five-stone sites visible from each site. Appendix B provides a list of O'Nuallain's multiple-stone circles (1984:4) and five other sites identified by Burl (2000:397-401) considered within the multiple-stone group. Listed are their location; number of stones used in their construction; interior area estimate; elevation (m.a.s.l.); distance from each site to its nearest multiple-stone neighbor; the distance from each site to the coast; and the number of sites visible from each multiple-stone site. The coordinate location (latitude and longitude) in decimal degree notation for each site was obtained from The Megalithic Portal (http://www.megalithic.co.uk/) which publishes GPS data obtained and submitted by visitors to archaeological sites. This data is compared to historical information from the national mapping agency of Ireland and reviewed for accuracy prior to posting (Burnham 2005). Location coordinates unavailable from the website were obtained by converting the Irish national grid reference designation, created by the Ordnance Survey of Ireland and published in O'Nuallain (1984) and Burl (2000), to coordinates in decimal degree notation.

3.2.2 Spatial Distribution

In Ireland, stone circles are concentrated in the northern and southern regions of the country (Figure 3.1). In the Republic of Ireland, a survey by Sean O'Nuallain (1984) identified 93 stone circles in the southern counties of Cork and Kerry. More recently, Aubrey Burl (2000:394) increased the number of possible sites in the southern region to 123. Burl lists 156 stone circles in Northern Ireland and 187 in the Republic of Ireland (ibid). The study area chosen for this analysis is similar to O'Nuallain's map (Figure 3.2) and encompasses the stone circle sites identified in southwestern Ireland (Figure 3.3). The Cork-Kerry type of stone circle in this region are not found elsewhere in Ireland or Britain, although certain similarities exist between them and stone circles found in northeast Scotland (O'Nuallain 1984:8; Burl 2000:215). Sean O'Nuallain reports that "No general custom of siting is evident" (1984:8) regarding the Cork-Kerry stone circles and that few sites are situated on hilltops or in otherwise prominent locations. He notes that sites located on hill slopes are often situated on small natural platforms that interrupt the general gradient of the hills. He reports that all sites are located between 15 – 275 meters above sea level except for two sites, each composed of five stones, which are located at an elevation of 335 m.a.s.l. O'Nuallain reports that only two of 45 (4%) stone circles composed of five stones are found below 90 m.a.s.l., while 20 of 48 (42%) larger stone circles are located below that altitude (ibid).

Figure 3.1 Distribution map of stone circles in Ireland.
(after O'Nuallain, in O'Kelly 1989:240)

Little has been documented regarding the distance between stone circles and their nearest neighbor, or their distance from the nearest coast. O'Nuallain reports "few of the forty-five five-stone examples are near the sea" (O'Nuallain 1984:8) and "The forty-eight multiple-stone sites are found throughout the distribution but predominate in coastal areas as do the boulder-burials" (ibid). Proximity to the coast may have been a factor in location selection of stone circles. Whether the stone circles of Counties Cork and Kerry described by O'Nuallain in 1984, and several more described since then, may be attributed to one or more cultures and/or periods is a question of interest to researchers of Irish prehistory and will be addressed in this paper.

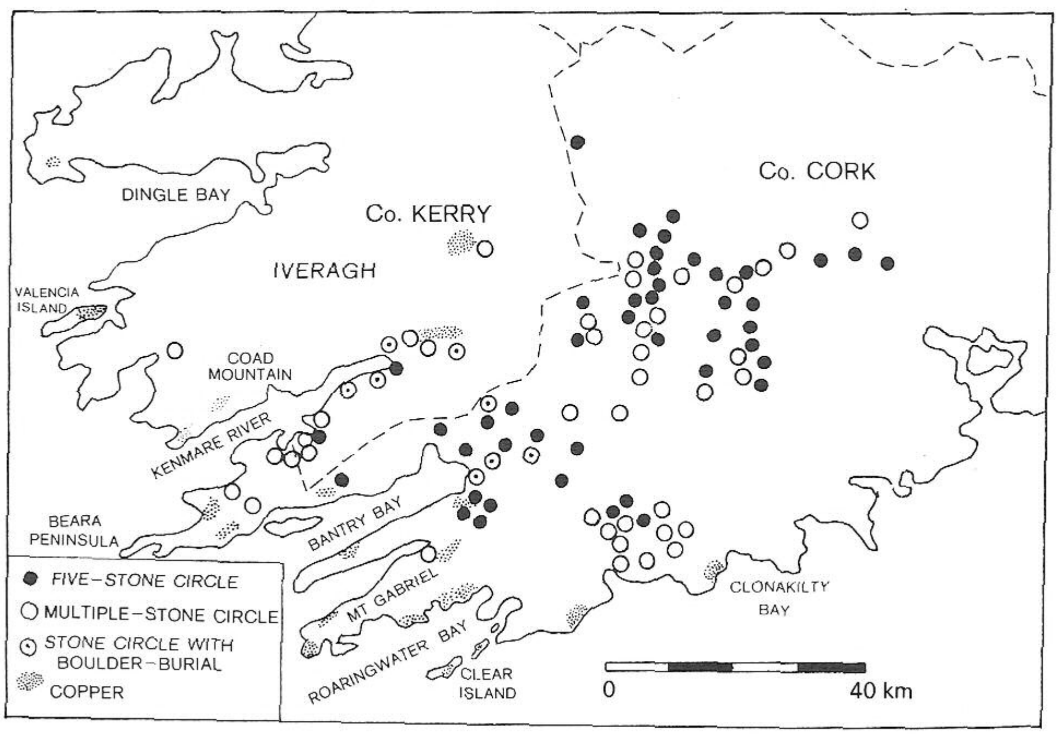

Figure 3.2 Map of stone circles in Counties Cork and Kerry.
(after O'Nuallain, in O'Kelly 1989:235)

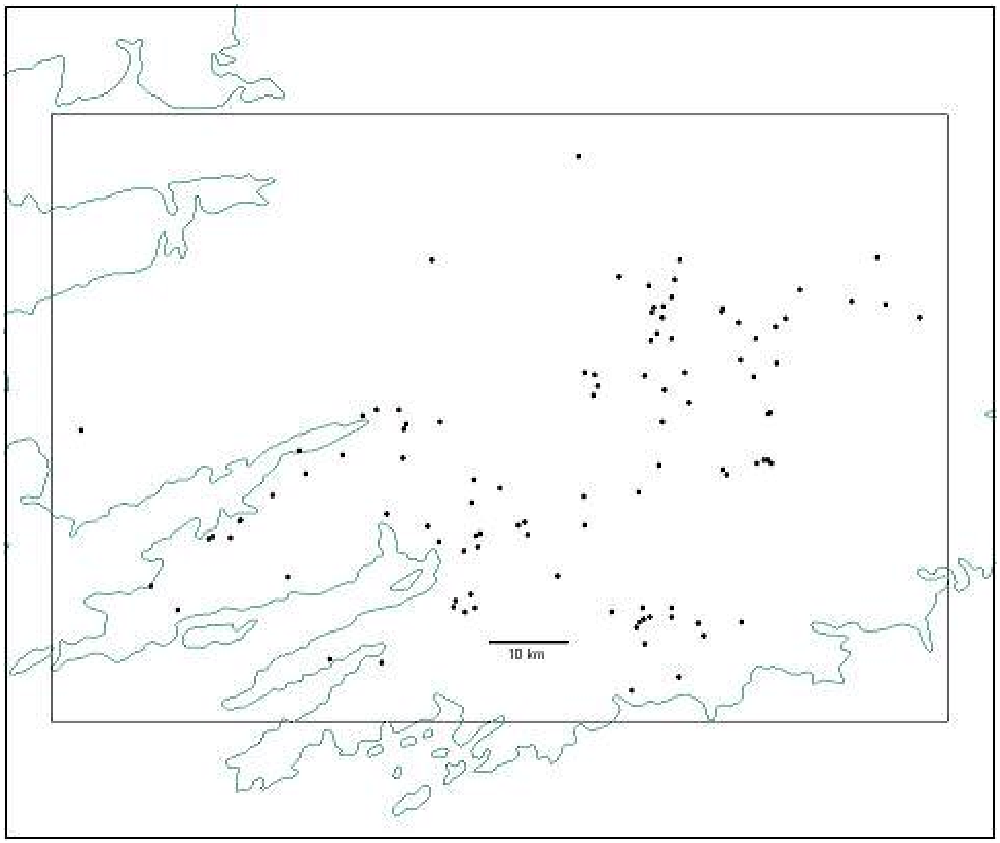

Figure 3.3 Study area enclosing the Cork-Kerry stone circles.

3.2.3 Morphology

The Cork/Kerry stone circles are unique to southern Ireland and of particular interest. They are defined by "an uneven number of spaced uprights symmetrically arranged with the axial stone (erstwhile 'recumbent stone') on the south-western section of the perimeter, standing directly opposite the entrance" (O'Nuallain 1984:3). The term 'axial' is used to describe a stone in which the long axis is horizontal to the ground rather than vertical. The stones are further described as decreasing in height from both sides of the entrance down to the axial stone (ibid). Additionally, O'Nuallain describes the stone circles as falling into two categories based on morphology: those consisting of five stones and those with a greater number of stones marking the perimeter. Forty-five of 93 stone circles reported by O'Nuallain consist of five stones. The 48 remaining stone circles, termed 'multiple-stone circles' are delimited by uneven numbers of stones ranging from seven to 19. O'Nuallain notes that only 16 of the stone circles are complete, but that in 16 others "the probable number can be deduced with a high degree of certainty. In nine other circles the number can be estimated with rather less confidence while the remaining seven were certainly of the multiple-stone type" (O'Nuallain 1984:3). Other distinguishing characteristics between the two groups include their shape, orientation to the sun, entrances and the types of monuments considered to be associated with them (ibid).

The five-stone circles are not true circles. O'Nuallain (1984:3) describes them as more D-shaped, with the axial stone representing the straight line of the 'D' (Figure 3.4). This description is understandable when one considers their smaller internal area in comparison to the multiple-stone circles. The five-stone circle diameters range from about 1.5 meters for Cashelkeelty East (O'Nuallain 1984:45) to 5 meters for Grenagh South (O'Nuallain 1984:34). The entrance stones suggested by O'Nuallain "are frequently set with their long axes approaching each other towards the east but in two instances they stand end-on to the enclosure to form a short passage as at a few multiple-stone examples" (O'Nuallain 1984:5). Unlike the multiple-stone circles, the axial stone is seldom the longest and varies considerably in shape and size (ibid).

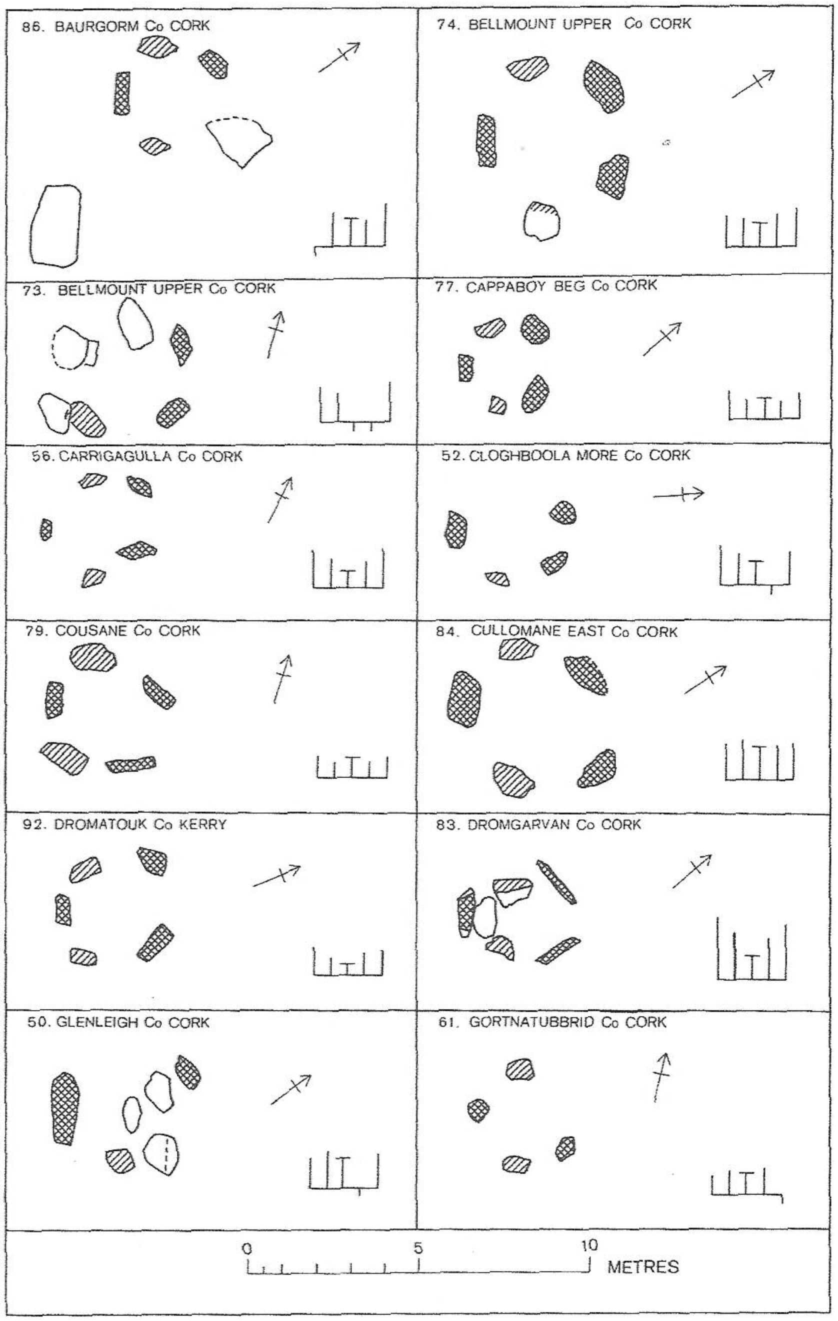

Figure 3.4 Examples of Five-stone circles. True north is indicated by the arrow. Entrance and axial stones are cross-hatched, erect stones are single-hatched. The relative heights of stones are represented by a diagram with a vertical line for each stone. The line at left represents entrance stone on observer's left from outside, facing entrance. Middle line with horizontal bar represents axial stone. Missing stones are indicated by tick below the horizontal line. (O'Nuallain 1984:66)

The multiple-stone circles are generally circular. Diameters range from 2.9 meters at the 7-stone site, Oughtihery SE, to 17 meters at two sites, the 13-stone Cashelkeelty W and 15-stone Kenmare (O'Nuallain 1984:3). An entrance is described in 31 multiple-stone circles and consists of two perimeter stones set on end and distinguished by their height (ibid). In three cases, two additional stones are positioned outside the perimeter to form an elongated entrance passage (Figure 3.5). The axial stone is set opposite the entrance with its long axis on the perimeter. The top surface of the axial stone is usually flat and generally level (ibid).

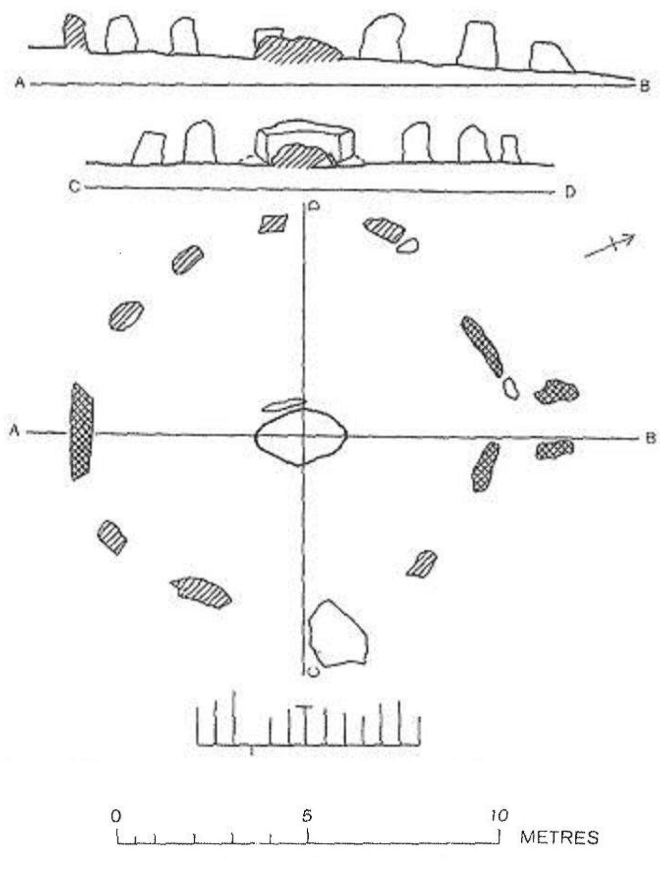

Figure 3.5 Example of multiple-stone circle, Gurteen, with entrance passage. (O'Nuallain 1984:58).

An orientation diagram constructed by O'Nuallain (Figure 3.6) illustrates the azimuths from the middle of the axial stones at sites with clearly defined axes. Although individual site measurements are not provided, a range of from 186° to 293° orientation is reported (O'Nuallain 1984:5). Both groups of stone circles are aligned towards the southwest and face the general direction of sunrises and sunsets.

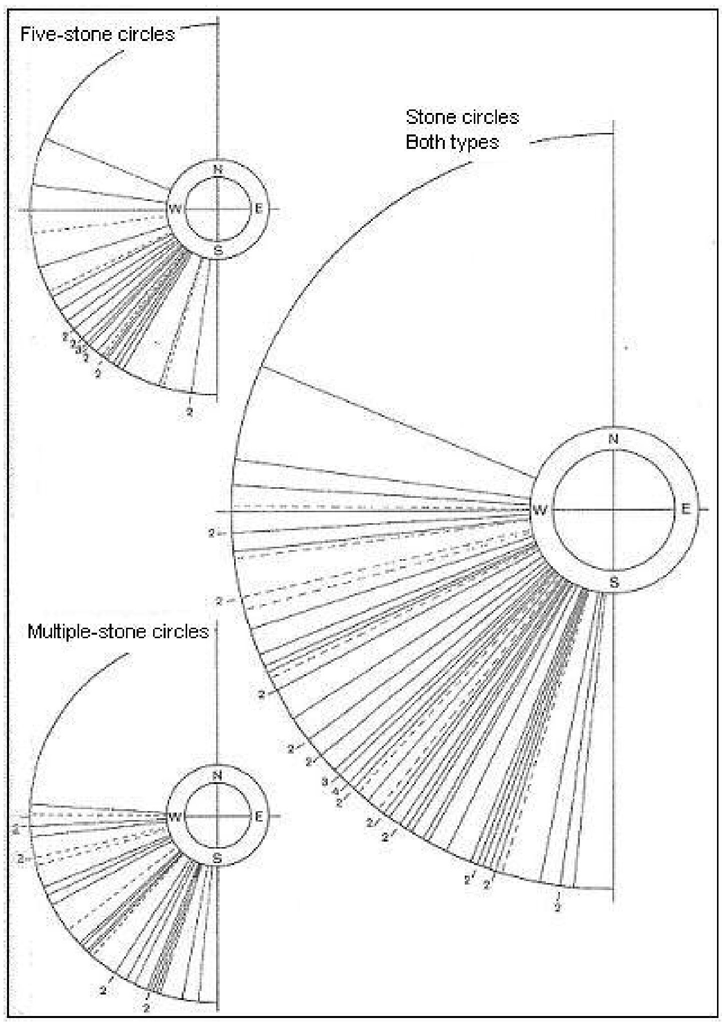

Figure 3.6 Azimuth orientation diagram of Cork-Kerry stone circles.
(O'Nuallain 1984:75)

3.2.4 Associations

Both types of stone circles occasionally may be found in association with other types of megaliths (Table 3.1). Multiple-stone circles may encircle a monolith or boulder burial, and on four occasions are associated with a fosse, or moat. In all, 20 of 53 multiple-stone circles are associated with internal stone structures, including eight burials. O'Nuallain reports that five of twelve internal monoliths are quartz. Eight multiple-stone circles contain an internal boulder burial while one external boulder burial is associated with a five-stone circle and a multiple-stone circle. The nearest association between a five-stone circle and a multiple-stone circle occurs at Cashelkeelty E and Cashelkeelty W where the two sites are 80 meters apart. Despite their proximity to each other, the two sites do not share a line-of-sight and are not visible to one another in today's landscape when viewed by a person of 5'5" stature. The nearest association between two multiple-stone circles is a 649 meter line-of-sight that separates Ardgroom from Ardgroom Outward. Between two five-stone circles, the nearest association is a 282 meter line-of-sight between Knockavullig NE and Knockavullig SW.

Table 3.1 Frequency of associated megaliths (after O'Nuallain 1984:7).

	Multiple-stone circles	Five-stone circles
External Monolith	3 (5.7%)	5 (9.8%)
Internal Monolith	12 (22.6%)	0
External Boulder Burial	1 (1.9%)	1 (2.0%)
Internal Boulder Burial	8 (15.1%)	0
External Fosse	3 (5.7%)	0
Internal Fosse	1 (1.9%)	0
Stone Row	0	3 (5.9%)
Stone Pair	2 (3.8%)	6 (11.8%)
Cairn	0	5 (9.8%)
Radial Enclosure	0	1 (2.0%)

3.2.5 Excavations

Aubrey Burl (2000:397-401) reports that within the region, eight stone circle sites have been scientifically excavated. Three sites are of the five-stone variety. Knocknakilla was examined over a one day period and no finds were reported although quartzite stones in one area suggested a portal floor (Gogan 1931:9). Kealkil revealed no artifacts or burial features but showed the presence of two shallow trenches of darker soil intersecting at right angles within the circle, suggesting the possible use of wooden beams. Examination of the stones revealed that they were not set deeply in the ground and were packed with small stones at the base (O'Riordain 1939:46). At Cashelkeelty E, a centrally placed rock slab covered a pit containing the cremated remains of an adult. A flint point and sandstone ard point were found within the circle, while five flint implements were found outside the circle near an adjacent row of three stones and included a leaf-shaped arrowhead, a barbed and tanged arrowhead, and a convex scraper (Lynch 1981:64). Dates from charcoal found within the circle are 2920 ± 60 BP (GrN-

9173) and 2665 ± 50 BP (GrN-9172) suggesting a time span of 970 – 715 BC (ibid), late in the period of stone circles.

Among the multiple-stone circles, excavation at Cashelkeelty W revealed a flint convex scraper. The sockets of missing stones suggest an original circle of 13 stones and a diameter of 17 meters (Lynch 1981:64). Bohonagh was excavated in 1959 and revealed a low mound of soil in the center of the circle that covered a pit containing small fragments of cremated bone. Also found on the surface were three pieces of flint (Fahy 1961:93). Reanascreena was excavated in 1961 and revealed a small pit in the center of the circle but contained no finds. Another pit was lined with peat and contained cremated bone. Radiocarbon dates of 830 ± 35 bc (GrN-17509) and 945 ± 35 bc (GrN-17510) were reported (Fahy 1962:59). Drombeg was excavated in 1957 and revealed compacted gravel over the subsoil within the circle. Five pits were found beneath the gravel. One pit contained cremated human bone and pot sherds. A second pit contained flecks of charcoal and cremated bone. Two stone sockets each contained a small convex flint scraper and a third socket held a broken flint. Radiocarbon dates were recalculated twice to 790 ± 80 bc (OxA-2683) and reasonably agree with the five-stone Cashelkeelty E and Reanascreena (Burl 2000:269). More recently, the Database of Irish Excavation Reports (www.excavations.ie) records that Lissyviggeen was excavated in 1998 (Site No. 282) to recover radiocarbon samples but none were found relating to its construction.

3.3. Geographic Information Systems (GIS)

A digital elevation model (DEM) with a 3 arc second (90 meter) resolution provides the topographic map of Ireland used in my research. This data was obtained as part of a space shuttle radar topography mission (SRTM), conducted during the 11-day flight of the SS Endeavour, STS-99, in February of 2000. The SRTM collected high-resolution digital topographic data between 60 degrees north latitude and 54 degrees south latitude, creating a near-global data set of land elevations. SRTM exceeded specification requirements of 30 meter x 30 meter spatial sampling with 16 meter absolute vertical height accuracy, 10 meter relative vertical height accuracy and 20 meter absolute horizontal circular accuracy (http://www-pao.ksc.nasa.gov/ kscpao/shuttle/ missions /sts-99/mission-sts-99.html., 02/03/2006).

The accurate digital construction of the topographic map, feature layers and spatial analysis of site relationships is accomplished using ArcGIS 9 software. Several functions of ArcGIS are used to incorporate site intervisibility into the spatial analysis of stone circles. These include a viewshed calculation that determines which areas can theoretically be seen from a given viewing location, and the determination of direct intervisibility among the sites. Line-of-sight between two points refers to the portions of the surface along the line that are visible to an observer. Viewshed is the sum of all lines-of-sight radiating from the observer and describes the locations that are visible from a specified point on a map. A cumulative viewshed map can be created where patterns of visibility within a group of sites is of interest. In this case, the viewshed maps for all stone circle locations are summed to create one map layer. The number of sites with a line-of-sight from each point, or cell, in the landscape can then be determined. In my research, an arbitrary height above ground level of 1.66 meters is chosen to represent eye level for a typical prehistoric Irishman viewing the surrounding landscape from each stone circle. An offset above ground level of 1.66 meters is also used for the person or object being viewed.

CHAPTER 4

SPATIAL ANALYSIS

4.1 Introduction

All archaeologists deal with sampling as an important consideration when using a statistical approach to infer information about cultures. Statistical data are defined as either a sample from a parent population, or as the entire statistical population. "If the parent population is recoverable then no sample can possibly be a better measure of its parameters than a total sample by complete excavation or collection" (Clarke 1968:549). In archaeology, it is rare for an entire population of data to be available for analysis. One can never be sure that all that can be found has been found. In most cases, what is archaeologically collected is considered a sample from an unknown population. This is certainly the case regarding megaliths. The problem then arises as to whether the sample is to be considered random, and therefore representative, of the parent population. Without the assumption of randomness, inferential statistics loses much of its ability to infer representation of the population from which it came. In archaeology, randomness in sampling can seldom be guaranteed because of the nature of discovery. Archaeological finds are seldom the result of statistically random sampling devoid of forethought and careful planning. The degree to which a sample is typical of the parent population has a great effect on how likely the sample will provide meaningful inferences about the parent population. An assumption is usually made, therefore, prior to statistically analyzing archaeological data. Either the data can be treated as the entire population and no future discoveries are expected to influence the data, or the data is considered to be a random sample of an unknown population when, in fact, it is less than random and, therefore, not fully representative of the population.

Descriptive statistics are used to describe the basic features of the data and present quantitative descriptions in a summary format with simple graphic analyses. Inferential statistics assume that the data represent a random sample from a population and seeks to allow inferences to be made from the sample about a more general population. Statistical analyses of archaeological data often will not fully meet the condition of a random sample from a population because the data cannot be guaranteed to be parent population data, nor can it be guaranteed to be a random sample of the parent population. The stone circles used in this research are acknowledged to be a sample of a larger unknown population. It can not be assumed that all stone circles in the region have been discovered. It is the largest sample currently available from the region but it is probably not the entire population of stone circles in the region. Neither is it a statistically random sampling of the population. Further, the sample does not include stone circles which may have been destroyed by man or nature. Nevertheless, the assumption is made that careful use of descriptive and inferential statistical analyses of the spatial characteristics of stone circles can suggest possible social behaviors linked to their location in the landscape.

4.2 Analyses

The following variables are listed in Appendices A and B and summarized in Table 4.2: Number of perimeter stones per site; area (m^2) within the circle; elevation (m.a.s.l.); distance to nearest neighbor (NND); distance to nearest coastline (NCD); and intervisibility among sites.

4.2.1 Number of Perimeter Stones per Site.

It is apparent from the sample data that 51 of 104 sites (49.0%) are composed of five stones (Figure 4.1). Based on the non-normal distribution of this variable, it is understandable that Sean O'Nuallain (1984:3) categorized these megaliths as falling into two groups: Five-stone circles and Multiple-stone circles (MSC). In examining the MSC separately, the distribution is found to be roughly normal, with a mean of 11.5 and a standard deviation of 2.77. Skewness is .579 and within acceptable limits for a normal

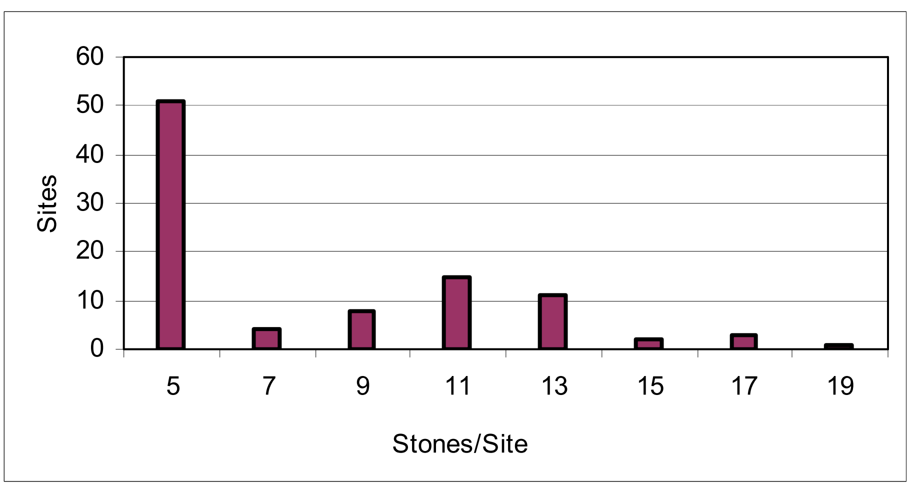

Figure 4.1 Distribution of stones per site.

distribution. Based on this information, the stone circles included within the MSC group might be considered to represent a normally distributed sample of similar sites. It is also apparent that all stone circles in the region are composed of an odd number of stones. No unequivocal evidence exists to explain this odd occurrence, which must certainly be considered non-random. It may be that this odd count is the result of the axial stone being added to the circle, which was first laid out by some process involving the generally symmetrical positioning of pairs of stones opposite each other around the circumference. This is speculation, however, and beyond the scope of this limited research to properly address.

4.2.2 Internal Area of Stone Circles.

The area of a circle increases exponentially as the circumference increases. An increase in circumference is usually accompanied by an increase in the number of stones used to describe the perimeter of stone circles. A scatterplot of the area and number of stones in each stone circle suggest a reasonably good fit between the area and the spacing of the stones that define the perimeter (Figure 4.2). An upper limit to the number of stones per site and internal area are suggested by the distribution, and the relationship between the two variables appears to weaken as the size of the circle increases. Greater variation is seen in the number of stones used to define the perimeters of stone circles as they increase in size, with the exception of 17- and 19-stone circles, which are represented in only a small number of cases.

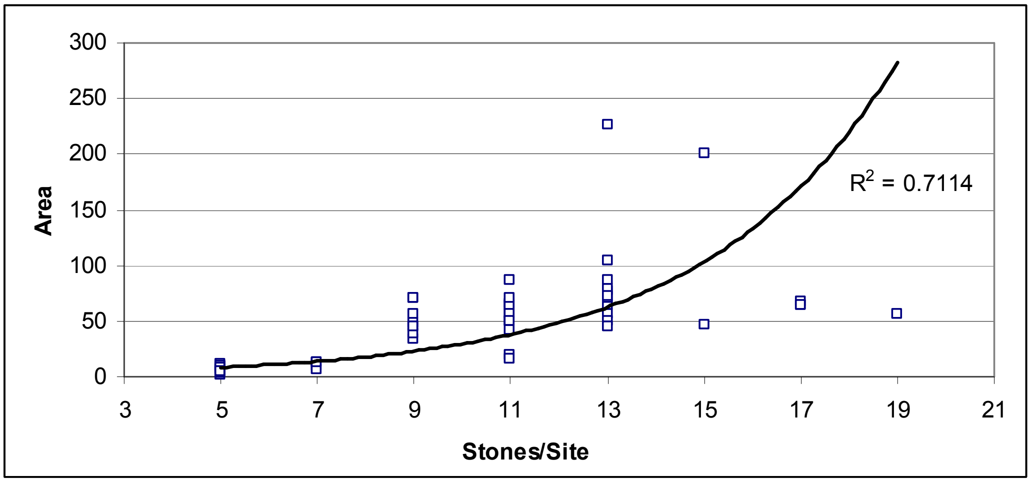

Figure 4.2 Distribution of area for each stone circle subgroup.

4.2.3 Elevation of Stone Circles.

Sean O'Nuallain (1984:8) reports a "general upland distribution" of stone circles, with 77% located above 90 m.a.s.l. He notes a tendency for Five-stone circles to be located at higher elevations compared to MSC, with only two of 45 Five-stone circles located below 90 m.a.s.l. while 20 of 48 MSC are found below that altitude (ibid). The distribution of stone circles grouped by stones per site shows a mean elevation for 51 Five-stone circles to be 181.7 m.a.s.l. and higher than any MSC subgroup (Table 4.2). If we consider the MSC as one group, a mean elevation of 133.7 m.a.s.l. is 48 meters (26.4%) lower in elevation than the mean elevation for Five-stone circles. A Student's t test to compare the Five-stone and MSC elevation variances indicates a significant difference between the two populations at the .05 confidence level. A further analysis of the relationship between elevation and stones per site reveals a Pearson correlation coefficient, a measure of association between two variables, of -

.218 (.05 level, 2-tailed). This indicates a weak but significant negative relationship between elevation and the number of stones per site (Figure 4.3). A stronger relationship is found between elevation and area (Figure 4.4). The bivariate correlation is weakly significant (Pearson = -.269, .05 level, 2-tail), but suggests that using the number of stones to define the size of stone circles is less predictive of elevation than area. While using stones per site as a heuristic device to categorize stone circles may be more efficient to the less discerning eye and more easily understandable than using area, there is no unequivocal evidence to suggest that either area or stones per site were more important regarding the purpose of stone circles. Until more is known about stone circles, it may be more appropriate to group stone circles by area instead of numbers of stones when elevation is considered. The data suggest that stone circles of smaller areas, including most Five-stone circles, tend to be situated at higher elevations than larger circles composed of more stones.

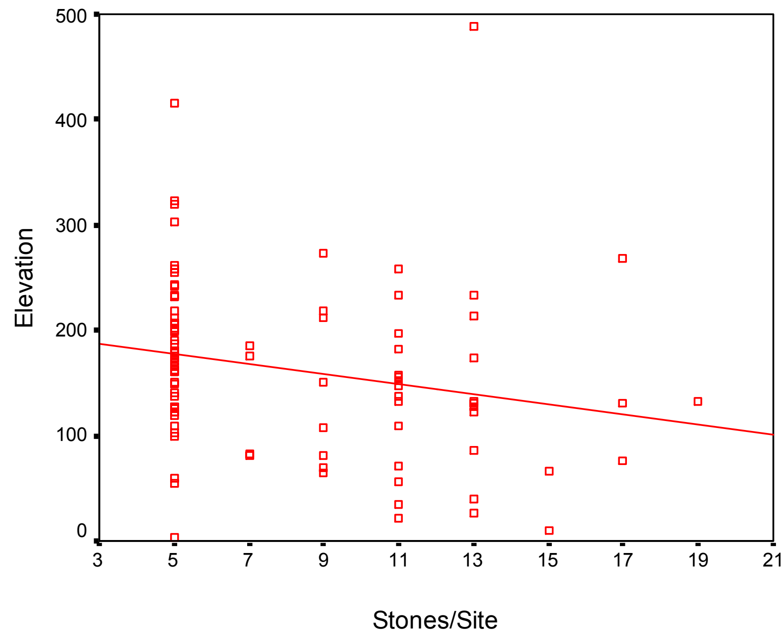

Figure 4.3 Distribution of elevation for each stone circle subgroup.

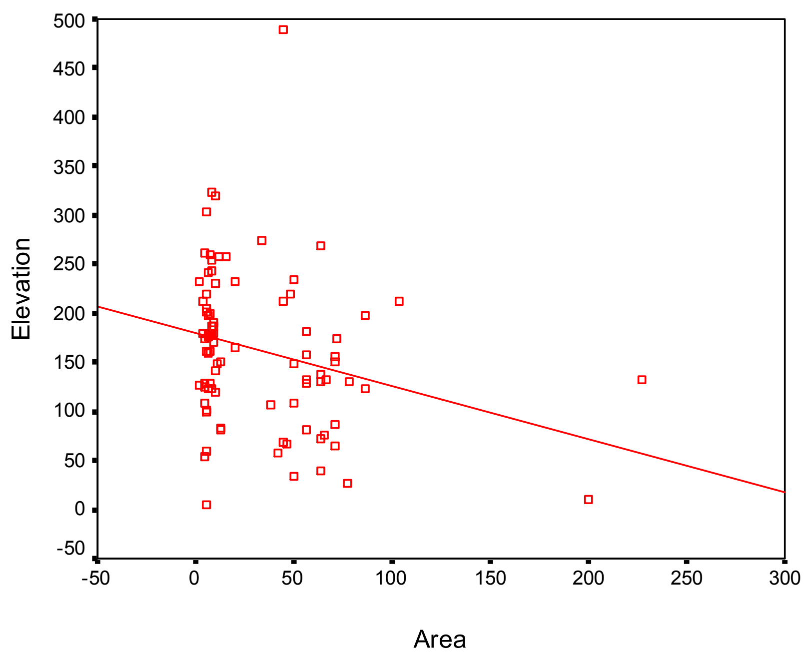

Figure 4.4 Correlation of stone circle elevation to area.

4.2.4 Nearest Neighbor Statistics

4.2.4.1 Nearest Neighbor Distance (NND)

The distance from each site to the site closest to it is summarized in Table 4.2. Data for each subgroup by stones per site is given, as well as for MSC (all sites, excluding Five-stone sites). A scatterplot of the data indicates no significant relationship between nearest neighbor distance and stones per site (Figure 4.5) or stone circle areas (Figure 4.6). When MSC are considered as a separate group from Five-stone circles, however, a significant correlation (Pearson = -.357, .05 level, two-tailed) is seen between NND and stones per site (Figure 4.7). In general, the smaller Multiple-stone circles are more distant from their nearest neighbor. The frequency distribution reveals a slight tendency for MSC to be more often situated between 3500 and 7000 meters from their nearest neighbor compared to Five-stone circles (Figure 4.8).

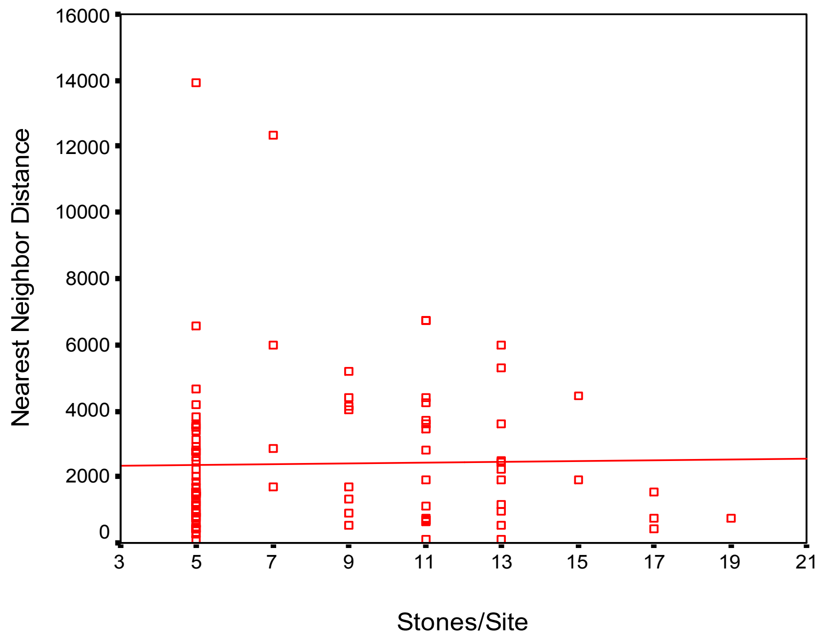

Figure 4.5 Distribution of nearest neighbor distance for each stone circle subgroup.

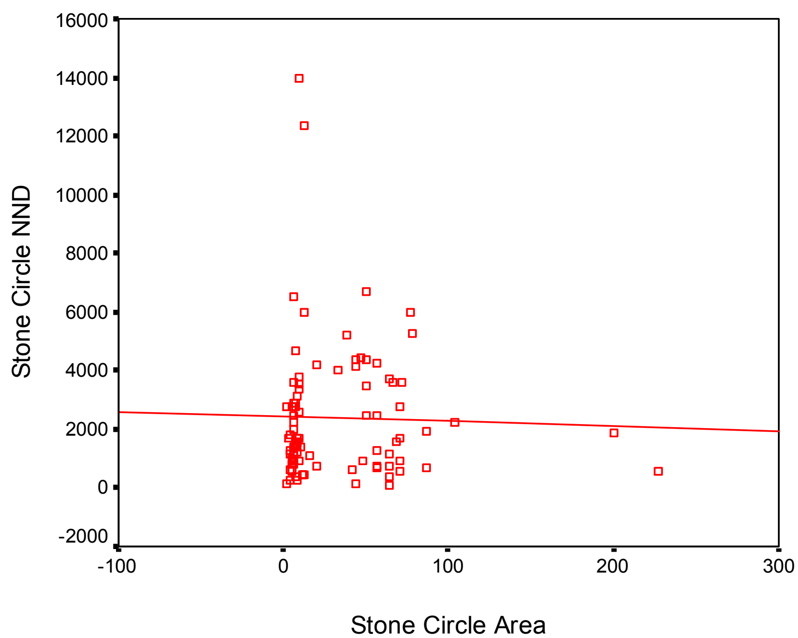

Figure 4.6 Correlation of nearest neighbor distance to stone circle area.

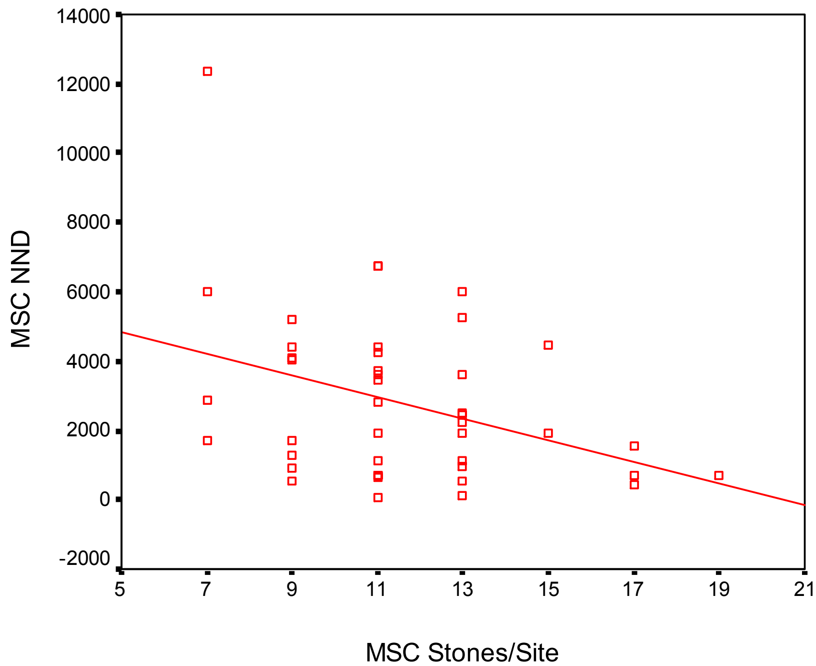

Figure 4.7 Correlation of MSC Nearest Neighbor Distance to Stones per Site.

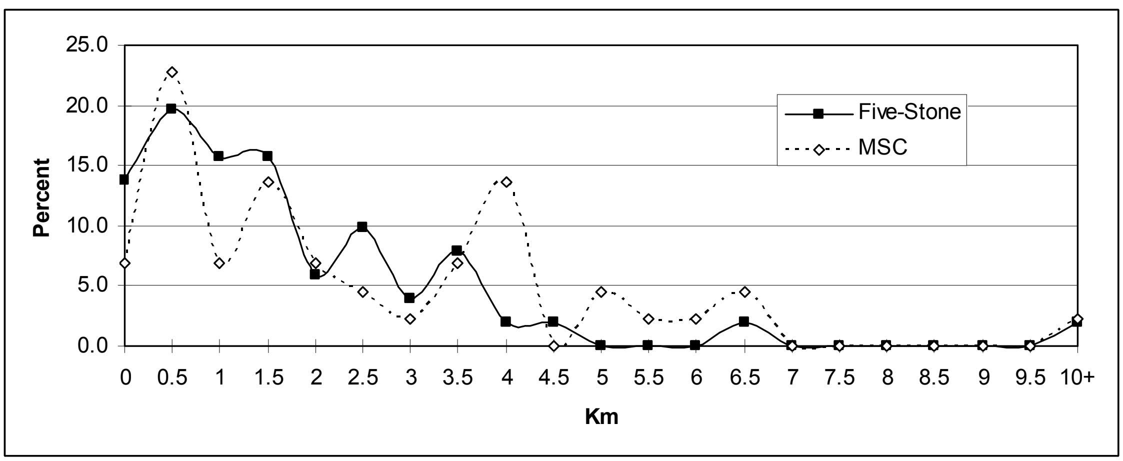

Figure 4.8 Frequency distribution of nearest neighbor distance for Five-stone circles and MSC.

The relationship of nearest neighbor distance and area is examined next for Five-stone circles and MSC. In both cases, there is no significant correlation at the .05 level between nearest neighbor distance and area for the two stone circle groups. To examine this potential relationship more closely, the three stone circle subgroups with the most cases, 9-stone, 11-stone and 13-stone, are plotted. The 9-stone data indicates a strong negative correlation between NND and area (Pearson = -.776, .05 level, two-tailed). The smaller 9-stone circles are more distant from their nearest neighbor (Figure 4.9). Neither the 11-stone subgroup (Figure 4.10) nor 13-stone subgroup (Figure 4.11) indicate a significant correlation between NND and area. A reasonable explanation for the relationship of nearest neighbor distance to stone circle area for 9-stone circles may have to await further research. It is plausible to suggest, however, that stone circles with areas smaller than the average 9-stone circle, approximately $50m^2$, tended to be situated at greater distances from their nearest neighbor.

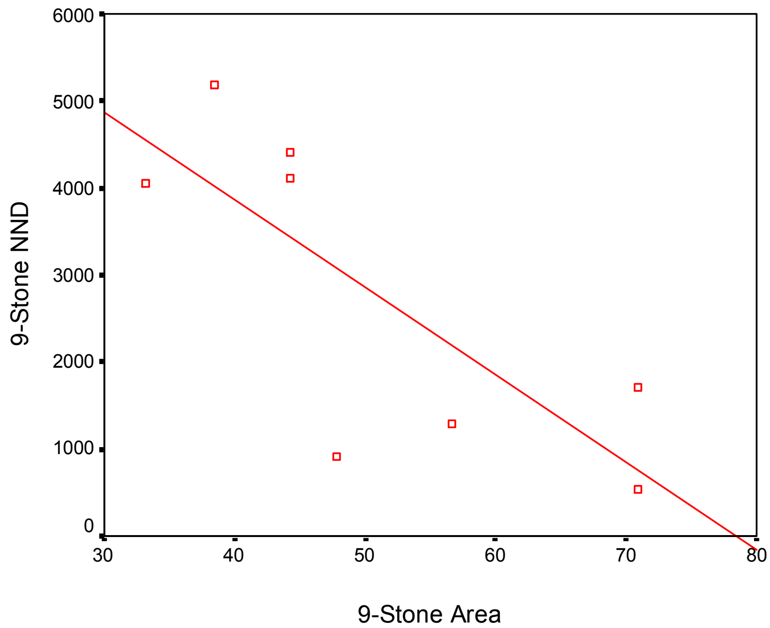

Figure 4.9 Correlation of Nearest Neighbor Distance and area among 9-stone circles.

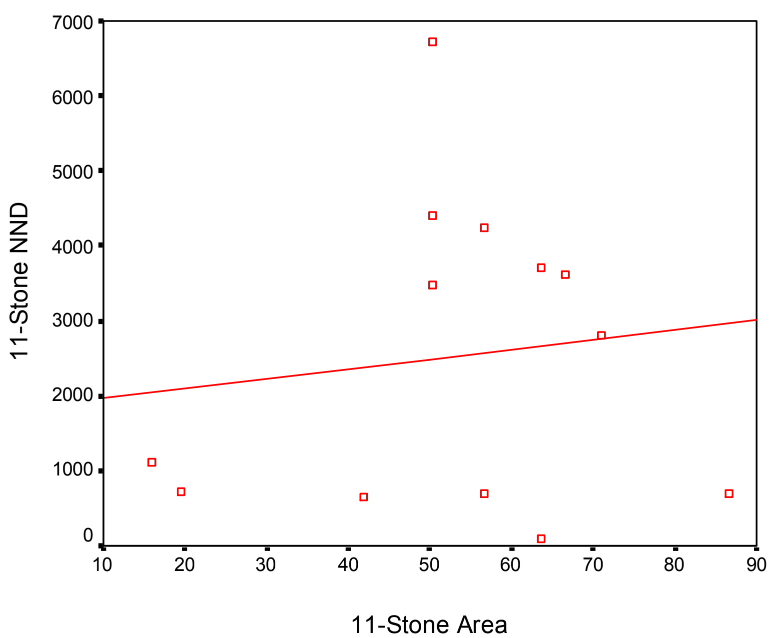

Figure 4.10 Correlation of Nearest Neighbor Distance and area among 11-stone circles.

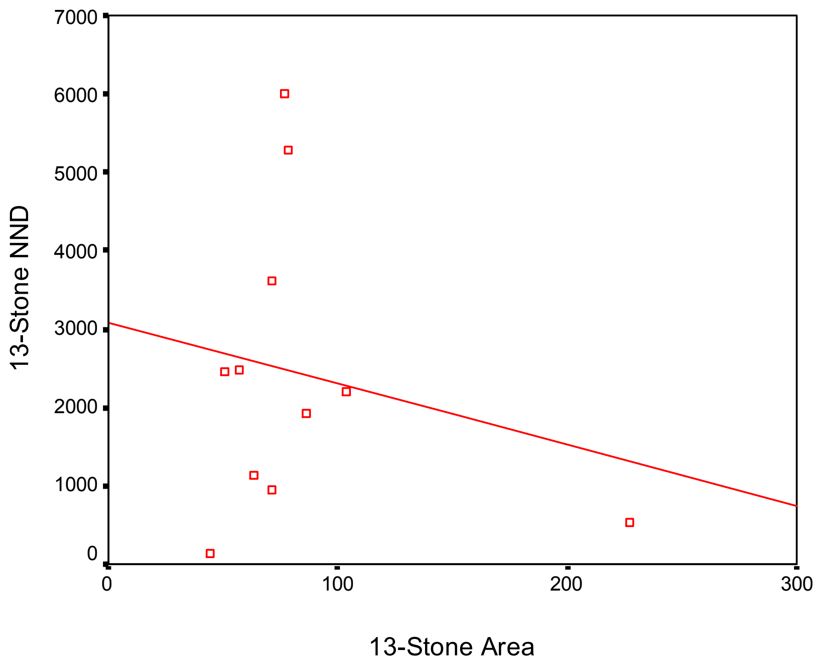

Figure 4.11 Correlation of nearest neighbor distance and area among 13-stone circles.

4.2.4.2 Nearest Neighbor Analysis

Nearest Neighbor Analysis is a technique developed by ecologists (Clark and Evans 1954) to measure point patterns for randomness. This technique has been applied in archaeology to distinguish non-random patterns within and among sites (Hodder and Orton 1976:38, Ebdon 1985:143). The data consist of the distances from each point to the point nearest to it within a given area. The observed mean NND for the sample points is calculated and compared to the expected mean NND for a random arrangement of points in the same area.

The observed mean NND, $\bar{d}_{obs}$, is given as

$$\bar{d}_{obs} = \frac{\sum d}{n} \qquad (4.1)$$

where n = number of points.

The expected mean NND, $\bar{d}_{exp}$, is given as

$$\bar{d}_{exp} = \frac{1}{2\sqrt{p}} \qquad (4.2)$$

where p = density of points per unit area.

A ratio of the observed and expected mean NNDs forms a more concise value, the Nearest Neighbor Index, which can be used in a significance test to indicate how probable it is for an observed pattern of points to occur by chance.

The Nearest Neighbor Index, R, is given as

$$R = \bar{d}_{obs} / \bar{d}_{exp} \qquad (4.3)$$

The test statistic, C, is similar in form to the Student's t, and is given as

$$C = (\bar{d}_{obs} - \bar{d}_{exp}) / SE\bar{d} \qquad (4.4)$$

where $SE\bar{d}$ is the standard error of the mean nearest neighbor distance, and is given as

$$SE\bar{d} = 0.26136 / \sqrt{np} \qquad (4.5)$$

The test statistic, C, is then compared to the standard normal distribution at a chosen significance level. Positive values denote a dispersed pattern and negative values a clustered pattern (Ebdon 1985:147). Analysis was performed on three categories of stone circles: All stone circles, Five-stone circles, and Multiple-stone circles. The area of the study region is composed of 1,100,524 cells, each 88m x 88m. Thus, the area is 8522.5 km^2. A significance level of .05 is assumed for a two-tailed test, giving a critical C of -1.960 to 1.960. Table 4.2 lists the results. Test C for each group is greater than the critical C of -1.960 indicating that each group can be considered to be significantly clustered within the study region at the .05 level.

Table 4.1 Nearest Neighbor Analysis.

	All Stone Circles	Five-Stone	MSC
n	104	51	53
p	.01220	.00598	.00622
$\bar{d}_{obs}$	2.36	2.05	2.8
$\bar{d}_{exp}$	4.53	6.47	6.34
R	0.521	0.317	0.442
$SE_{\bar{d}}$	0.232	0.473	0.455
C	-9.35	-9.34	-7.78

4.2.5 Nearest Coastal Distance (NCD)

The distance from each site to the nearest coastline is considered. Sean O'Nuallain reports "few of the forty-five five-stone examples are near the sea" (O'Nuallain 1984:8) and "The forty-eight multiple-stone sites are found throughout the distribution but predominate in coastal areas as do the boulder-burials (ibid). This suggests that the economy of Five-stone builders may have relied less on the sea than a MSC economy. It is also possible that the coastal plain was more suitable for cereal cultivation (O'Nuallain 1984:8). If this is the case, then agriculture may be more closely associated with larger populations which may be inferred from larger stone circles.

Analysis of nearest coastal distance for all stone circles based on area indicates a significant correlation. (Pearson = -.316, .01 level, two-tailed). A slightly stronger correlation between NCD and stones per site subgroups is also seen (Pearson = -.330, .01 level, two-tailed) (Figure 4.12). Smaller stone circles tend to be located farther from the coast. Among both the Five-stone group and the MSC group, no significant correlation is seen between NCD and area. In the MSC group, a significant correlation (Pearson = -.346, .05 level, two-tailed) is seen between NCD and stones per site (Figure 4.13). The smaller sites within the MSC group, based on stones per site, tend to be located farther from the coast. Nearest Coastal Distance, therefore, may not be a suitable characteristic to distinguish Five-stone circles from MSC. The tendency for smaller sites to be located farther from the coast extends beyond the Five-stone group and is observed within the MSC group.

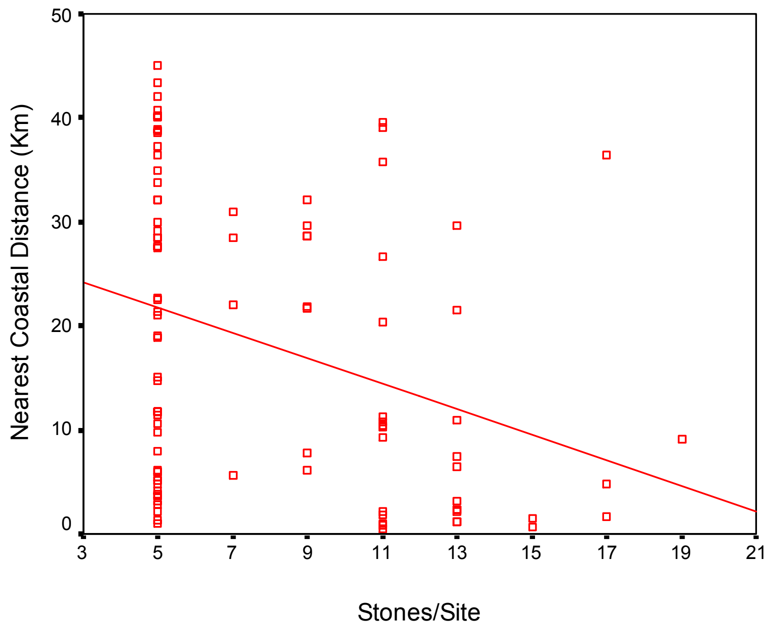

Figure 4.12 Correlation of Nearest Coastal Distance for all stone circles.

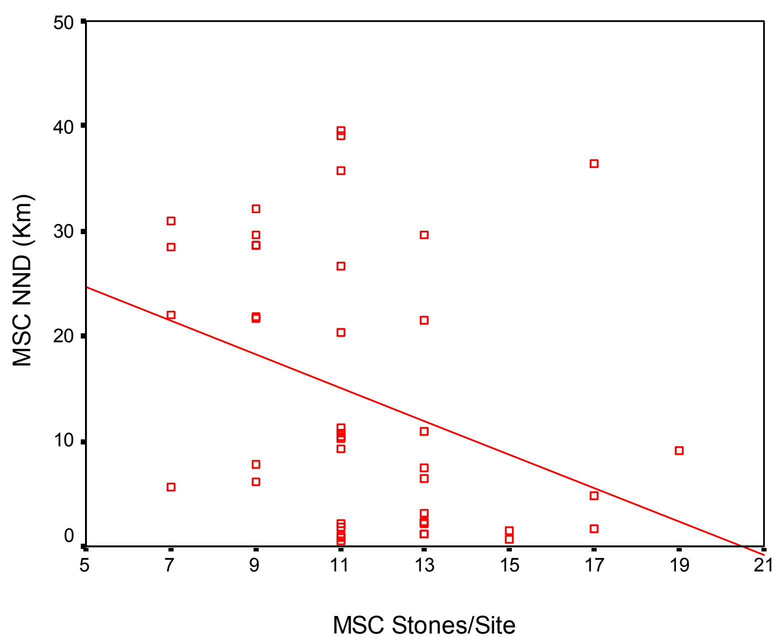

Figure 4.13 Correlation of Nearest Coastal Distance within MSC group.

The mean NCD for MSC sites is illustrated in Figure 4.14. Two groups of sites, one composed of 5-, 7- and 9-stone NCD data, and the other composed of 11-, 13-, 15-, 17- and 19-stone NCD data are examined. A Student's t-test indicates a significant difference in NCD data at the .05 confidence level (two-tailed). The two groups are unlikely to represent equal populations of NCD data. The mean nearest coastal distances for stone circle subgroups composed of 5-, 7- and 9-stones are farther from the coast than the remaining subgroups. As a group, they display a significant difference in means compared to sites composed of eleven or more stones. Based on nearest coastal distance data alone, categorizing stone circles as either Five-stone or MSC may not accurately reflect the nature of stone circles. It may be more appropriate to consider the smaller stone circles, those composed of 5, 7 and 9 stones, as a separate group from larger stone circles when considering nearest coastal distance.

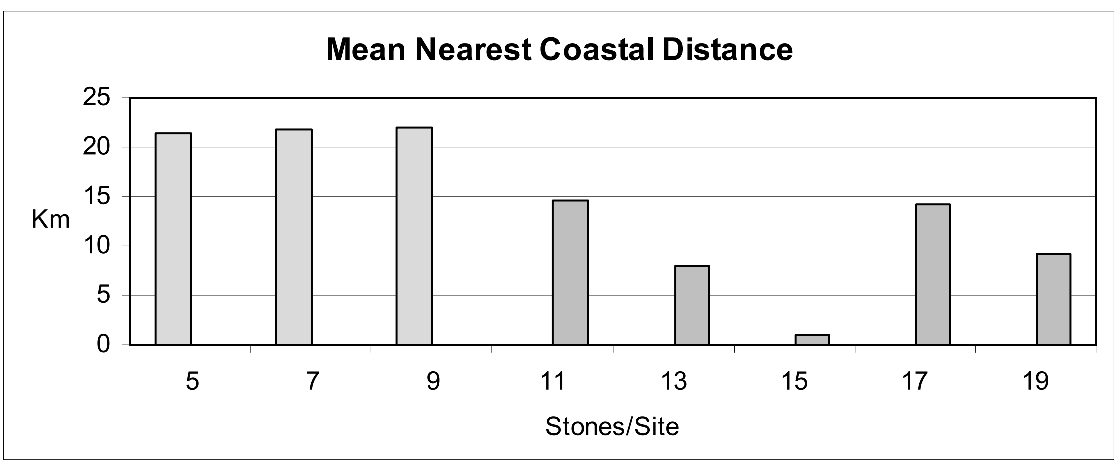

Figure 4.14 Mean nearest coastal distance for each stone circle subgroup.

4.2.6 Thiessen Polygons

Unweighted Thiessen polygons offer a theoretical model of how space can be divided based on distance between sites on an undifferentiated plane, with no consideration of site size, character, hierarchy or terrain. Their value is not so much that of producing a reliable reconstruction of actual territories, but rather in creating a baseline against which actual land use can be compared. While knowledge of land use during the Irish Neolithic/Bronze Age is extremely limited, Thiessen polygons are a reasonable step in the spatial analysis of stone circles. Thiessen polygons were created for stone circle maps using Arcmap GIS software. The appearance of clustering is suggested in several regions of the map of stone circles (Figure 4.15). Different patterns of clustering are suggested when Five-Stone circles and MSC are treated as separate groups (Figure 4.16 and Figure 4.17).

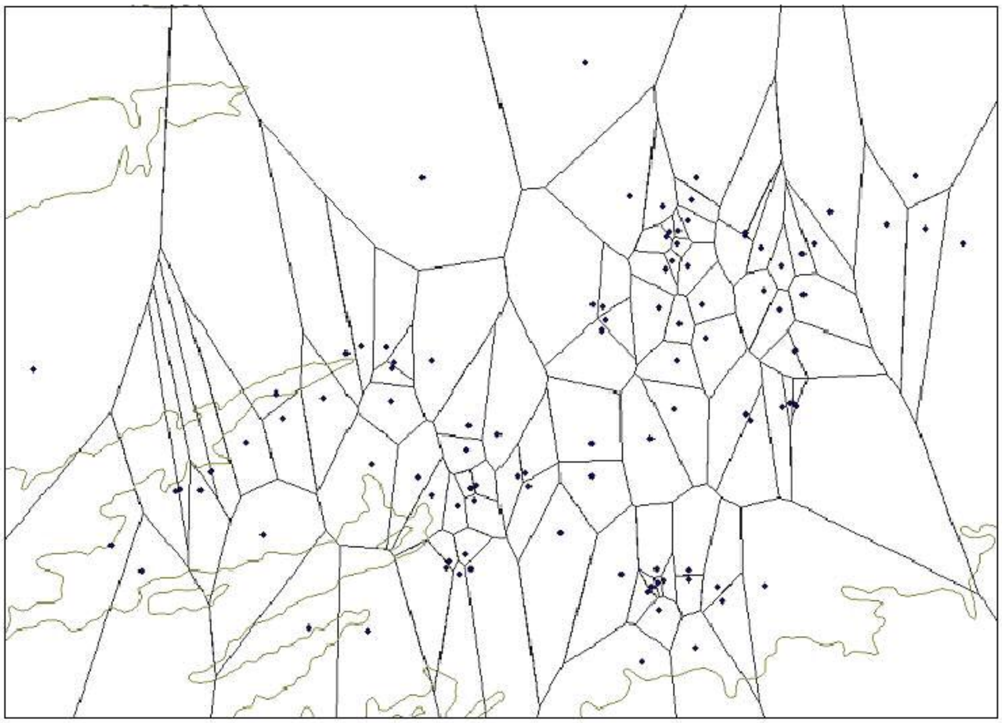

Figure 4.15 Thiessen polygons of all stone circles.

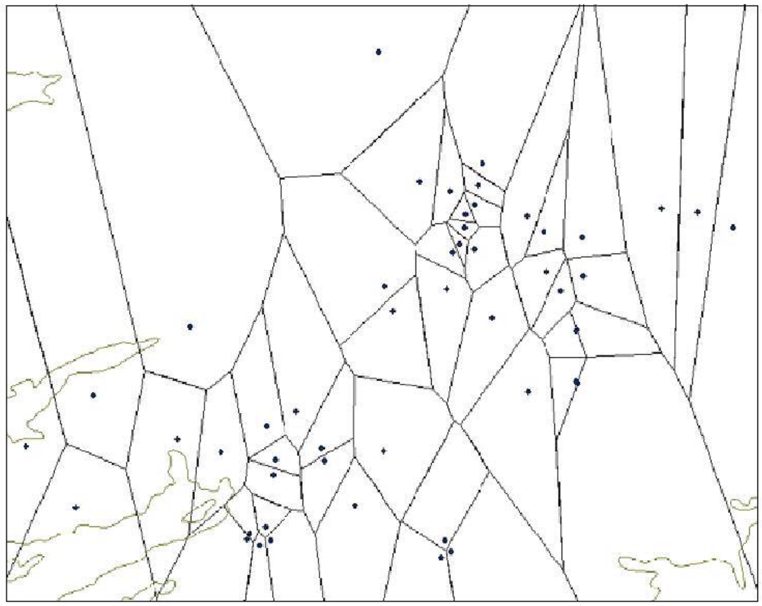

Figure 4.16 Thiessen polygons of Five-Stone circles.

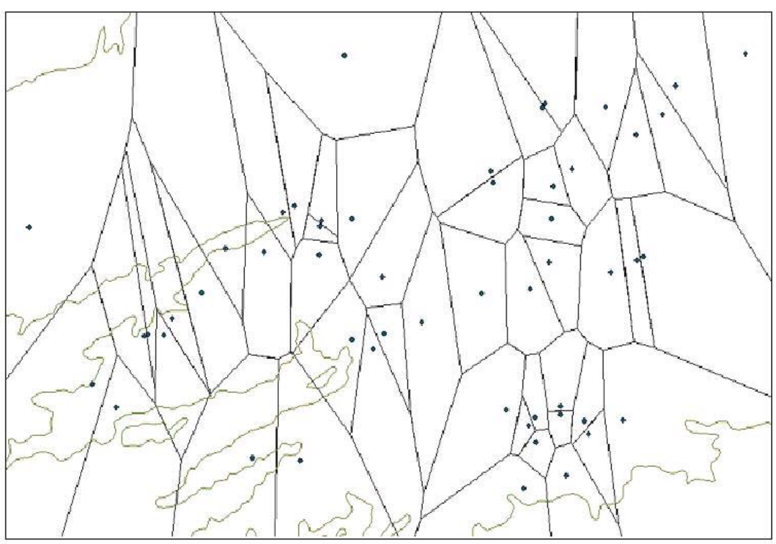

Figure 4.17 Thiessen polygons of Multiple-Stone circles.

4.2.7 Mean Nearest Neighbor Buffers

Buffering defines an area within a specified distance around a site and can be useful to visualize theoretical territories, service areas or other zones of influence. A buffer with a radius equal to the mean nearest neighbor distance for Five-stone circles (Figure 4.18) and MSC (Figure 4.19) suggest clustering in several regions. It should be noted that the topography during the Irish Neolithic/Bronze Age was likely to have been different from the topography of today. This should not prevent us from using what information is available to suggest general trends regarding possible topographic scenarios. Buffers extending to the mean nearest neighbor distance for each group reveal several interesting clusters of sites.

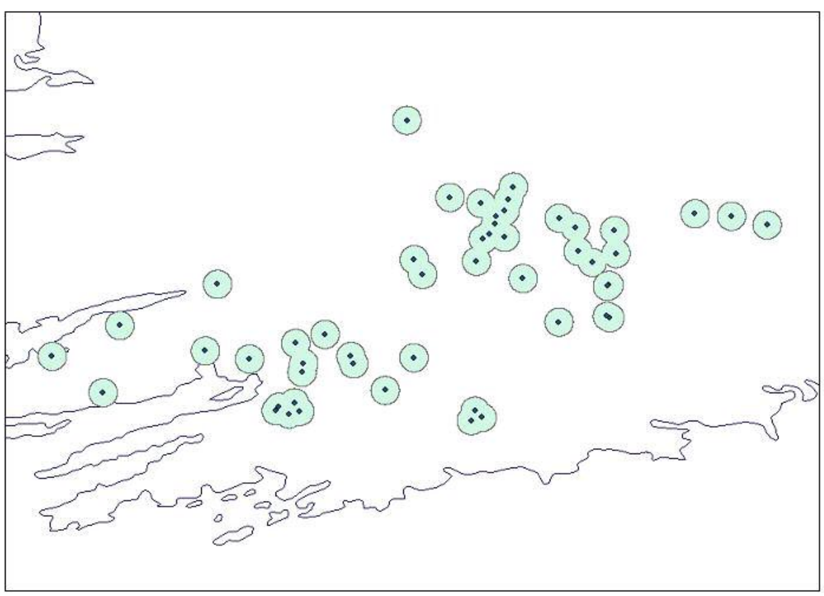

Figure 4.18 Buffer of mean nearest neighbor distance radius around Five-stone circles.

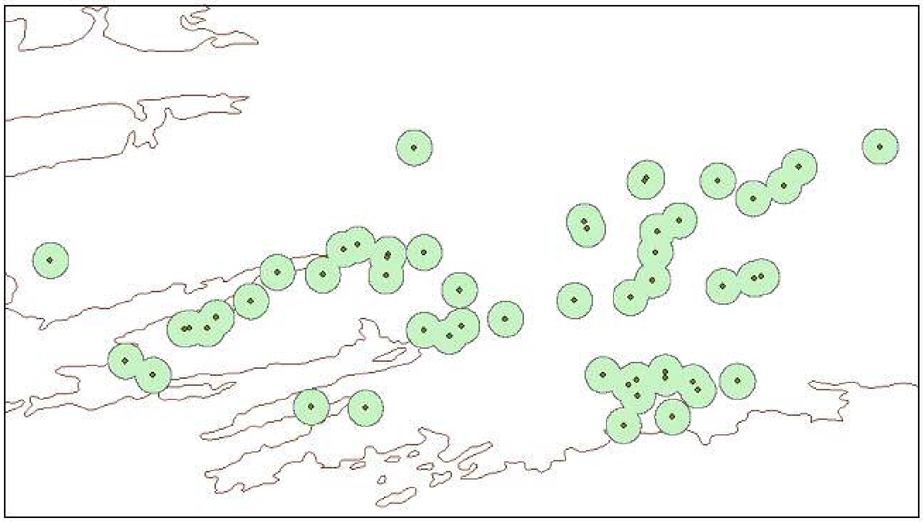

Figure 4.19 Buffer of mean nearest neighbor distance radius around Multiple-stone circles.

4.2.8 Intervisibility

4.2.8.1 Line-of-Sight (LOS)

An examination of intervisibility among stone circles can be helpful in answering the question of why a particular site is located in a particular place, rather than all the other places it might have been located. Line-of-sight determinations among stone circles were limited to a 5000m radius from each site. A height of 1.66m was chosen for the observer as well as for the object or person being viewed. Because these two offsets above ground level are the same, a line-of-sight from site A to site B implies a reciprocal line-of-sight from site B to site A. GIS ArcMap software was used to construct viewsheds for each site. The frequency of line-of-sight visibility among and between subgroups is given in Figure 4.20. Within a viewing radius of 5km, there are 54 lines-of-sight between stone circles. Forty-one (39.4%) stone circles have a line-of-sight to at least one other stone circle. Sixteen (31.4%) Five-stone circles share a line-of-sight with at least one other Five-stone circle. Among the MSC, only one pair of sites (18.2%) composed of the same number of stones, 13-stone Dromkeal and Cappanaboul, share a line-of-sight across 3321 meters. Twenty (37.7%) MSC share a line-of-sight with another MSC. Fourteen (13.5%) lines-of-sight exist between a Five-stone circle and a MSC. Nine of eleven (81.8%) 13-stone circles display intervisibility among other MSC. Among the nine MSC whose stones per site are unknown ("5+"), three (33.3%) have lines-of-sight to each other.

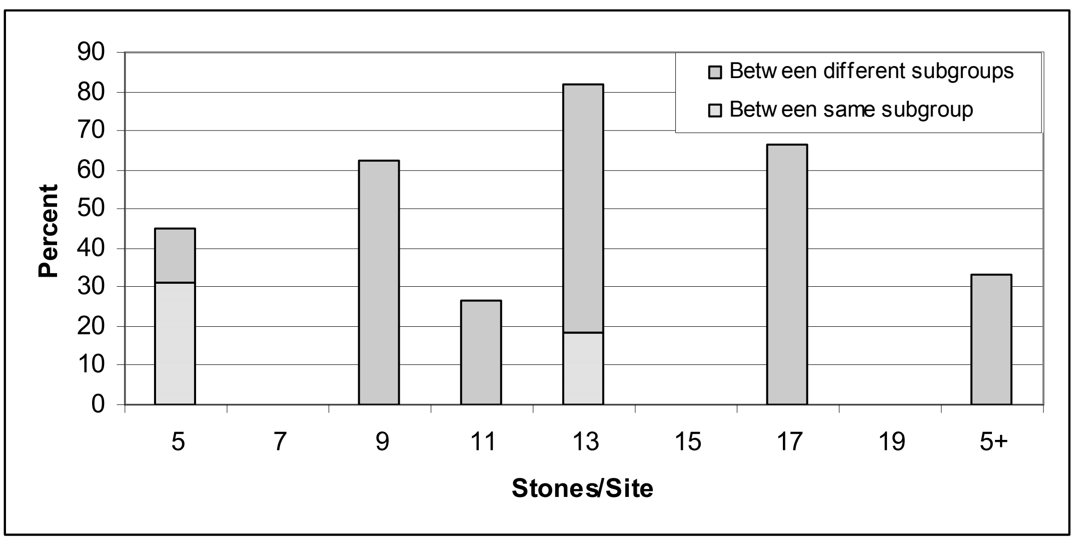

Figure 4.20 Frequency of line-of-sight occurrences among and between stone circle subgroups.

Nearest visible neighbor distance (NVND) was determined for those sites with visible neighbors within a 5km radius (Figure 4.21). There is considerable variation around a mean of about 1700 meters and no significant correlation exists between the stones per site subgroups and the distance to their nearest visible neighbor.

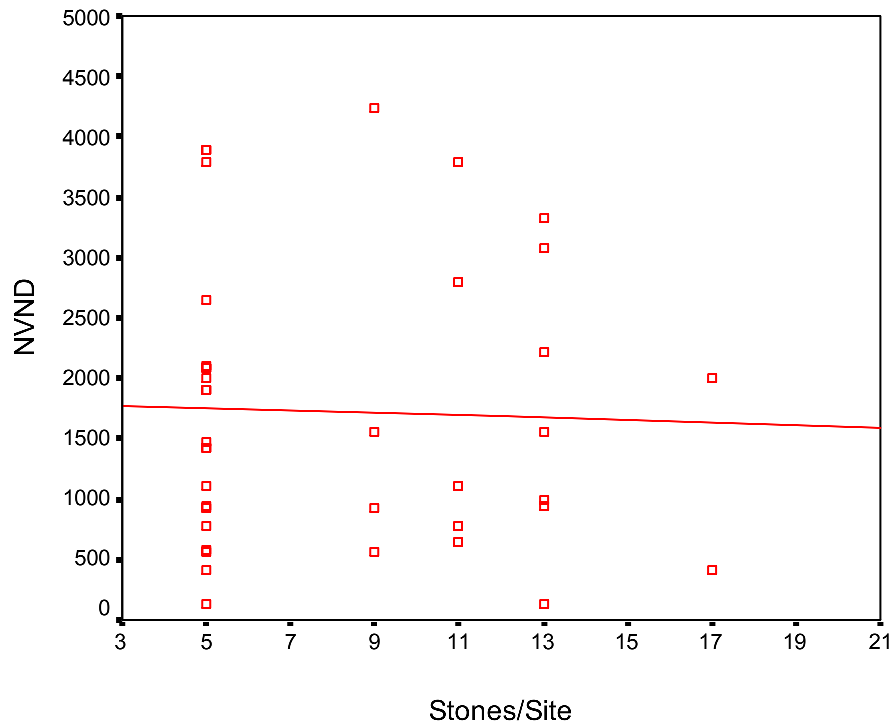

Figure 4.21 Nearest visible neighbor distance among stone circle subgroups.

Higher elevation can be expected to result in increased visibility in most circumstances. The relationship of elevation and intervisibility within a 5km radius from Five-stone circles to any other stone circles, however, indicates no significant correlation (Figure 4.22). The relationship of elevation and intervisibility within a 5km radius for MSC is also not significant (Figure 4.23). For both groups, therefore, elevation is not a significant factor regarding intervisibility within a viewing radius of 5000 meters.

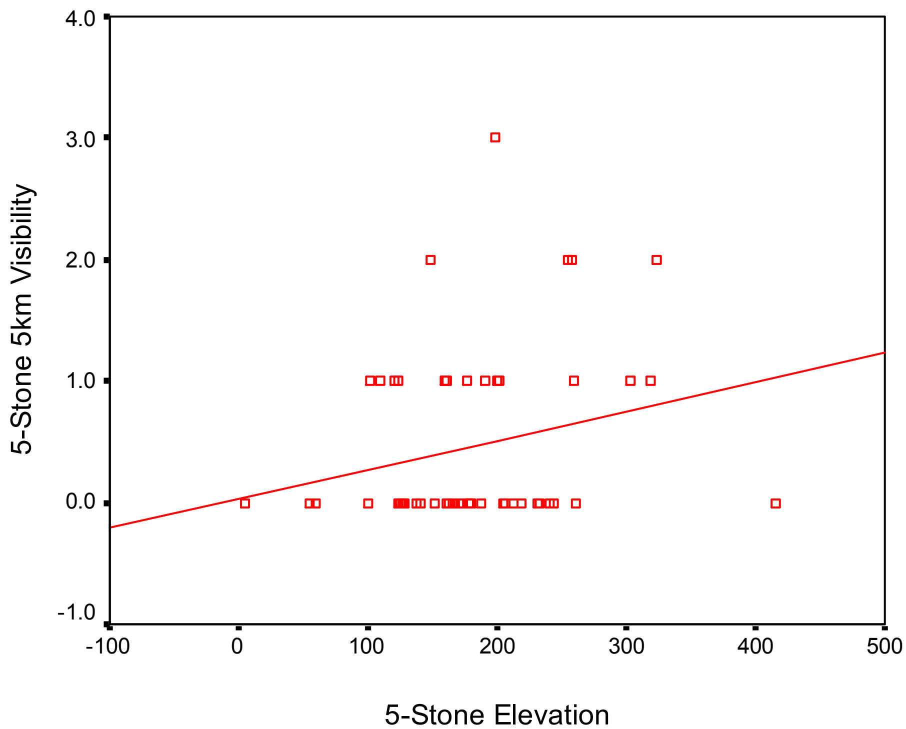

Figure 4.22 Correlation of Five-stone circle elevation to visibility.

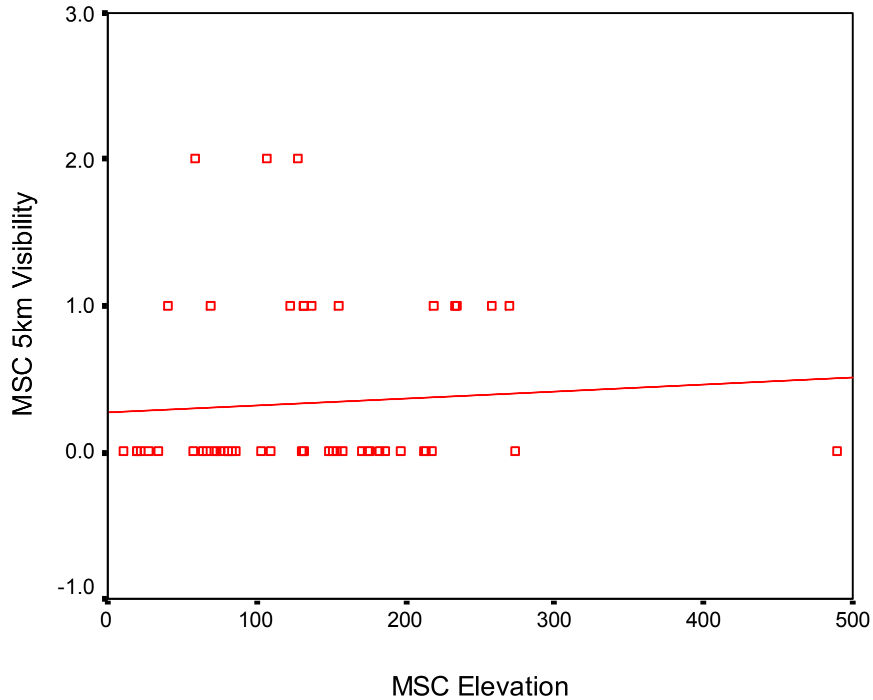

Figure 4.23 Correlation of Multiple-stone circle elevation to visibility.

4.2.8.2 Cumulative Viewshed Analysis

Cumulative viewshed analysis is a GIS technique that can be used to infer relationships of intervisibility among archaeological monuments (Wheatley 1995, 2002). A raster map is created from cells (pixels) of digital elevation data and forms the foundation upon which site points, such as stone circles, are situated based on their locational coordinates. An attribute table accompanies the raster map, which lists the number of lines-of-sight that exist for each cell. The raster map becomes a background standard for the analysis which represents, for each cell in the landscape, the number of other cells with a line-of-sight from that cell. Individual viewshed maps for each site location are constructed based on the cell that holds each site location. An example is given in Figure 4.24. A cumulative viewshed map is then created by merging individual site viewshed maps onto the DEM map to create one surface map (Figure 4.25). The resulting cumulative viewshed map represents, for each site in the landscape, the number of other sites with a line-of-sight from that site. After compensating for software rules defining a site as being visible to itself, a test for intervisibility among stone circles can be performed.

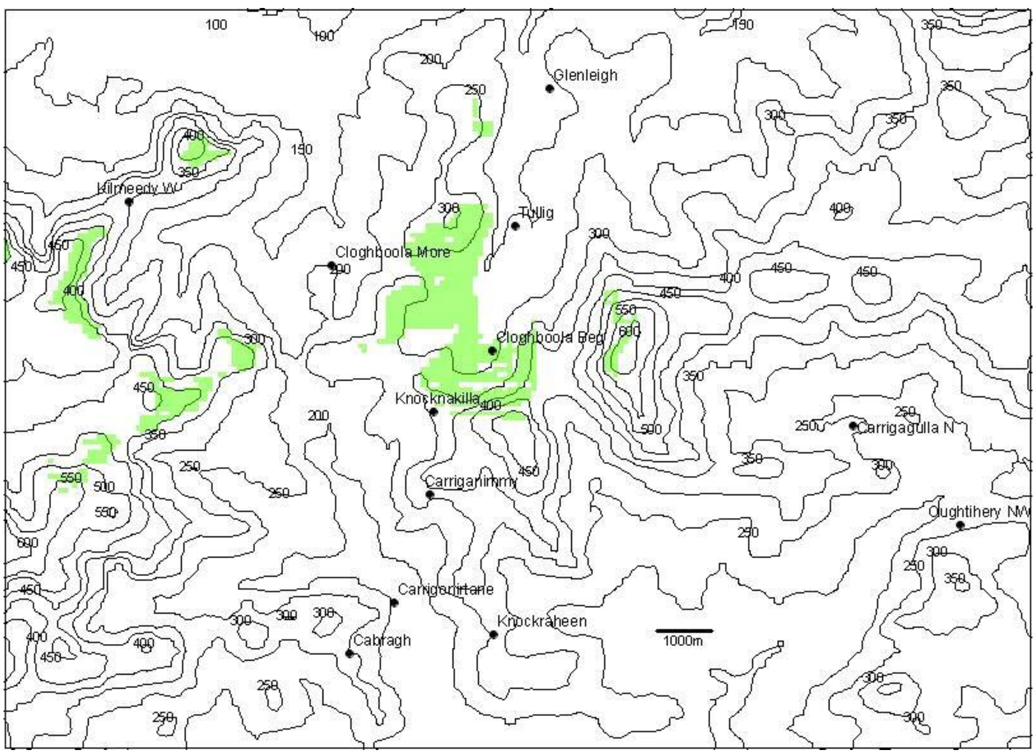

Figure 4.24 Viewshed map for Cloghboola Beg stone circle.

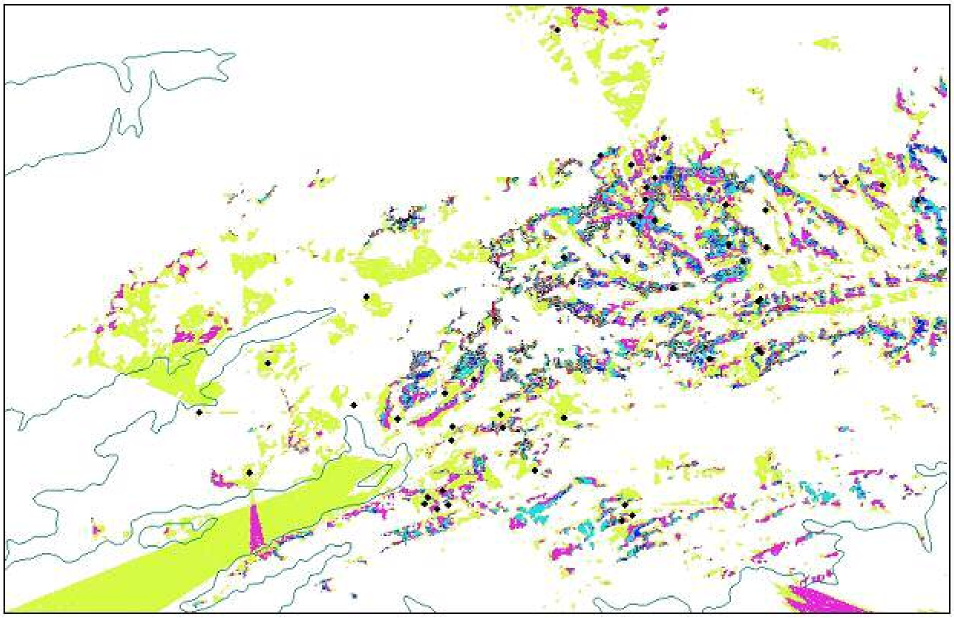

Figure 4.25 Cumulative viewshed map for Five-stone circles. Each color represents a different number of overlapping viewsheds.

The Kolmogorov-Smirnov (K-S) test is a one-sample non-parametric test used to compare an observed probability distribution with a theoretical Poisson distribution in order to test a hypothesis of random variation, and is considered well suited to comparing a site sample to a background standard (Ebdon 1985:53, Kvamme 1990:373). The K-S test allows the use of the entire dataset describing an environmental variable as the referent distribution, while using the set of site locations as the sample set to test whether the two differ significantly (ibid). The landscape map can be considered a statistical population made up of the number of cells visible to one another. In the case of the study region for my research, the population consists of 1,100,524 cells. Each cell is 88m square. The stone circle sites can be regarded as a sample from that population. A null hypothesis for the K-S test states that the sample data which produced the observed probability distribution have been drawn from a population which possesses the theoretical Poisson distribution. A testable hypothesis is constructed as follows:

H_o: Stone circles are distributed in the study region irrespective of the number of other sites which are visible.

H_1: Stone circles are not distributed in the study region irrespective of the number of other sites which are visible.

The K-S test measures the absolute difference between the observed and expected cumulative distributions. The maximum difference, *Dmax*, is compared to the critical value, *Dcrit*, which is obtained from the sample size and desired confidence interval (Ebdon 1985:199). For confidence level alpha = .05 and a two-tailed test, the value *Dcrit* is given as

$$Dcrit = 1.36 \, / \, \sqrt{N} \qquad (4.6)$$

If *Dmax* exceeds *Dcrit*, then the sample distribution can be considered significantly different from the population distribution and the null hypothesis is rejected. The K-S test is applied to three sets of data within the same study region: All stone circles, Five-stone circles and Multiple-stone circles. A viewshed map for each site is generated and the maps are then merged into a cumulative viewshed map for each group. The observed and expected probability distributions for all stone circles (Table 4.3), Five-stone circles (Table 4.4) and Multiple-stone circles (Table 4.5) are examined.

4.2.8.2.1 All Stone Circles

The value of *Dcrit* is calculated as follows:

N = 104

$Dcrit = 1.36 / \sqrt{N}$

$Dcrit = .133$

The maximum difference in cumulative distributions between the background population and the site sample occurs for 48 stone circles, which have no line-of-sight to any other stone circles (Table 4.3). A Dmax value of .384 exceeds Dcrit value of .133. The null hypothesis is rejected, therefore, and one can state that stone circles are not distributed in the study region irrespective of the number of other sites that are visible. Stated another way, the stone circles are not distributed randomly but are distributed in the study region with respect to the number of other stone circles that are visible.

4.2.8.2.2 Multiple-Stone Circles

The value of *Dcrit* is calculated as follows:

N = 53

$Dcrit = 1.36 / \sqrt{N}$

$Dcrit = .187$

The maximum difference in cumulative distributions between the background population and the site sample occurs for 41 stone circles, which have no line-of-sight to any other Multiple-stone circles (Table 4.5). A Dmax value of .160 does not exceed Dcrit value of .187. The null hypothesis is not rejected, therefore, and one can state that Multiple-stone circles are distributed in the study region irrespective of the number of other sites that are visible. Stated another way, the Multiple-stone circles are distributed randomly in the study region with respect to the number of other Multiple-stone circles that are visible.

4.2.8.2.3 Five-Stone Circles

The value of *Dcrit* is calculated as follows:

$N = 51$

$Dcrit = 1.36 / \sqrt{N}$

$Dcrit = .190$

The maximum difference in cumulative distributions between the background population and the site sample occurs for 22 stone circles, which have no line-of-sight to any other Five-stone circles (Table 4.4). A Dmax value of .371 exceeds Dcrit value of .190. The null hypothesis is rejected, therefore, and one can state that Five-stone circles are not distributed in the study region irrespective of the number of other sites that are visible. Stated another way, the Five-stone circles are not distributed randomly but are distributed in the study region with respect to the number of other Five-stone circles that are visible.

To illustrate this intervisibility, the location of a cluster of five Five-stone circles is examined (Figure 4.26). The viewshed for each stone circle suggests intervisibility might have been a factor in their placement (Figures 4.27 – 4.31). Colin Renfrew's comments on the placement selection of megaliths, referred to as markers, on Rousay in the Orkneys, is relevant.

> In Rousay it seems likely that the markers were sited so as to be visible from the entire territory and hence were located on a hill-slope at one side of the territory. In other cases, as perhaps in Arran, the marker might be sited at the edge of a territory, at the boundary with the land of another segmentary group. (1979:222)

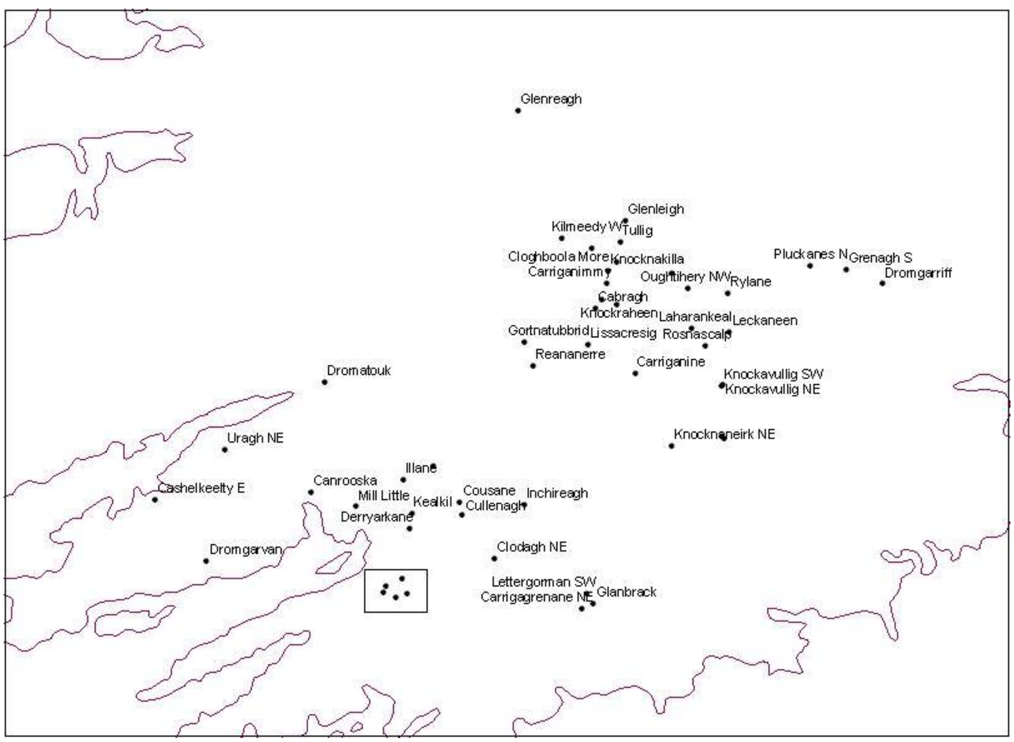

Figure 4.26 Cluster of five Five-stone circles.

The sites in this cluster, Trawlebane, Inchybegga, Cullomane E, Baurgorm S and Baurgaum N are located on hill slopes surrounding a valley. All are within 2500m of each other. Baurgorm S is on the western slope of a hill with a view extending from the northwest to the southwest (Figure 4.27). Its nearest neighbor, Baurgaum N, is 816m to the north and just beyond a position of intervisibility with Baurgorm S. Neither site takes advantage of the hilltop which would allow an expanded view of the region. The viewshed of Baurgaum N extends in a northeastern direction and includes Trawlebane almost 2000m away (Figure 4.28). Trawlebane's viewshed extends broadly in a southern direction taking in much of the valley and reaches just beyond Baurgaum N on a neighboring hill (Figure 4.29). Inchybegga is located on a hillside facing north with views extending to four hills in the west, north, east and more distant south (Figure 4.30). Its nearest neighbor, Cullomane E, is just within view approximately 1418m away to the west. The viewshed of Cullomane E extends up the hill to the west and broadly to the southeast (Figure 4.31). Inchybegga is just visible to Cullomane E on the far side of an eastern hilltop.

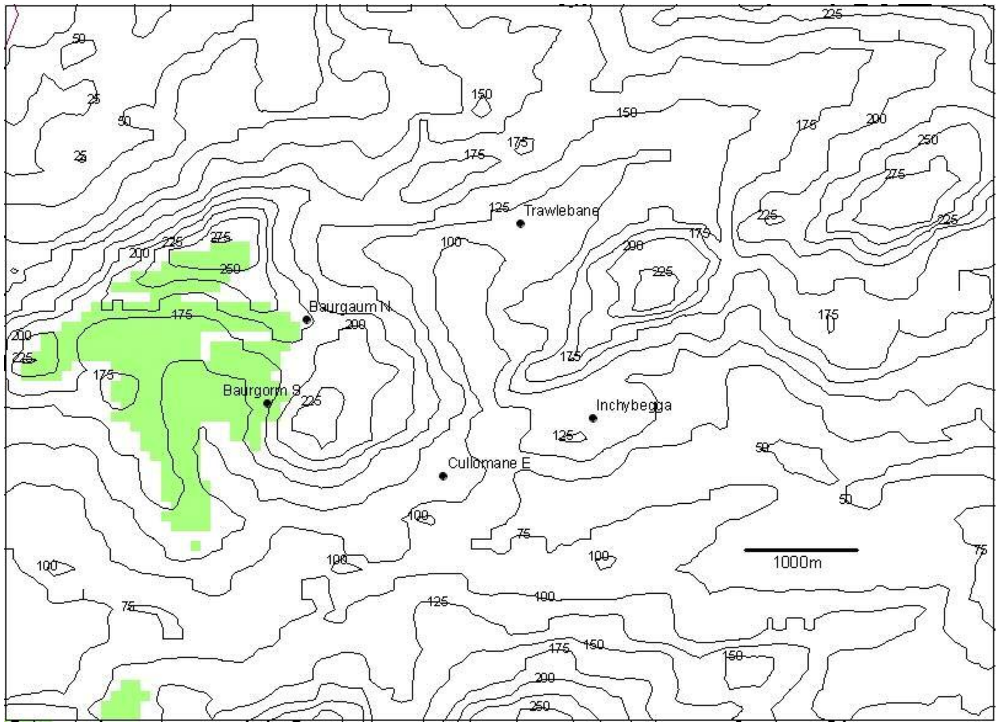

Figure 4.27 Baurgorm S stone circle viewshed.

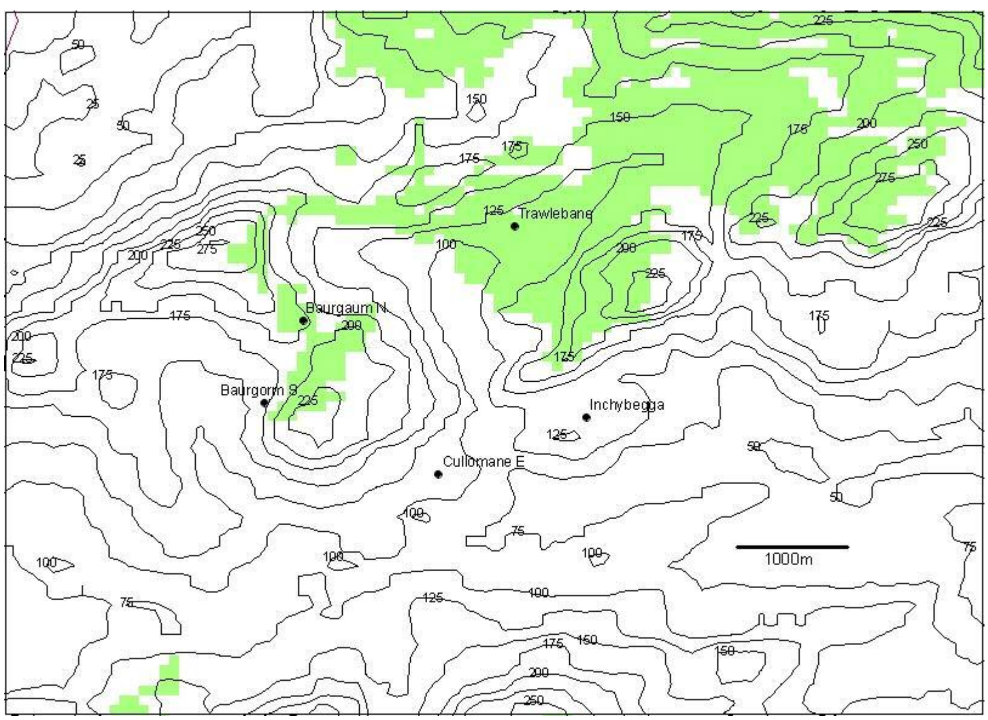

Figure 4.28 Baurgaum N stone circle viewshed.

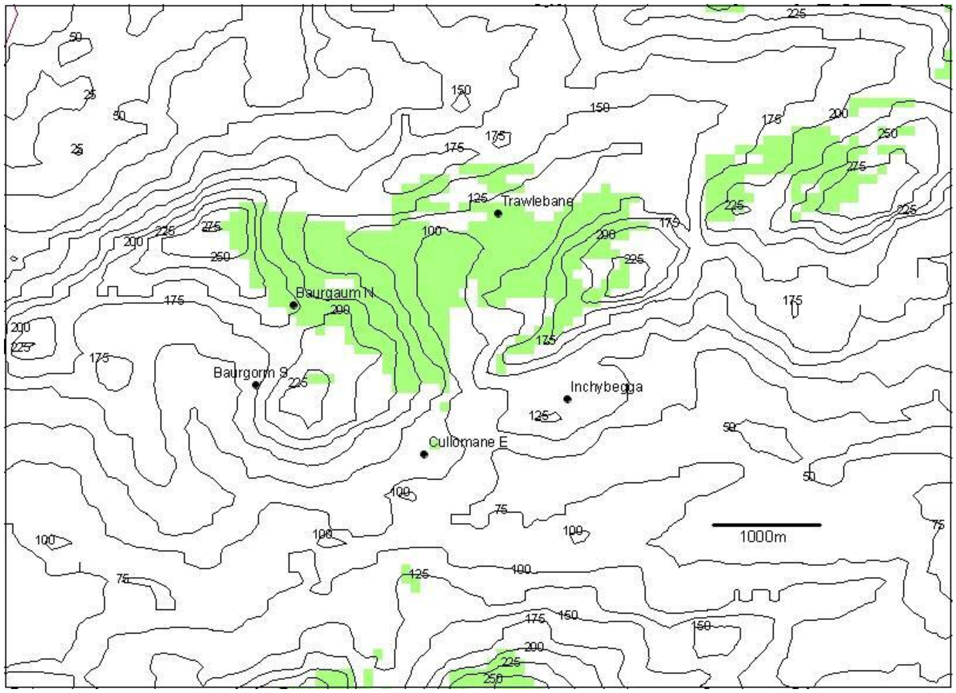

Figure 4.29 Trawlebane stone circle viewshed.

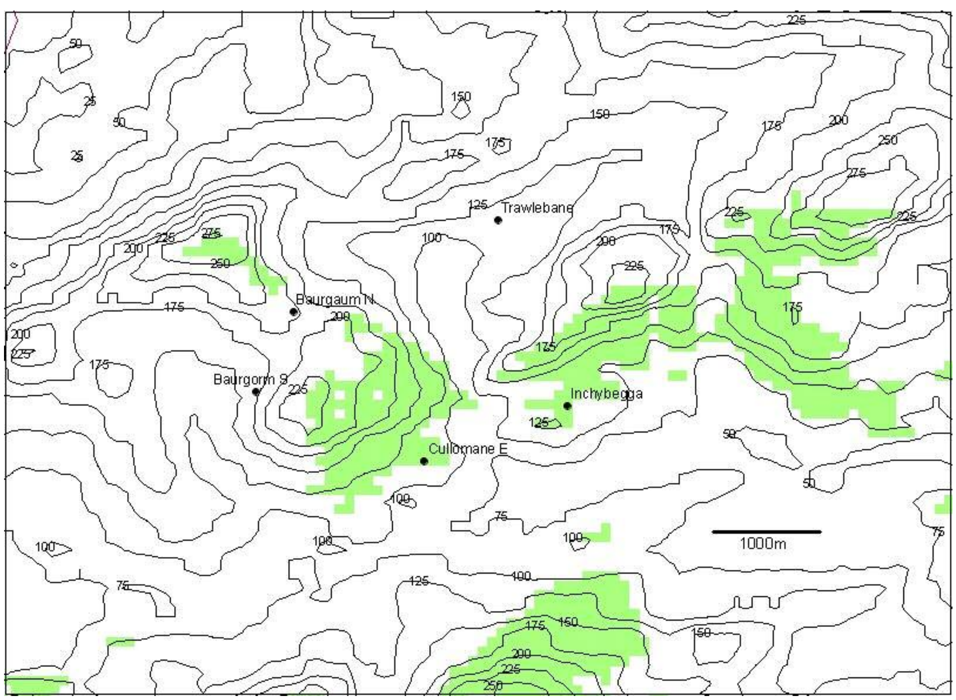

Figure 4.30 Inchybegga stone circle viewshed.

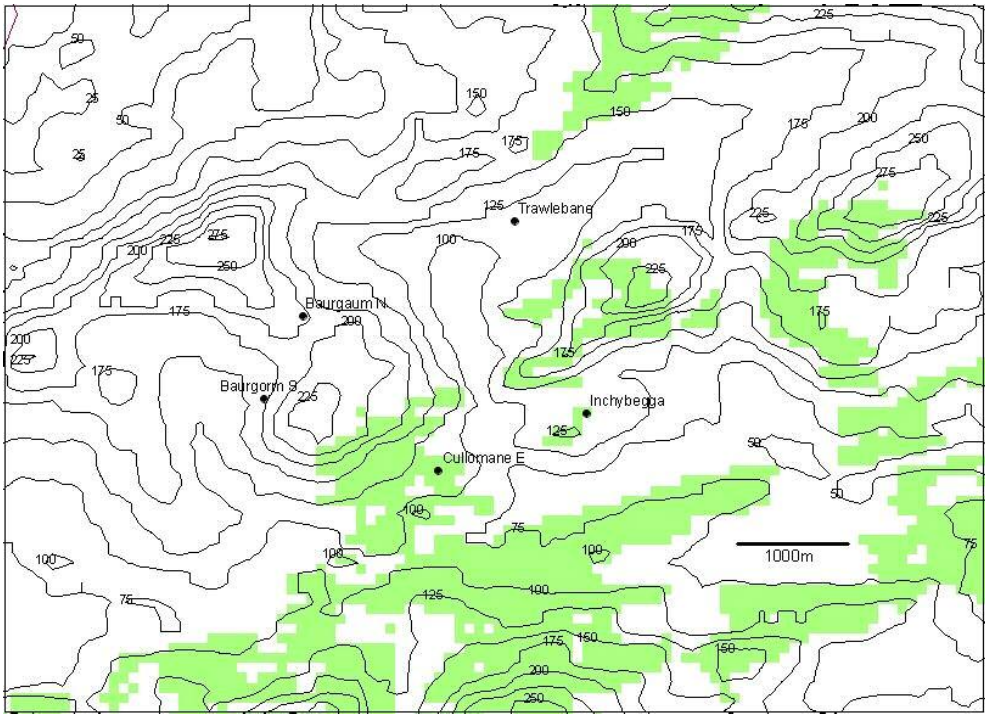

Figure 4.31 Cullomane E stone circle viewshed.

Table 4.2 Summary of descriptive statistics.

Number of Stones / Circle Perimeter

		5	7	9	11	13	15	17	19	MCS
AREA	N	47	4	8	13	11	2	3	1	42
	Average	7.1	10.2	50.8	53.3	84.6	123.4	65.1	56.7	61.9
	Std Dev	3	2.9	14.1	19.4	50.1	108.7	2.5		40.2
	Median	6.4	10.8	46.0	56.7	71.6	123.4	63.6		56.7
ELEV	N	51	4	8	15	11	2	3	1	44
	Average	181.7	131.5	147.1	136.5	161.5	38.5	158.7	132.0	133.7
	Std Dev	71.5	57.3	79.7	68.6	125.8	40.3	99.4		84.4
	Median	178	129.5	129	148	130	38.5	131		131
NND	N	51	4	8	15	11	2	3	1	44
	Average	2051	5731	2778	2767	2430	3178	899	720	2799
	Std Dev	2151	5350	1921	2169	1801	1049	484		2434
	Median	1502	1311	2880	2796	2456	569	1141		1906
NCD	N	51	4	8	15	11	2	3	1	44
	Average	21424	21812	22072	14649	8020	1023	14248	9120	13506
	Std Dev	14104	11341	10078	14205	9371	629	19232		12679
	Median	21395	25300	25219	10362	3240	1023	4800		9131
5k VIS	N	51	4	8	15	11	2	3	1	44
	LOS Sites	30	0	5	4	9	0	2	0	24

Table 4.3 Kolmogorov-Smirnov Test for all stone circles. The distribution of the population background is compared to the sample cases with respect to the number of lines-of-sight among all stone circles. Dmax is .384; Dcrit is .133 at the .05 level.

	Population:			All Stone Circles			Dcrit=.133	
Lines of Sight	Raster Cells	Area %	Cumulative %	Cases	Cases %	Cumulative %	D	
0	930508	84.55	84.55	48	46.15	46.15	**0.384**	(Dmax)
1	71586	6.50	91.05	22	21.15	67.30	0.238	
2	39319	3.57	94.63	22	21.15	88.46	0.062	
3	21895	1.99	96.62	3	2.88	91.34	0.053	
4	13860	1.26	97.88	4	3.85	95.19	0.027	
5	7845	0.71	98.59	1	0.96	96.15	0.024	
6	5044	0.46	99.05	2	1.92	98.07	0.010	
7	3105	0.28	99.33	1	0.96	99.03	0.003	
8	2045	0.19	99.52	1	0.96	100	-0.005	
9	1603	0.15	99.66	0	0.00	100	-0.003	
10	1095	0.10	99.76	0	0.00	100	-0.002	
11	751	0.07	99.83	0	0.00	100	-0.002	
12	551	0.05	99.88	0	0.00	100	-0.001	
13	379	0.03	99.91	0	0.00	100	-0.001	
14	258	0.02	99.94	0	0.00	100	-0.001	
15	168	0.02	99.95	0	0.00	100	0.000	
16	123	0.01	99.96	0	0.00	100	0.000	
17	110	0.01	99.97	0	0.00	100	0.000	
18	77	0.01	99.98	0	0.00	100	0.000	
19	70	0.01	99.99	0	0.00	100	0.000	
20	49	0.00	99.99	0	0.00	100	0.000	
21	39	0.00	99.99	0	0.00	100	0.000	
22	22	0.00	100.00	0	0.00	100	0.000	
23	16	0.00	100.00	0	0.00	100	0.000	
24	5	0.00	100.00	0	0.00	100	0.000	
25	1	0.00	100.00	0	0.00	100	0.000	
	1100524			104				

Table 4.4 Kolmogorov-Smirnov Test for Five-stone circles. The test compares the distribution of the population background and the sample cases with respect to the number of lines-of-sight among Five-stone circles. Dmax is .371; Dcrit is .190 at the .05 level.

	Population:			Five-stone Sample:			Dcrit=.190	
Lines of Sight	Raster Cells	Area %	Cumulative %	Cases	Cases %	Cumulative %	D	
0	883014	80.24	80.24	22	43.14	43.14	**0.371**	(Dmax)
1	136454	12.40	92.64	12	23.53	66.67	0.260	
2	39938	3.63	96.27	9	17.65	84.32	0.120	
3	17720	1.61	97.88	3	5.88	90.20	0.077	
4	8611	0.78	98.66	2	3.92	94.12	0.045	
5	4696	0.43	99.09	0	0.00	94.12	0.050	
6	3013	0.27	99.36	2	3.92	98.04	0.013	
7	1980	0.18	99.54	0	0.00	98.04	0.015	
8	1726	0.16	99.70	1	1.96	100	-0.003	
9	1155	0.10	99.80	0	0	100	-0.002	
10	770	0.07	99.87	0	0	100	-0.001	
11	560	0.05	99.92	0	0	100	-0.001	
12	356	0.03	99.96	0	0	100	0.00	
13	243	0.02	99.98	0	0	100	0.00	
14	100	0.01	99.99	0	0	100	0.00	
15	76	0.01	99.99	0	0	100	0.00	
16	71	0.01	100	0	0	100	0.00	
17	22	0.00	100	0	0	100	0.00	
18	14	0.00	100	0	0	100	0.00	
19	3	0.00	100	0	0	100	0.00	
20	1	0.00	100	0	0	100	0.00	
21	1	0.00	100	0	0	100	0.00	
	1100524	100.00		51	100.00			

Table 4.5 Kolmogorov-Smirnov Test for Multiple-stone circles. The test compares the distribution of the population background and the sample cases with respect to the number of lines-of-sight among Multiple-stone circles. Dmax is .160; Dcrit is .187 at the .05 level.

	Population:			Multiple-Stone Sample:			Dcrit=.187	
Lines of Sight	Raster Cells	Area %	Cumulative %	Cases	Cases %	Cumulative %	D	
0	1027725	93.39	93.39	41	77.36	77.36	**0.160**	(Dmax)
1	40003	3.63	97.02	10	18.87	96.23	0.008	
2	18606	1.69	98.72	2	3.77	100	-0.013	
3	7781	0.71	99.42	0	0	100	-0.006	
4	3815	0.35	99.77	0	0	100	-0.002	
5	1615	0.15	99.92	0	0	100	-0.001	
6	491	0.04	99.96	0	0	100	0.00	
7	328	0.03	99.99	0	0	100	0.00	
8	77	0.01	100	0	0	100	0.00	
9	55	0.00	100	0	0	100	0.00	
10	27	0.00	100	0	0	100	0.00	
11	1	0.00	100	0	0	100	0.00	
Total	1100524	100.00		53	100.00			

CHAPTER 5

DISCUSSION

The initial step in my analysis, following O'Nuallain's categorization, was to examine the frequency of occurrence for each subgroup of sites as a function of the number of stones per site. Based on frequency of occurrence, it would seem reasonable to assume that Five-stone circles correspond to a distinctive group while all other stone circles are lumped into another group, Multiple-stone circles. An obvious concern with this approach, however, is that the characteristic "stones per site" criterion used to define the group of Five-stone circles is ignored in defining the remaining group of stone circles with any other number of stones. Based on the number of stones used to construct the circles, categorization into two groups of Five-stone and everything else seems to be an expedient, if somewhat simplistic and certainly artificial, way to segregate stone circles into groups. While this characteristic may be useful as a first step in distinguishing stone circles for the purpose of further examining their possible function, we should remember that the number of stones per site is only one of many variables which can be used to group stone circles. Other variables, such as internal area or intervisibility, may reveal more about the social activities of the people who built and used stone circles.

There is a reasonable correlation between the internal area of stone circles and the number of stones used to define their circumference. It seems reasonable to assume that both the number of stones used to define the circumference and the area of the circles may have been relevant to the functions of stone circles. O'Nuallain summarized his data of azimuthal orientations of stone circles based on the placement of the axial stone. "It is clear then that the builders observed a custom of aligning the main axes of their circles on the sectors of the heavens in which the sun rises and sets" (O'Nuallain 1984:5). If we assume that the azimuthal orientation of a stone circle to the sun's movement across the sky was intentional, then the position of stones to create possible sight lines becomes an important consideration regarding function. Given that only two points are needed to describe a line, the use of several stones to form a circle, or any other shape, implies additional behavior is involved besides only sighting a distant object. Defining an inner space for stone circles suggests a more elaborate social activity, perhaps involving a relationship between officiant and spectators. The size needed for the activity becomes relevant if the area within the circle or around its perimeter are assumed to have been occupied by people. If astronomical observations were one aspect of the purpose of these sites, for example, then the nature of this social behavior is relevant regarding who was doing the observing and where they were positioned to do the observing. In other words, if we consider the number of stones and their positions as relevant to *what* was being done, then area and circumference may be informative regarding *how many* people were participating in the activity. Additional questions can then be considered regarding whether the number of people interacting at a stone circle is proportional to the population living near the stone circle and what the nature of their social hierarchy may have been. As a variable of the unique social space defined by stone circles, the area of stone circles is likely to have been an important aspect of the social interactions which took place at these sites.

An upper limit to the size of stone circles is suggested by the lack of stone circles with more than 19 stones or more than a maximum area of approximately 227 m^2 (Figure 4.2). Aubrey Burl implies the likelihood that the area of a stone circle was related to the number of people who would have used it. "It is arguable that the size of a ring, whatever its shape, was determined by the number of people in the congregation that was going to use it" (Burl 2000:44). It may be that this maximum stone circle area is related to the upper limit of the population using these structures. Burl makes what appears to be a cavalier assumption that a person in a stone circle would occupy approximately $2.6m^2$ based on a 1.8m body-space of outstretched arms and that half the circle was reserved for officiates directing the activity (Burl 2000:45). Based on those guidelines, the maximum number of people occupying the largest stone circles in the region can be estimated at around forty-four. Further assumptions that the 44 people were adult men and were capable of moving the heaviest stone in the circle would allow a very rough estimation of the total population using the circle to be made.

Elevation is a variable mentioned by O'Nuallain to distinguish Five-stone from Multiple-stone circles (O'Nuallain 1984:8). Analysis of the data indicates that on average, Five-stone circles are found at significantly higher elevations than any other subgroup of stone circles based on stones per site (Table 4.2). The mean elevation of

Five-stone circles is almost 36% higher than the mean elevation for MSC as a group. A stronger correlation is found between elevation and area, however, suggesting that elevation is more predictive of area than of stones per site. Stone circles of smaller areas tend to be located at higher elevations than larger area circles, regardless of the number of stones used in their construction. Elevation is not a reliable distinguishing characteristic of either Five-stone or MSC groups. If we assume that a relation exists between the area of a stone circle and the number of people using it, then elevation becomes a predictor of population size. We can infer that smaller groups of people interacted with stone circles at higher elevations while larger groups of people interacted with stone circles at lower elevations. Higher elevation may be suggestive of a lower resource base. It may also be associated with smaller social groups due to some ideological concept. The location of suitable stones is also a factor affecting the labor cost of building a stone circle. It may have been easier to build multiple stone structures at lower elevations, since fewer stones would need to be hauled up a hill. Based on the topography of the region, the coastal plain is considered more suitable for cereal cultivation than higher elevations. Early agricultural efforts at lower elevations, therefore, can be considered a possible factor associated with increased population size among settlements in more fertile, lower lying areas.

Nearest Neighbor Analysis indicates that the entire population of stone circles in the study region display significant clustering and a lack of spatial randomness. When the sites are divided into Five-stone and MSC groups, each group continues to display significant clustering. This suggests that spatial clustering might not be a reliable predictor of Five-stone circles as a separate group since the degree of clustering is significant whether Five-stone circles are considered separately or as a portion of the entire population of stone circles. Upon closer examination, NND does not show a significant correlation to area among the Five-stone group. When Multiple-stone circles are considered as a separate group, again there is no significant correlation between NND and area. There is a weak but significant correlation within the MSC group, however, between NND and stones per site, with the smaller sites being located at greater distances from their nearest neighbor. Among MSC, the number of stones per site is a slightly better predictor of NND than is the area of the stone circle. This association suggests that the distance between nearest neighbors can be considered a distinguishing characteristic of the MSC group. To examine this relationship more closely, the three MSC subgroups with the most cases, 9-, 11- and 13-stone were examined. Only the 9-stone indicates a significant correlation between NND and area, and suggests a tendency for smaller area sites to be spaced at greater distances from their nearest neighbor. If we continue our assumption that larger area stone circles represent larger populations, then we might expect larger populations to have larger critical resource areas resulting in a spacing of nearest neighbors at greater distances, but this is not suggested by the data. Other factors may have influenced the size and density of the resource area needed to support a population. Cereal cultivation, for example, presumably increased resource density and productivity beyond that required for a pastoral economy. As agricultural efficiency improved, larger populations could live closer to one another. It should also be noted that population increases over time could also have affected the size of resource areas. These chronological distinctions are difficult to make due to unresolved issues of contemporaneity. Based on the available NND data, the distance from a stone circle to its nearest neighbor appears to be closely related to area within the 9-stone subgroup. This also suggests that area may be preferable to stones per site as a predictor of NND among stone circles of $50m^2$ or less. Among stone circles of larger area, the number of stones per site is a better predictor of nearest neighbor distance.

Analysis of Nearest Coastal Distance among the entire population of stone circles indicates a weak but significant correlation to both stones per site and area. Smaller sites, whether categorized as Five-stone or MSC, tend to be located farther from the coast. Among MSC, a significant correlation is indicated between NCD and stones per site. Among the Five-stone group, however, there is enough variation in the NCD to indicate no significant correlation between NCD and area. If the Five-stone circles, irrespective of area, are identified with a social group that is distinct from social groups associated with MSC, then we might surmise that people associated with Five-stone circles may not have relied upon the coast to the same extent as those people associated with MSC.

The frequency of intervisibility is similar for both Five-stone (31.4%) and MSC (37.7%) groups. With the exception of one pair of MSC, sites within the same MSC subgroup, based on stones per site, do not display intervisibility among one another. This may suggest a level of association regarding intervisibility among sites within the Five-stone group, as well as across MSC subgroups. Based on these frequencies of intervisibility, the categorization of Five-stone and Multiple-stone circles as legitimate groupings is questionable. One aspect of intervisibility, Nearest Visible Neighbor Distance, might be thought to represent significant social links among neighboring settlements. If intervisibility were important, one would expect it to be associated with a site's nearest neighbor. A correlation between intervisibility and NND, however, is not found. The data do not suggest that sites are visible to their nearest neighbor at a significant level.

Increased elevation is often assumed to be directly related to increased visibility across a landscape. It is interesting to note that within a viewing radius of 5km, no correlation is shown to exist between stone circle elevation and intervisibility. This may be due in part to the abundance of rolling hills and valleys which can often restrict visibility regardless of the elevation of the viewer. If intervisibility exists among stone circles at significant levels, therefore, it is more likely to be the result of intentional positioning of the site rather than from random placement at higher elevations.

Thiessen polygons and buffers provide a convenient way to visualize theoretical territories surrounding stone circles. Clustering suggests the possibility that intervisibility may have been a factor in their placement. Nearest Neighbor analysis indicates that both Five-stone circles and Multiple-stone circles are clustered in a non-random manner. Both Thiessen polygons and buffering reveal smaller clusters of sites and sites spatially linked by mean NND buffer zones into linear chains. These groupings may provide potential opportunities for future research into the possible social connection among the builders of stone circles. If contemporaneity is assumed, the examination of a small cluster of Five-stone circles suggests a tendency for sites to be located along an “intervisibility border” where their visibility of another site may be determined by only tens of meters in one direction or another. The cluster of five Five-stone circles, previously examined, suggests that maximum visibility of the landscape was not a priority since none of the sites are positioned at any nearby hilltops. These stone circles also do not appear to be situated to maximize privacy from all other sites. Rather, these stone circles seem to be located so as to balance their view of a portion of the surrounding landscape while maintaining some visual privacy from nearby stone circles.

When cumulative viewshed analysis is applied to stone circles in the study region, the level of randomness of site location regarding intervisibility is quantitatively tested. The results indicate that as a single group, all sites are distributed throughout the landscape with respect to their intervisibility. Further, Five-stone circles are also distributed non-randomly with respect to their intervisibility. Multiple-stone circles, while displaying clustering based on nearest neighbor analysis, are not distributed with respect to the number of other visible sites. This may suggest that the MSC category is not a suitable typological group to use in researching the social connections that may have existed between the social groups that built and used stone circles. Of course, it may also be that settlements associated with MSC did not consider intervisibility as high a priority as the builders of Five-stone circles. Given that elevation can be eliminated as a significant predictor of intervisibility, the difference in intervisibility between Five-stone and MSC groups may support the contention that settlements associated with Five-stone circles may be considered culturally distinct from social groups associated with other stone circles. The builders of Five-stone circles may represent a distinctive social group that differed in its social activities, economy and use of stone circles compared to the builders of other stone circles in the region.

CHAPTER 6

CONCLUSION

6.1 Summary

This spatial analysis of stone circles in the southwest region of Ireland has been purposely restricted in its scope and provides only a limited treatment of a few variables that may have influenced their siting. This approach, where size and location of stone circles is analyzed within a spatial framework, emphasizes only one aspect of the available archaeological information. But from these data on size and location it is possible to begin to investigate, in a rather elemental way, questions of settlement size, resource areas, cultural identity and social connectedness. The specific functions of stone circles remain unknown although they are generally believed to have played a role as places of congregation where social activities periodically took place. As integrative centers for people within early settlements, stone circles may have served to maintain the cohesiveness of social groups. It is difficult to imagine people expending the energy necessary to construct a stone circle only to leave it solely as a marker in the landscape. It seems more likely that stone circles were used, at least periodically, as places where important social activities took place. The early settling of southern Ireland may have been a multicultural phenomenon based on the distinctive sizes and placement of stone circles in the landscape. The stone circles of Counties Cork and Kerry have been shown to be distinctive in several ways, some of which do not always provide the best correlation with their popular categorization as either Five-stone circles or Multiple-stone circles.

For example, the elevation of stone circles is associated more closely with their area than with their number of stones. The smaller the area of a stone circle, regardless of the number of stones used, the greater its elevation. Since area is associated with elevation more closely than stones per site, it may be more useful to categorize stone circles in increments of area rather than the number of stones used in their construction. Also, a site's distance to its nearest neighbor becomes weakly significant only when the subgroups within the MSC are considered. This suggests that the MSC group should not be considered as one homogeneous group and that NND should not be used to distinguish the MSC as a group. On the contrary, the MSC should be separated further into individual groups based on size.

A site's nearest distance to the coast is associated with both stones per site and area, with smaller stone circles located farther from the coast. This tendency for smaller sites to be located farther from the coast extends beyond the Five-stone group and is observed among the MSC subgroups. This again suggests that the MSC group may be too general a category to be considered distinctive when considering NCD. If the number of stones in a stone circle is to be used as a typological characteristic, it may be more reasonable to consider all eight groups rather than only two. Alternatively, for the variables of elevation, NND, NCD and intervisibility, a typology based on area of the stone circles appears to provide a closer correlation than the number of stones used to define the circumference, and seems more closely associated with socially occupied space.

Intervisibility, as a measure of social connection among groups associated with stone circles, has been shown to be detectable, significant and relevant to the study of early human settlement in Ireland. Cumulative Viewshed Analysis demonstrates statistically that stone circles, considered as a single population, are positioned in the landscape with respect to their intervisibility. Analysis of Five-stone circles as a separate group also indicates intervisibility as a factor in their location. The fact that elevation is not related to intervisibility among the rolling hills and valleys of the region suggests that intervisibility is not just an unintentional byproduct of Five-stone circle placement at higher elevations. The Multiple-stone circles do not indicate intentional positioning with respect to their visibility from other sites. Through closer examination, the MSC group is too heterogeneous to be considered a distinct group since only a single pair of MSC subgroup sites exhibits intervisibility. Regarding intervisibility, a clear distinction is suggested between the Five-stone circles and all other stone circles.

6.2 Future Research

This spatial analysis has attempted to quantify certain aspects of stone circle placement in order to shed light on human behavior during the Irish Neolithic/Bronze Age. There are several problems with this approach which cannot easily be dismissed and should be mentioned. Although several hundred stone circles survive today in Ireland, these extant sites are the result of many factors which have changed the original spatial patterning that existed during the Neolithic/Bronze Age. Natural erosion over several millennia may have reduced some sites to an unrecognizable scattering of stones. Local interests regarding land use, construction and development have not always included preservation of stone circles as a high priority. Intentional destruction of stone circles in efforts to clear farmland has undoubtedly occurred as well. An improved understanding of stone circles, and megaliths in general, may be gained from future archaeological research that includes the analysis of a more complete list of relevant variables. A more comprehensive understanding of the vegetative evolution of Ireland, for example, would permit more precise recreations of topographic maps which may improve the accuracy of statistical interpretations.

The distribution of stone circles is also likely the result of varying research interests in different regions of Ireland. Activities leading to the discovery and investigation of stone circles may have varied from region to region and influenced the resulting distribution pattern. Also, as the area of investigation increases, the more difficult it becomes to assess the archaeological implications of the data. In an area as large as the region considered in this study, obtaining a reliable indication of stone circle distribution during the period of their construction and use is somewhat conjectural and should remain largely theoretical.

In addition to the problems associated with the survival and discovery of stone circles, there is the difficulty resulting from our inability to date these megaliths accurately. Very few stone circles have reliable dates associated with them. It is hoped that new dating techniques will be developed to more accurately ascribe a chronology to the hundreds of stone circles found throughout the British Isles. In many cases, unscientific investigations occurred long before precise and systematic archaeological excavation methods were developed. In other cases, the refinement of a reliable typology might not yet be fully understood, making it difficult to interpret a distribution map in which all stone circles are considered to be contemporaneous. These problems are likely to be resolved only by the application of more accurate dating techniques and a more detailed understanding of cultural development on a regional level.

Also of importance in the spatial analysis of stone circles is the use of good data. In this research, I have been fortunate to have access to GPS coordinate readings, which in previous years might not have been so readily available or as accurate as they are with today's instrumentation. The coordinates are presumed to be accurate and the result of the continual check and balance of updated readings. They are, nevertheless, the result of independent contributions to an internet website dedicated to the further understanding of megaliths. I have not verified or attempted to duplicate their accuracy, but have relied on them as accurate enough for this study.

Even with good data, however, there may be concerns associated with the methods and statistical techniques used to analyze the data. As discussed earlier, the statistical tests which have been used require certain assumptions to be made about the data. In many cases in archaeology it is impossible to make assumptions of sample randomness and population size that meet the requirements for use of inferential statistics. As a result, these tests should be regarded with caution when applying a statistical interpretation to archaeological data. Statistical methods such as Nearest Neighbor Analysis and Cumulative Viewshed Analysis were chosen as a way to quantify stone circle data and minimize the subjective nature of interpreting map patterns. These tests allow the degree of departure of an observed pattern from the expected pattern to be measured and related to the probability that stone circle location selection was intentional. The role that these various environmental factors may have played in site selection, however, remains largely inferential. Perhaps the best way of testing the reliability of observed patterns of sites is to collect additional data to determine how they fit in with previous observations.

The value of spatial analysis lies in its quantitative approach which can provide greater objectivity in the demonstration of spatial patterns, trends and relationships. The popularity of GIS software among archaeologists will continue to inspire exploration of these relationships. Important uses of spatial analysis of archaeological data include hypothesis testing, as well as the ability to discover patterns that have not been revealed by more traditional archaeological methods. These new patterns may lead to questions which give the archaeologist more information to work with and explain. In some cases, the possibility exists that spatial analysis might be used to predict the location of undiscovered sites.

It has been demonstrated that spatial analysis is relevant to the archaeology of stone circles and that their distribution in the landscape is an important aspect of the archaeological data. From the few variables considered here and their spatial interrelationships in the landscape, certain aspects of human behavior during the earliest stages of Irish settlement have been suggested. Correlations among these variables have allowed general predictions to be made about stone circles and have enhanced our knowledge of the social groups who built them. It appears likely, based on this research, that intervisibility among Five-stone circles and the people who used them was intentional. It is hoped that based on this spatial analysis, new insights have been revealed that may aid others in future research to determine what function stone circles played in the early settling of Ireland.

APPENDIX A

FIVE STONE CIRCLES

Table A.1 Five Stone Circles

SITE NAME	Latitude	Longitude	Area	Elev.	NND	NCD	Vis.
Baurgaum N	51.666632	-9.412822	5.3	202	816	3636	1
Baurgorm S	51.659923	-9.417672	5.1	219	816	3791	0
Bellmount Upper	51.825902	-8.827459	12.6	151	428	21042	2
Bellmount Upper SW	51.828567	-8.831860	11.0	149	428	21395	3
Cabragh	51.966119	-9.051193	8.0	255	1231	38870	2
Canrooska	51.766652	-9.542985	4.5	174	5663	1420	0
Cappaboy Beg NW	51.796113	-9.331342	3.3	180	3989	11448	0
Carrigagrenane NE	51.642369	-9.072584	N/A	137	1467	9748	0
Carrigagulla N	52.00349	-8.91700	7.1	259	2654	36355	1
Carriganimmy	51.992370	-9.029970	8.6	323	1502	39990	4
Carriganine	51.895707	-8.980880	N/A	161	6643	32226	8
Carrigonirtane [1]	51.974403	-9.039308	6.2	198	1231	38728	2
Cashelkeelty E	51.757032	-9.813786	1.8	126	9503	994	0
Clodagh NE	51.696246	-9.224852	5.7	205	6544	14988	0
Cloghboola Beg	52.015884	-9.013031	8.6	244	1554	41966	0
Cloghboola More	52.029978	-9.055895	7.5	200	3275	39953	1
Cousane	51.757078	-9.285297	6.0	176	1521	11839	0
Cullenagh [2]	51.743648	-9.280572	N/A	416	1521	11678	2
Cullomane E	51.654261	-9.395097	10.4	120	1418	5421	1
Derryarkane [3]	51.728594	-9.372055	7.1	128	1778	5081	0
Dromatouk	51.885486	-9.521343	5.7	102	13291	4176	0
Dromgarriff	51.991278	-8.549104	7.1	178	4671	14785	6
Dromgarvan	51.692229	-9.723984	5.7	4	9503	2080	0
Glanbrack	51.648115	-9.053359	6.2	160	1467	10634	1
Glenleigh	52.059152	-8.997971	9.1	180	2596	44986	0
Glenreagh	52.177838	-9.186283	9.6	231	16170	38631	0
Gortnatubbrid	51.929553	-9.173476	4.5	261	3122	28526	6
Grenagh S	52.006964	-8.612352	19.6	165	4429	18940	1
Illane	51.780325	-9.383187	4.9	125	3989	7878	0
Inchireagh	51.754557	-9.174004	5.7	100	7374	19114	0
Inchybegga	51.658980	-9.376022	6.4	123	1418	6148	1
Kealkil	51.744450	-9.368916	5.5	161	1778	5974	0
Kilmeedy W [4]	52.040534	-9.110067	9.6	319	3898	37298	2
Knockavullig NE	51.883770	-8.828880	4.3	128	282	27743	2
Knockavullig SW	51.881960	-8.831750	8.0	123	282	27520	2
Knocknakilla	52.005861	-9.028823	5.7	303	1502	40652	1

Table A.1 – *Continued*

Knocknaneirk NE	51.818046	-8.917227	9.5	190	5994	22642	3
Knockraheen	51.969277	-9.012867	11.6	258	1906	40225	2
Laharankeal	51.944130	-8.883439	1.8	233	2780	32125	4
Leckaneen	51.940389	-8.816476	9.6	141	3381	27550	1
Lettergorman SW	51.659508	-9.065763	6.8	178	1531	11697	1
Lissacresig	51.926465	-9.063350	8.5	187	4486	34986	1
Mill Little	51.752283	-9.464730	5.8	59	5663	3079	0
Oughtihery NW	51.987230	-8.888654	6.1	241	2638	33836	0
Pluckanes N	52.011107	-8.676490	9.3	170	4429	22514	0
Reananerre	51.903096	-9.158693	3.9	212	3122	28377	2
Rosnascalp	51.924543	-8.858343	7.1	162	2775	29990	3
Rylane	51.981446	-8.818677	8.4	179	4570	29138	0
Trawlebane [5]	51.674418	-9.385452	4.5	109	1840	4811	1
Tullig	52.036607	-9.006941	N/A	207	2347	43250	0
Uragh NE [6]	51.812116	-9.694332	4.7	54	10337	2757	0

N/A: Not Available

Note 1. Burl 2000:398. O'Nuallain private communication, 2/11/1987.
Note 2. Burl 2000:398. Power et al., 1992, 24, no. 71.
Note 3. Burl 2000:399. O'Nuallain private communication, 12/10/1989.
Note 4. Burl 2000:399. O'Nuallain private communication, 2/11/1987.
Note 5. Burl 2000:400. Power et al., 1992, 25, no. 82.
Note 6. Burl 2000:401. *J. Kerry Arch. Hist. Soc*. 20, 1987:112-13.

APPENDIX B

MULTIPLE STONE CIRCLES

Table B.1 Multiple Stone Circles

SITE NAME	Latitude	Longitude	Stones	Area	Elev.	NND	NCD	Vis.
Ahagilla [1]	51.641522	-8.962777	3+ ?	38.5	103	1712	9131	0
Ardgroom	51.735709	-9.872432	11	41.9	57	649	948	1
Ardgroom Outward	51.738180	-9.863992	5+ ?	N/A	59	649	967	2
Ballvackey	51.627215	-8.953810	9 *	56.7	81	1712	7706	0
Bohonagh	51.580102	-8.998987	13	77.0	27	6009	2397	0
Breeney More	51.741670	-9.376071	5+ ?	153.9	131	2537	5560	1
Cappanaboul	51.723786	-9.398683	13 *	86.6	123	2537	3240	1
Carrigagrenane SW	51.636924	-9.078233	19 **	56.7	132	1416	9120	0
Carrigagulla S	51.99989	-8.91838	17 *	63.6	269	5585	36377	1
Carrigaphooca	51.909715	-9.026626	5+ ?	23.8	81	3470	35274	0
Cashelkeelty W	51.756379	-9.815353	13	227.0	132	5360	1085	0
Coolaclevane	51.823362	-9.034815	9	44.2	212	4392	28690	1
Coolmountain	51.786998	-9.174556	11 **	66.5	132	6917	20374	0
Coulagh	51.679683	-9.978270	5+ ?	56.7	20	4450	233	0
Currabeha N	51.829019	-8.839958	9	38.5	107	982	21677	0
Currabeha S	51.825330	-8.852944	13 **	56.7	128	982	21480	0
Derreenataggart	51.653852	-9.928941	15 *	46.6	67	4450	1468	0
Derrynafinchin	51.805428	-9.380911	11	50.3	148	7075	10233	0
Doughill	51.869483	-9.507735	17 *	63.6	131	725	4800	0
Dromagorteen [2]	51.830777	-9.512245	13	78.5	130	3607	6385	0
Drombeg	51.564553	-9.087020	17	67.9	76	6347	1568	0
Drombohilly	51.786070	-9.754225	11 *	56.7	158	5360	2239	0
Dromkeal [3]	51.734117	-9.443732	13	63.6	40	3328	1219	1
Dromod	51.858377	-10.112688	7 *	12.6	81	21544	5729	0
Dromroe	51.832862	-9.625474	13	70.9	86	5620	2050	0
Dunbeacon	51.595722	-9.549079	11	50.3	109	6716	1015	0
Garryglass	51.654653	-9.123737	11	N/A	153	3722	10745	0
Glantane East	52.004426	-9.044853	11 *	15.9	258	695	39600	0
Glantane SW	51.998850	-9.049338	11	19.6	233	695	39046	0
Gortanacra	51.927558	-9.157142	13	50.3	234	1562	29670	2
Gortanimill	51.913950	-9.151706	9	47.8	219	1562	29729	1
Gorteanish [4]	51.597981	-9.645940	11	50.3	34	6716	495	0
Gortroe	51.792446	-9.074690	11 **	56.7	182	4392	26660	0
Gowlane N	52.023995	-8.772835	9 *	33.2	274	4048	28662	0
Gurteen	51.872081	-9.443934	11	86.6	197	4420	9209	0
Kenmare	51.878315	-9.587902	15	200.3	10	1896	578	1
Kilboultragh	51.929569	-8.987695	11 *	63.6	137	3485	35721	0
Killowen	51.886331	-9.563507	11	N/A	22	1896	1847	0
Kilmartin Lower	51.991638	-8.800229	7	9.1	186	4048	28456	0
Knockaneirk SW	51.811823	-8.908401	9 *	70.9	151	4100	21775	0
Knocks NW	51.659082	-9.012283	11 **	63.6	72	1102	11235	0
Knocks SE	51.649197	-9.012063	5+ ?	56.7	73	1102	10106	0
Lackaroe [5]	51.863157	-9.510427	5+ ?	50.3	217	725	4745	0

Table B.1 – *Continued*

Lissard	52.060806	-8.627668	5+ ?	50.3	170	10772	24115	1
Lissyviggeen	52.058809	-9.461611	7	12.6	83	20720	22144	0
Maughanclea NE	51.754239	-9.298250	13 *	103.9	213	5566	10970	0
Oughtihery SE	51.968607	-8.854820	7 *	6.6	176	4553	30918	0
Reanascreena	51.617300	-9.061886	13	71.6	174	2456	7372	0
Shronebirrane	51.737246	-9.831959	13 *	44.2	489	2213	2357	0
Teergay	51.872835	-9.030142	9 *	44.2	69	4110	32240	0
Templebryan	51.643162	-8.883359	9 *	70.9	64	5186	6100	0
Tuosist (Lohart)	51.837101	-9.706877	5+ ?	95.0	20	5620	10	1

* = Deduced
**= Estimated
\+ ? = Plus unknown stones.
N/A = Not Available

Note 1. Burl 2000:397. O'Nuallain private communication, 9/10/1990.
Note 2. Burl 2000:401. *Arch Ire 11* (3), 1997.
Note 3. Burl 2000:399. Power et al., 1992, 22, no. 53.
Note 4. Burl 2000:399. Power et al., 1992, 43, no. 215.
Note 5. Burl 2000:401. P. Walsh, private information.

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