Spatial distribution of England's crop circles:

Using GIS to investigate a geo-spatial mystery

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Abstract - What factors influence the location of crop circles? What is their relationship to various geographical variables such as population density, road networks, and cultural heritage sites? This paper examines the spatial distribution of crop circles that appeared in the English countryside during 2002 and seeks to understand their positioning in terms of various artificial features. Through Geographic Information System (GIS) mapping and spatial analysis, the distribution of reported crop circles is shown to be a highly clustered one, which centres on certain cultural heritage sites such as Avebury and high population density areas across England, particularly in the south. Crop circles are also shown to be aligned with some of England's principal motorways. These findings cast doubt on paranormal theories explaining crop circles as the result of natural forces such as plasma vortices, indicating instead that some form of intelligence (human or otherwise) is the principal agent.

Introduction

Crop circles are perhaps the best-known geo-spatial mystery of the modern era. Circular patterns have been appearing in English crop fields in large numbers since the early 1980s, with the complexity of the designs having increased markedly from the simple circles of the earlier period, with patterns now tending to take the form of complex geometrical patterns, as shown in Figure 1.

Fig. 1. Typical “fractal” type crop circle formation

While it is widely believed that most, if not all, of these circles are produced by hoaxers, there are still many who believe that crop circles are a natural, even supernatural, phenomenon. This paper

seeks to analyse the distribution of crop-circles across England in 2002, in an attempt to identify significant factors accounting for their geo-spatial positioning. It will be demonstrated that crop circles tend to be placed in locations that maximise their accessibility to visitors, such as in areas close to major population centres, main roads and cultural heritage sites. Hence, it will be suggested that crop circles are a form of symbolic art or sign language, and as such, their purpose is to be "read" or appreciated by an audience. It is contended that this will be the case regardless of whether crop circles are "hoaxes" produced by individuals or are created by some other form of intelligence.

Past Research

There has been little in the way of mainstream scientific research on the origins of crop circles. One possible exception is the work of the "BLT" team of researchers in the United States, which have undertaken a series of chemical analyses of plant and soil samples obtained from crop circle sites. BLT researchers have proposed a geophysical theory of crop circle causation based on a hypothesised "ion plasma vortex" (Levengood, 1994; Levengood & Burke, 1995; Levengood & Talbott, 1999), which they contend accounts for over 95% of worldwide crop circle formations.[1] However, theories such as these, which attribute natural (albeit unconventional) causes to crop circle formations, have paid little attention to the distribution of crop circles in order to establish whether they follow a "natural" placement (e.g., a random distribution or, at the very least, a pattern that is independent of artificial features). Obviously, if the location of crop circles does not follow a natural pattern, then the viability of such explanations is cast in serious doubt.

Surprisingly, there have been no efforts to explore the geo-spatial aspects of crop circles. Only a few attempts have been made at crop circle mapping (undertaken by crop circle enthusiasts themselves), and no attempt has ever been undertaken to subject such mapping to detailed spatial analysis. As will become evident during the course of this examination, the study of crop circles can be related to the study of other forms of landscape monuments, which shed important light on the rationale for crop circle positioning. Archaeological projects studying the spatial distribution of megalithic monuments (including stone circles) in England have a particularly close parallel. Renfrew (1973) holds that megalithic tombs in England tend to follow ancient settlement patterns. Baldia (1995) argues, in contrast to Renfrew, that the location of megalithic sites in England is best explained by their correspondence to major communication routes or prehistoric roadways, which increased their visibility and made them accessible to travellers and perhaps even pilgrims. Both roads and settlement patterns are key variables being investigated in the present study, and although thousands of years separate the two phenomena, the hypothesis tested in this investigation is that the locations of crop circles are subject to the same kinds of determinants as those postulated for prehistoric megaliths, albeit in areas limited to crop farming.

If this hypothesis is substantiated, then natural causes for crop circles would tend to be ruled out. Importantly, however, it would not rule out explanations that posit extraterrestrial or spiritual agencies for crop circles. Such explanations may be fully compatible with the proximity of crop circles to roads, population centres and ritual centres of significance, as non-human intelligences may well be motivated to maximise accessibility to crop circle formations in order to spread their message (whatever that message might be) to the widest audience possible. Of course, hoaxing explanations would also be fully compatible with such a spatial pattern. Hence, while a spatial analysis of crop circle distribution is unlikely to confirm the precise causal agency underlying crop circle formations (and resolve the believer-skeptic dispute that surrounds the phenomenon), it can certainly falsify theories that postulate natural forces as agents.

[1] Also see Meaden (1991).

Source of Data

Data for this project was taken from the International Crop Circle Database (available online at www.cropcircleresearch.com), maintained by Paul Vigay of the Independent Research Centre for Unexplained Phenomena (IRCUP). Vigay's database contains information on the formation dates, patterns and locations of reported crop circles for the last twenty-two years. The 2002 formations on the database (the most recent ones when this investigation began) numbered just over 100 formations (see Vigay, 2003). Each listing has a date, description and location – in several cases accompanied by a photograph of the formation. The manner in which formations become 'hot' news in the crop circle researcher network and investigated by keen researchers (including Vigay himself) creates its own built-in verification process for the authenticity of the reports. However, it is not always the case that reported formations are clearly definable as 'crop circles.' For example, based on the reported descriptions, two formations were removed from the dataset because they appeared to be tyre marks (incidentally, another three were removed because they appeared outside the focus study area in Scotland).[2]

Unfortunately, the absence of coordinates for the majority of the circles reported in 2002 (only the nearest towns are mentioned) meant that it was necessary to determine the coordinates for many of the crop circle formations by approximate means. It is fortunate, however, that England has a high density of villages, towns and cities that are generally in close proximity to one another, and so consequently a reasonable estimate of the error margin for crop circle coordinates is ± 3-4 kilometres. At any rate, the analysis of the mapped data was conducted at a sufficiently large scale (1:5500000) that the effect of marginal geo-referencing error would be minimal.

Whether Vigay's data set represents the entire population of crop circle formations that appeared in 2002 is an important issue. The IRCUP database consists only of those crop circles that have been reported, and so there is no way of determining how many other crop circles appeared that went unreported. If the dataset is only a sample, then the question arises as to whether certain biases may have been involved in reporting formations. In particular, it might be wondered if there was a bias towards reporting crop circles that appeared close to main roads, major population centres and cultural heritage areas where there were more passers by to report formations. If so, these are the very same variables that are being investigated in terms of crop circle locations. Given the widely traversed nature of England's relatively small land area (particularly by air), and the keen interest of a small but dedicated band of crop circle researchers keen to document the appearance of crop circles from far a field, it was felt that any reporting bias would have been minimal.

Vigay's crop circle data, once georeferenced, was entered into ArcView 3.2, a Geographic Information System (GIS) that is specifically designed to represent and manipulate mapped data. Various other mapped data (derived mainly from government sources) were also entered into the system, such as population distribution, road networks, and cultural heritage information. The findings presented in this paper are the result of the application of standard statistical and spatial analytical techniques to understand the relationships within and between these data sets.

Spatial Distribution

The spatial mean centre, median centre and standard distance for the 2002 crop circles are shown below in Figure 2.

[2] The circles in question are a formation reported at Dorset on May 30, 2002 and a formation reported at Leicestershire on July 8, 2002.

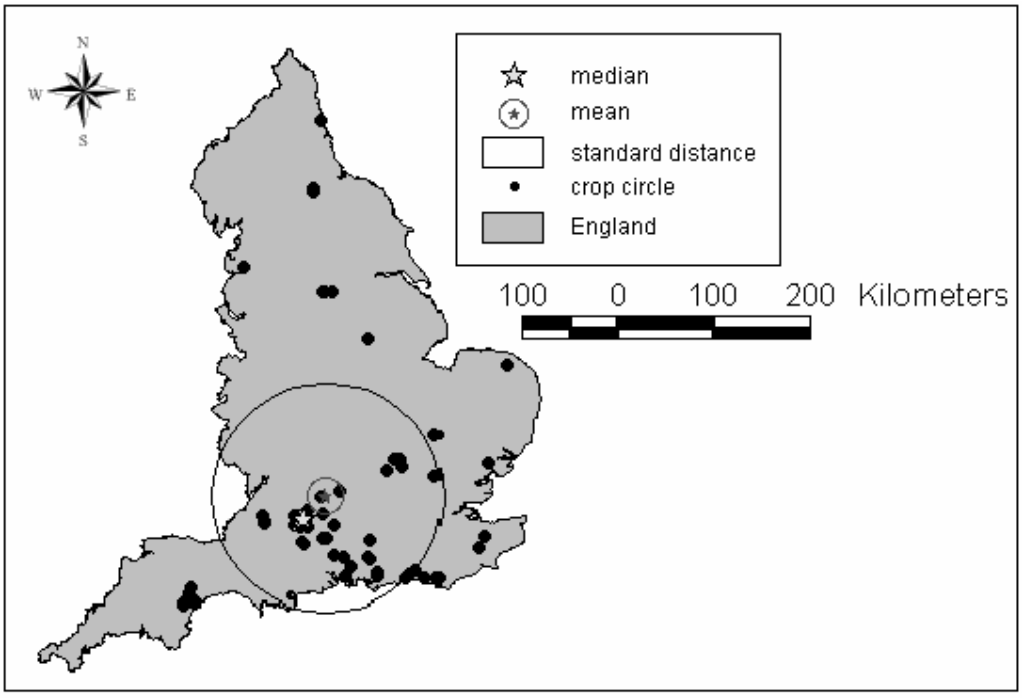


Fig. 2. Statistical map of crop circle distribution

The median centre falls in the centre of the main crop circle cluster around Avebury. The mean centre lies just north east of Avebury, close to the township of Uffington, and reflects the effect of the concentration of crop circles around Avebury and the numerous circles in the south, balanced by the wide dispersion of circles to the north and east of the country. Indeed, the standard distance indicates that there is considerable dispersion amongst the coordinates, which reflects the fact that circles appear along the length and breadth of England.

The concentration of crop circles in the south of England, however, is undeniable. Some 46 per cent of crop circles were reported in Wiltshire, and 10 per cent reported in Hampshire. A small number were found in Devon county in south-west England in the area around Exeter, and also in West Sussex. Over two-thirds of the English counties that were host to a crop circle in 2002 were located in the southern half of England. Additionally, these southern counties accounted for seven-eighths of all crop circles (that is, 84 out of the 96 crop circles).

REGION	km²	circles	density
North	648.1	1	1.54
North West	741.7	1	1.35
Yorkshire & Humber	4241.3	7	1.65
East Midlands	5734.3	2	0.35
West Midlands	2628.2	0	0.00
East Anglia	7784.9	8	1.03
South East	4279.4	25	5.84
South West	3499.7	52	14.86
		MEAN =	3.25
		VAR =	21.81

Fig. 3. Crop circle density per 1000km² of crop area by region

The strong concentration of crop circles in southern England becomes particularly pronounced when the relationship between crop circles and crop growing area is examined. As Figure 3 above demonstrates, the 2002 crop circles are not concentrated in the main crop growing regions of England. If anything, they tend to be found in areas characterised by mixed farming, where the density of crop farming is considerably lower. This is reflected in the density statistic for crop circles per 1000km² of crop area by UK crop region (based on the 1996 MAFF figures for crop production).

The variance-to-mean ratio (VMR) is 6.71, which indicates a strong overall clustering effect. In fact, 77 crop circles, representing 80.2 per cent of the 2002 crop circle dataset, are found in the two southern regions. Some 42 of the 96 circles are located within a 15km radius of Avebury (approximately 44% of the total 2002 crop circle population). The reasons why crop circles are concentrated in the South West shall now be examined.

The Avebury Cluster and Cultural Heritage Factors

Avebury is both the mode and median centre of the crop circle data set in 2002. Figure 4 illustrates the way Avebury serves as the epicentre of the crop circle phenomenon.

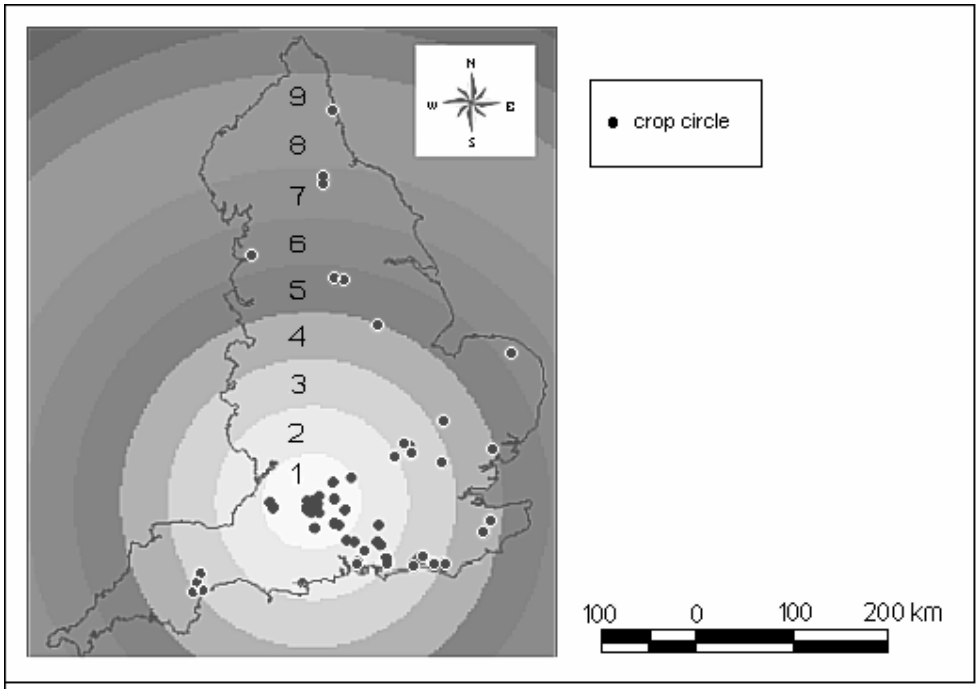


Fig. 4. Distance from Avebury (at 50km intervals)

When we plot the number of crop circles per zone (as numbered in Figure 4), the relationship between crop circle frequency and their distance from Avebury can be seen as being roughly exponential.

From Figure 5, we can see that as we move away from Avebury, each zone (with exception of zones 2, 7 and 9) has roughly half (1/1.935 to be exact) the number of crop circles found in the previous zone, which constitutes a "distance decay exponent" (Taylor, 1975, 14).

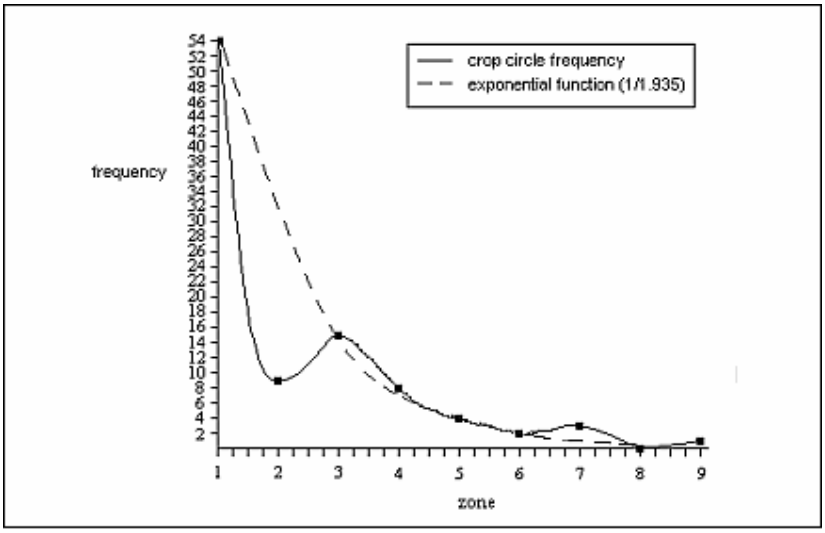


Fig. 5. Distance decay exponent from the Avebury epicentre

So what explains Avebury as the epicentre of the crop circle phenomenon? The Avebury cluster is mostly found in an area of very low population density (less than 1.47 people per hectare, and between 40-50km from the nearest major population centre). The Avebury cluster is also located away from the main motorways. So it would seem that population and accessibility factors are not relevant. What needs to be considered, however, are cultural heritage factors.

It is perhaps no coincidence that the largest stone circle in Europe, the Avebury monument, lies at the heart of the crop circle phenomenon, and that the most famous stone circle in the world, Stonehenge, is nearby (with two crop circles in 2002 being found in its immediate vicinity). The Wiltshire stone circles are among the few stone circles in England that are in close proximity to crop land. It could be the case, then, that the circle makers are inspired by the stone circles, which may have provided a prehistoric archetype for the modern crop circle phenomenon.

There are other features in the Avebury landscape that also might account for the concentration of crop circles in this area. The area is littered with both ancient and modern attempts at what archaeologist Peter Fowler (1995) refers to as "conscious landscape architecture." The area is well known not only for the Avebury and Stonehenge monuments, but also for its ancient burial mounds, long barrows, and, of particular relevance to the crop circle phenomenon, its white horse formations carved into hillsides.

The curious white horse patterns are a mostly modern phenomenon, but were no doubt inspired by the ancient "horse" formation found at Uffington (itself host to two crop circles in 2002, and just 5km west-south-west of the mean centre for the 2002 crop circles). The numerous white horses in the area (see Wiltshire White Horses, 2001) are mostly the result of a horse carving "craze" that occurred during the 17th and 18th centuries, many of which survive to the present day.

There is, then, a long history of landscape artistry in Wiltshire that preceded the crop circle phenomenon, and it is tempting to see the crop circles of Wiltshire as a continuation of this "sacred art" tradition (Fowler, 1995). It might be pointed out that Sussex, which is the location of several crop circles, also has its own local tradition of landscape artistry, featuring the Long Man of Wilmington (or the Wilmington Giant) and the white horse formation at Litlington.

The concentration of crop circles in the Avebury area, and to a lesser extent at places such as Uffington, Exeter and Sussex, would seem to relate to what Baldia (1995) found with respect to megalithic tombs in Europe - that is, that they are located along pilgrimage routes. People visit these areas for their mystical significance, and it may well be the case that crop circles are produced in sacred areas because they are made to appeal to spiritual-oriented visitors and tourists.

Spatial Distribution of the Non-Avebury Crop Circles

Questions remain about other circles located away from the Avebury region. Do their spatial arrangement also indicate clustering, and, if so, why? If we consider crop circle density (per 1000km²), the higher-than-average densities in the southern regions that were found in the crop circle density for the whole data set (as discussed earlier) are sustained even when the Avebury cluster is excluded, as shown in Table 1.

Table 1
Crop circle density (per 1000km²) for non-Avebury formations

REGION	AREA	NON-AVEBURY CROP CIRCLES	
	km²	No. non-Avebury	Density/1000km²
North	648.1	1	1.54
North West	741.7	1	1.35
Yorkshire & Humber	4241.3	7	1.65
East Midlands	5734.3	2	0.35
West Midlands	2628.2	0	0.00
East Anglia	7784.9	2	0.26
South East	4279.4	30	7.01
South West	3499.7	11	3.14
		MEAN =	1.83
		VARIANCE =	4.62

With a variance-mean-ratio of 2.52, a strong clustering effect is again evident (albeit not as strong as when the Avebury cluster is included).

There are two explanations that may account for the concentration of non-Avebury crop circles in the south. The first explanation is a contagion effect, which involves phenomenon in a particular location encouraging more occurrences of that phenomenon in nearby areas (Green & Flowerdew, 1996). In other words, southern England may be characterised by a strong regional tradition of crop circle making. The second explanation is what I refer to as the "London effect," which shall be discussed below in relation to population factors.

Crop Circles and Population Centres

Do crop circles tend to be found in areas that are highly populated? The relevance of "central place theory" (Christaller, 1966) in explaining crop circle distribution can be tested by measuring the proximity of crop circles to population centres. Zones of 10km intervals were placed around medium-high population density areas (8.67+ people per hectare), as shown in Figure 6.

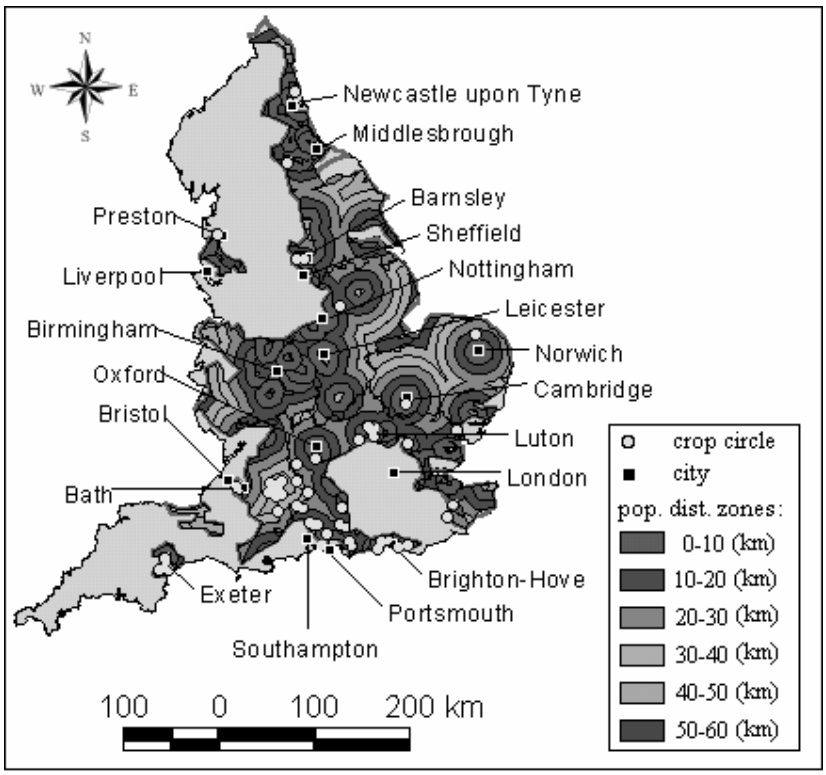


Fig. 6. Distance from medium-high population density areas

We can see from Figure 6 that a considerable number of crop circles are found within a 10km radius of medium-high population density areas. Low numbers of crop circles are found in zones beyond the 10km radius, except in the 40-50km zone, which are generally those belonging to the Avebury cluster. When we exclude the Avebury cluster, the 10km zone around medium-high population density areas contains 59.3 per cent of non-Avebury circles.

Table 2
Relationship between percentage of non-Avebury crop circles and percentage of crop land per population distance zone

HIGH POPULATION					MEDIUM-HIGH POPULATION			
zone	number of	crop area	location		zone	number of	crop area	location
(km)	circles (%)	(%)	quotient		(km)	circles (%)	(%)	quotient
0-10	40.7	18.7	2.2		0-10	59.3	26.5	2.2
10-20	14.9	26.9	0.6		10-20	16.6	38.7	0.4
20-30	16.6	22.8	0.7		20-30	14.8	12.0	1.2
30-40	11.1	15.5	0.7		30-40	9.3	12.5	0.7
40-50	13.0	11.2	1.2		40-50	0.0	7.5	0.0
50-60	3.7	4.0	0.9		50-60	0.0	2.4	0.0

The significance of these percentages needs to be weighed against the amount of crop farmland occupied by these zones in relation to England's overall crop growing region, as defined by the Ministry of Agriculture, Fisheries and Food (1996). Location quotients can be calculated for each zone to measure this relationship, which are shown in Table 2 above. Given that the 10km zone around medium-high population density areas contains only 26 per cent of England's crop farming area, we can see that there is more than double the number of crop circles within this zone than what would be expected if crop circles were evenly distributed in crop growing areas.

The skew towards medium-high population density areas would be even more pronounced if we factored in the percentage of crop circles that appear in crop farming land surrounding the London city region. The fact that crop circles do not appear close to London is not surprising, given that there is little crop growing land in its immediate vicinity. But a visual inspection of Figure 6 reveals that numerous crop circles are located in the crop-growing regions that are closest to London. Consequently, it might be legitimate to treat these particular circles as being in close proximity to London. In fact, if a 15km buffer zone is placed around the crop area adjacent to the London region, twenty crop circles fall within this zone, which is some 36 per cent of all non-Avebury crop circles.

The skew towards areas of high population density might be expected to extend even further still if we factored in the proximity of crop circles to smaller cities and large towns, as we have only considered sizeable areas of medium-high population density. However, the lack of accuracy in crop circle coordinates, which were in many cases approximated to the nearest town, rules out any meaningful analysis at this level of scale.

Although crop circles tend to be found near high population centres, it should be pointed out that their distribution is not proportionate to the size of those population centres (except in the case of London). For example, the Birmingham area has a very high population density, but no reported crop circles in its vicinity. It could also be the case that the relationship between population density and crop circle frequency might be an artefact (to some degree at least) of the relationship between crop circle frequency and main roads. After all, main population centres tend to be located on major motor ways. It is the effect of main roads that shall be examined next.

Crop Circles and Main Roads

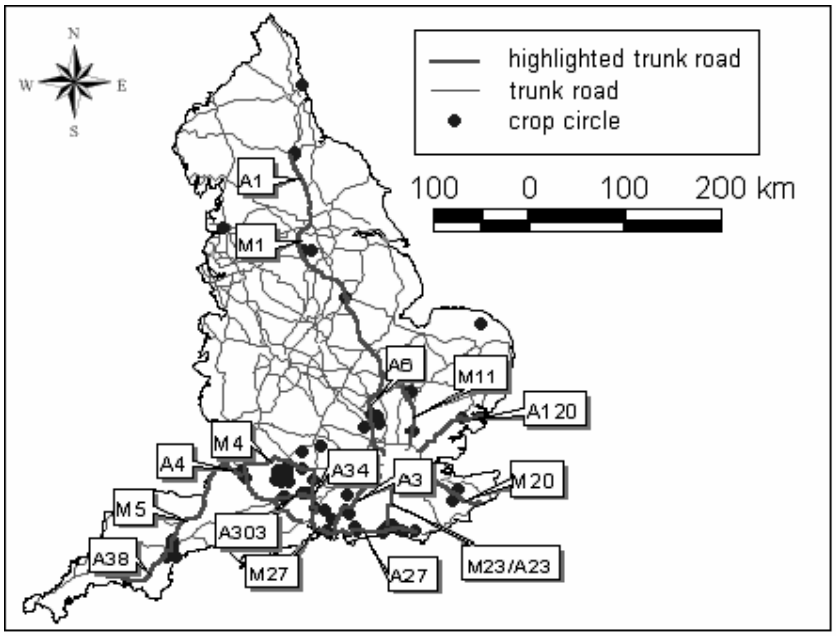


Fig. 7. Alignment of crop circles to trunk roads[3]

If the location of crop circles is determined by their ability to provide maximum accessibility to visitors, then it would be expected that crop circles would be located close to major motorways. In

[3] Road data derived from the Highways Agency's (n.d.) trunk road network map.

the following analysis, "trunk" roads - that is, roads identified as England's key motorways by the Highways Agency (n.d.) - shall be examined against the 2002 crop circle data set.

From Figure 7 above, we can see that many crop circles are located close to a principal motorway (the highlighted roads are those that feature crop circles along their route). In fact, almost one-third of crop circles (32.3 per cent) are located within 3 km of a major trunk road. When we exclude the 42 circles that make up the Avebury cluster, this ratio rises to 57 per cent.

In the central and northern regions of England, most of the crop circles are found along England's principal motorway - the A1 – or its adjacent tributaries, the M1/A6 and M11/A14. The relationship between crop circles and the A1 in terms of 30km zone intervals is shown below in Figure 8.

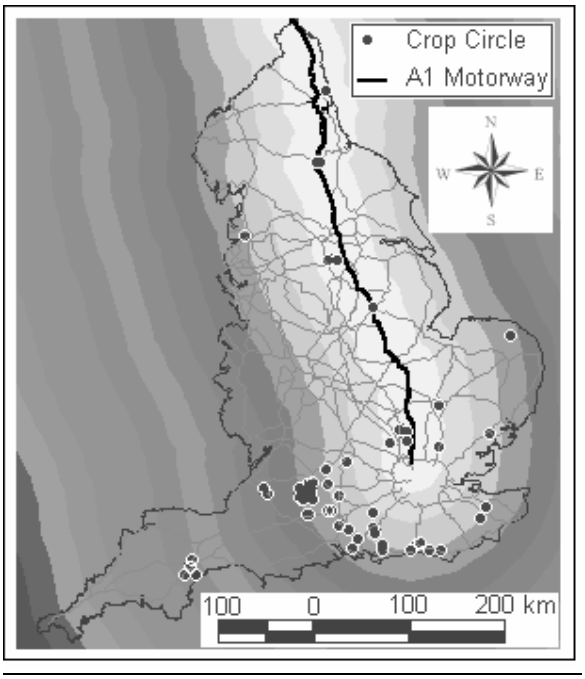
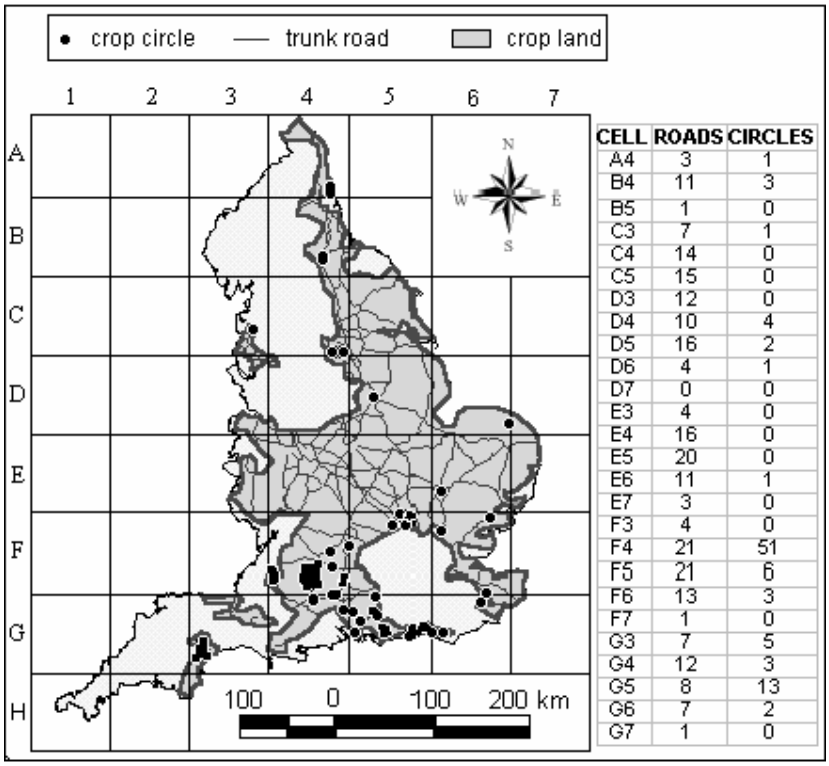


Fig. 8. Distance zones (30km intervals) from the A1 Motorway

All but two of the crop circles in the northern regions are within 30km of the A1. In the southern regions, several crop circles are located along the main coastal road, the A27/M27, between Southampton and Brighton.

It would seem, then, that many crop circles are located not too far off the main motorways. It should be pointed out, however, that the location of crop circles does not correlate strongly with the "thickness" of the trunk road network. A measure of the correlation between trunk roads and crop circles can be obtained through a line intersection count of trunk roads in crop areas, which can then be compared to the frequency of crop circles. Road network density can be roughly measured by the number of times a road intersects with cell boundaries and/or crop area boundaries within a cell using the grid shown below in Figure 9. For the frequency table, only those cells that overlap with the English crop growing region have been included.



CELL	ROADS	CIRCLES
A4	3	1
B4	11	3
B5	1	0
C3	7	1
C4	14	0
C5	15	0
D3	12	0
D4	10	4
D5	16	2
D6	4	1
D7	0	0
E3	4	0
E4	16	0
E5	20	0
E6	11	1
E7	3	0
F3	4	0
F4	21	51
F5	21	6
F6	13	3
F7	1	0
G3	7	5
G4	12	3
G5	8	13
G6	7	2
G7	1	0

Fig. 9. Grid layout of trunk road intersection/crop circle count

The correlation coefficient is 0.41, which indicates moderate correlation between crop circle frequency and trunk road frequency (as expected), but not a strong relationship. Some of the densest areas of the trunk road network in the English crop growing region, such as the Birmingham area, are void of crop circles altogether. Hence, while it would seem that being near a main road is a prerequisite for most crop circles, it is not a primary determining factor. Rather, particular trunk roads, such as the A1, seem to have more influence than other trunk roads. Indeed, Birmingham, it might be noted, does not lie along the A1 or M1 - apparently the preferred "beat" of the crop circle makers.

Combining Cultural, Population and Road Variables

It is when cultural, population and road factors are combined that the spatial distribution of England's 2002 crop circles becomes generally explainable. Figure 10 shows the spheres of influence of the three different factors examined in this investigation within England's crop growing region. Cultural heritage influences are defined by a 15km radius around Avebury, a 7km radius around Stonehenge, and a 7km radius around Uffington. Main road influence is defined by a 3km buffer zone around trunk roads. Finally, population influences are defined by a 16km zone around medium-high population density areas and a 15km perimeter buffer around the London city region.[4]

[4] It could be argued that the parameters defined here are somewhat arbitrary. For example, who is to say that a 16km measure accurately reflects the zone of influence for population centres? Further refinement of the zone parameters is, of course, possible. Of particular benefit would be a more detailed identification of the cultural heritage zones.

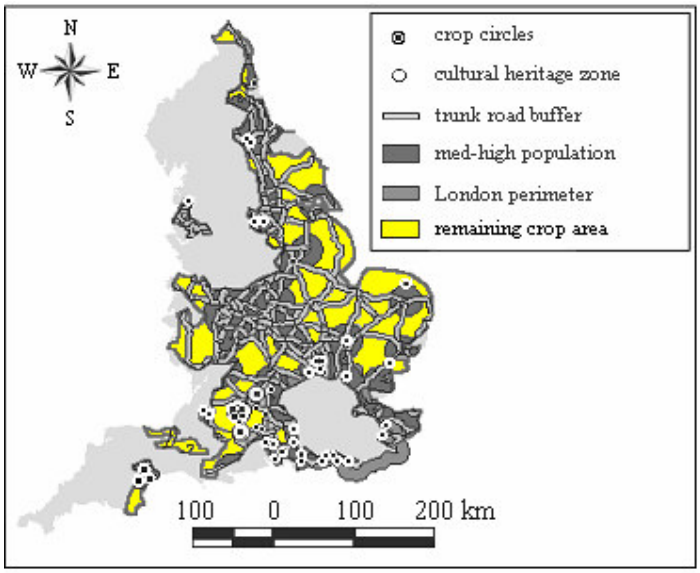


Fig. 10. Combined variable effect for 2002 crop circles

The frequency of crop circles in the various zones is summarised in the following frequency matrix (Table 3).

Table 3

FEATURE	Road	Population	London	Avebury	Uffington	Stonehenge
Road	10	21*	8	0	0	2
Population	21*	9	16*	0	0	0
London	8	16*	4	0	0	0
Avebury	0	0	0	42	0	0
Uffington	0	0	0	0	2	0
Stonehenge	2	0	0	0	0	0

* includes 8 crop circles that are in proximity to trunk roads, population centres and the London city region collectively.

The diagonal cells from the upper left to the lower right in the matrix show the number of crop circles found in only one feature zone. The remaining cells show the frequency of crop circles that are in proximity to more than one feature. We can see that cultural heritage influences are the single largest factor accounting for the location of crop circles, with population influences second (that is, when the London effect is combined with other population influences) and trunk roads third. The remaining crop circles (approximately 43 per cent) cannot be distinguished in terms of their primary influencing factor, but rather accord with multiple factors.

The fraction of England's crop growing region that these variables collectively account for is almost two-thirds of England's total crop region. What is the significance of all of the 2002 crop circles being located within two-thirds of England's crop region? Given that the remaining one-third of England's crop growing area represents the most remote, inaccessible part of England's crop growing area (remembering, of course, that England is a relatively small country with a large population that is well dispersed), it would not seem coincidental that no crop circles from the 2002 season were reported in this area.

One of the benefits of identifying a crop circle distribution zone is that it then becomes possible to calculate a probability score. If we divide the crop area of England into three zones (with two zones

corresponding to the parameters defined above, and the third zone covering the remaining crop growing area), then a crop circle, if it is randomly distributed, has a one in three chance of falling within any one zone. The probability that all 96 crop circles would fall exclusively in two zones of the crop growing area that is closest to main roads, major population centres and cultural heritage areas is approximately 124 quadrillion to one.[5]

Of course, the proximity parameters for this study have been determined in a post hoc fashion through exploratory analysis of the data set. Hence, in terms of a probability test, the boundaries of the zones have been unfairly delineated based on prior knowledge of the outcome. As Openshaw warns, the hypothesis needs to be formulated prior to any knowledge of the data on which it is to be tested (1996, 62). For this reason, it is important to map the distribution of crop circles from previous years and in the years to come to see whether they conform to the same zoning. In this way, the present findings can be tested against an independent data set, and using a much larger sample that is more representative of England's crop circle phenomenon.

As the first stage of this wider examination, the 2003 crop circle data set (again obtained from Paul Vigay's database) have been plotted against the same zoning, as shown in Figure 11.

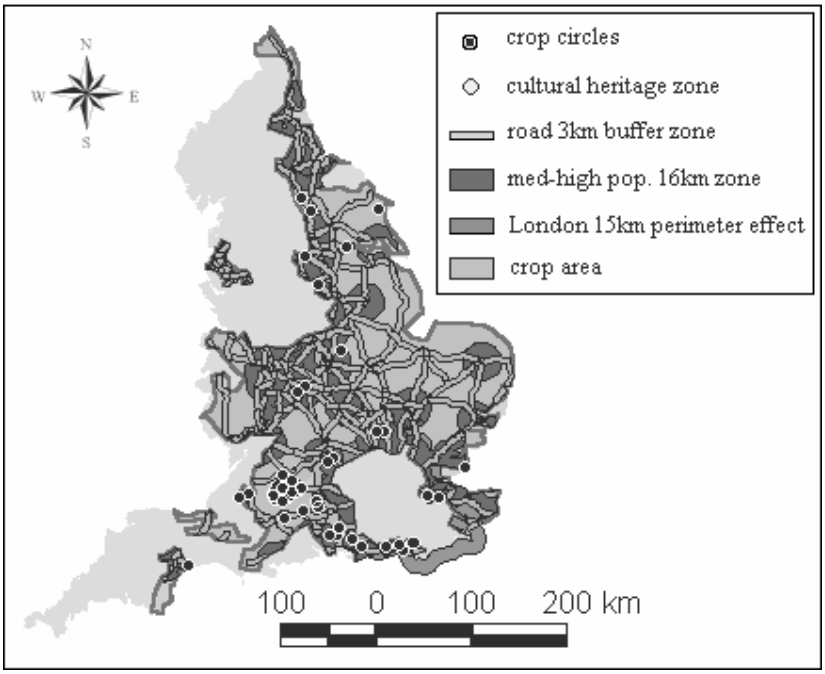


Fig. 11. Combined variable effect for 2003 crop circles

The concentration of circles around the Avebury epicentre is again evident, with almost half of the 2003 formations being within a 15km radius of Avebury. Also evident is the proximity of formations to London (with almost a quarter being found in the London perimeter zone) and to the central axis following the A1 (with six of the nine formations in the northern regions appearing within 30km of the A1 motorway). Only two of the 80 crop circles in the 2003 data-set fall outside the designated zone. One of these, at Blackberry Hill near Bath, is just a few kilometres from a high population/main road zone. The other formation lies at Rudston near Bridlington in East Yorkshire - a town containing the highest standing megalith in Britain - and so a cultural heritage

[5] A quadrillion is a 15-zero figure in the U.S. numerical system. This calculation is based on the equation: $p(0) = ⅔ \text{ ^ } 96 = 1.24520005 \times 10^{-17}$.

zone. Setting aside such post hoc rationalisations, however, the probability that 78 of the 80 crop circles would fall within the designated zone if their distribution were random is remote.[6]

Conclusion

Three factors have been identified in this paper as having a strong influence on the spatial distribution of crop circles in England: proximity to main roads, proximity to areas of medium to high population density, and proximity to significant heritage areas. The fact that reported crop circles are located in areas of high accessibility would seem to support the view that crop circles are part of a modern-day pilgrimage tradition, perhaps as British megaliths once were.

Whether we are closer to resolving a "mystery" is another matter, with the question of ultimate causation being beyond the scope of the present investigation. Undoubtedly skeptics would interpret the results as supporting a hoaxing explanation of crop circles, given that locations close to major roads and population centres would be consistent with hoaxers wishing to minimise travel distances and maximise exposure. However, some crop circle enthusiasts would see no contradiction here with an extraterrestrial or other paranormal explanation for crop circles, for they might argue that aliens (or some other form of intelligence) would create formations close to major roads and population centres in order to maximise visibility and accessibility for humans. It might even be argued that towns and roads themselves have emerged in those locations as a result of 'spiritual energies' such as ley lines that shape settlement patterns (Devereux, 1990) – that is, the same forces that some paranormal proponents claim produce crop circles. Quite clearly, the view that human agency is the principal cause and that crop circles are a form of sacred landscape artistry is an ontological claim that is based on a mundane perspective of reality, even though such an explanation might fully accord with the empirical evidence.

This investigation has revealed, however, that at the very least the reported 2002-03 crop circles are not randomly distributed across the English countryside. Further, the results indicate that, unless a massive effect from reporting bias is postulated (which is unlikely), these crop circles were influenced in their placement by intentional factors such as proximity to roads, population centres and cultural heritage areas, and not by postulated (and unsubstantiated) natural phenomena such as plasma vortices. With several years of crop circle formations remaining to be investigated, it is felt that the present model provides a firm foundation for apriori hypothesis testing that will confirm whether the factors identified here are generalisable to formations that have appeared in other years.

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[6] Approximately 6.5 trillion to one (a trillion being a 12-zero figure in the U.S. system). This calculation is based on the equation: $P(2) = C(80,2) \times ⅓\text{^}2 \times ⅔\text{^}78 = 6.46139612 \times 10^{-12}$.

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