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Early Manx chapels, burial grounds, territorial divisions, and measurements

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17.1 The research problem

At the end of the Sixth Report of the *Manx Archaeological Survey*, which was published in 1968, its compiler, J. R. Bruce, produced a map showing the distribution of the early Manx chapels and burial grounds, (known respectively as *keeills* and *rhullicks* in Manx), in relation to the *treen* units in the sheading of Rushen. Looking at this map one is immediately struck by the way many of the sites look to be on or near the treen boundaries. Bruce himself made no direct comment on this.

In 1983 C.E. Lowe published a map showing the locations of the keeills, early burial grounds, and boundaries of the treens, together with the boundaries of their constituent *quarterlands*, in the parish of Kirk Michael, and drew attention to the 'peripheral distribution' of these sites 'within the quarterlands' (Lowe 1983, p. 125, Fig. 15). He suggested that this 'was a fairly common feature' which might be explained as a reflection of a process of placing burial grounds and keeills on marginal lands (Lowe 1983, p. 126). Unfortunately, there is no detailed soil survey or land-use data of a sufficiently high resolution with which to test this hypothesis rigorously. However, if the apparent tendency of keeills and rhullicks to be sited in the vicinity of boundaries is coincidental and due to an independent process in which both boundaries and sites favour marginal land, it would be surprising to find the pattern persisting in the upland estates which are on marginal land.

On inspecting the positions of those keeills in these marginal expanses the impression of peripheral locations does not disappear. A good illustration of the phenomenon is Lag-ny-Keeilley, in Kirk Patrick, which lies in a hollow torn out of the almost perpendicular face of Cronk ny Arrey Laa. This keeill-site is distinguished as being one of a very few examples which does not lie on a treen or quarterland, but on the

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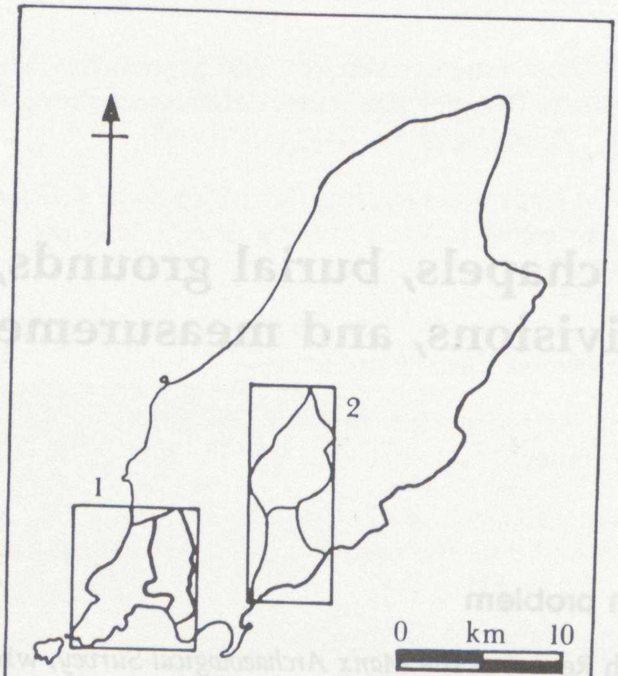

Figure 17.1: Map showing the locations of Sample Areas 1 and 2

commonland. It is located just a few metres from the parish boundary of Patrick and Rushen, which also happens to be the boundary between the sheadings of Rushen and Glenfaba and the island's primary division between the Northside and the Southside. Several other examples, within the treen/quarterland areas can also be cited.

The point is that if the posited boundary associations of the keeills and burial grounds is real, it seems that the land-use model proposed by Lowe does not fully account for the phenomenon. Christopher Lowe tells us he has also abandoned this model.

Assuming for the moment that the phenomenon has some cultural interest and, in the absence of any oral or historical testimony, on what criteria can an archaeologist demonstrate or deny such an association? Put another way, is it likely that the distribution of Manx chapels and boundaries have nothing to do with each other and that the suggested association might be more apparent than real. Clearly what is required is some rigorous method of determining whether the observed distribution is nothing more than the product of chance.

17.2 Quantifying boundary associations

A number of attempts have been made to quantify boundary associations in British medieval archaeology. In particular the debate that has surrounded the origin of the parishes of England is directly relevant to the examination of the relationship of the Manx keeills and burial grounds to the Manx land system. Investigations by D. J. Bonney and more recently A. J. Goodier seemed to indicate that the pagan Anglo-Saxons exhibited a marked preference for placing burial sites near parish boundaries. In a series of papers, Bonney (Bonney 1966, Bonney 1972, Bonney 1976) drew attention

Parish	Number of Sites				
	total	within 1Y unit 100m annulus	%	within 2Y unit 100m annulus	%
RUSHEN	13	9	69	7	54
ARBORY	10	7	70	6	60
MAROWN	10	8	80	4	40
SANTON	8	7	88	6	75

Table 17.1: The distribution of sites over quarterlands, or primary level units (1Y), and treens, or secondary level (2Y), units in each parish

to what he considered to be the unusually high proportion of burial-sites that lay close to, or actually on, the earliest determinable ecclesiastical boundaries in southern England. *Close* was arbitrarily defined as being within 500 feet of the boundary without further comment. Bonney's correlations were not tested for statistical significance, and no explanation was offered as to why the apparent association should have occurred at all. Moreover, the criteria by which the specified boundary annulus width was selected are not apparent.

Goodier (Goodier 1983, Goodier 1984), however, adopted a more rigorous and explicitly statistical approach to the problem. Her method was to establish the total area containing both sites and parishes and to estimate the proportion of this land that lay within a specifiable distance of the parish boundaries. Equipped with this information a calculation of the number of burial sites one would expect to find within the boundary annulus, assuming a random distribution, can be made. From the sample as a whole 17.9% of the pagan Anglo-Saxon burial sites were located in a boundary zone. This figure was smaller than those obtained by Bonney, who obtained a value of 49% in Wiltshire for instance, but was still said to be statistically significant.

It was thought that Goodier's approach might provide a first indication as to whether the proposed association between early chapels and burial grounds and the Manx land unit boundaries was statistically significant.

Two Sample Areas were selected for examination (see Fig. 17.1): Sample Area 1 consisted of the contiguous parishes of Rushen and Arbory; Sample Area 2 consisted of the parishes of Marown and Santon. The observed number of sites in Sample Area 1 is twenty-three, and the observed number of sites in Sample Area 2 is eighteen.

The actual site-to-boundary distances were measured using purpose-built software, and the number of sites within 100m of a boundary was counted. The boundaries of the units of interest are recorded on a set of maps prepared by Woods (Woods 1867). Unfortunately, these maps were not projected on a regular basis. They were therefore digitised so that their scales and orientations could be normalised. Since the maps were digitised it was also possible to develop other software which will allow the analyst to determine very rapidly the whereabouts of any site-locations in relation to the land units.

The total area of the entire study zone was calculated by measuring the area of each constituent unit in the sample, again using purpose-built software. Goodier's test was then applied to the distribution of sites and primary level units both Sample Areas together. It was then applied separately to two Sample Areas just defined. After that, each parish was considered separately (see Table 17.2) The entire procedure was

	STUDY AREA	NUMBER OF SITES IN BOUNDARY ZONE				ACCEPT or REJECT NULL HYPOTH
				EXPECTED		
		TOT	OBS	FROM	TO	
PRIMARY UNITS	FULL SAMPLE	41	31	10.3	27.0	REJECT
	SAMPLE AREA 1	23	16	4.3	16.7	ACCEPT
	SAMPLE AREA 2	18	15	2.8	13.7	REJECT
	RUSHEN	13	9	1.2	10.4	ACCEPT
	ARBORY	10	7	0.6	8.8	ACCEPT
	MAROWN	10	8	0.4	8.6	ACCEPT
	SANTON	8	7	0.0	7.3	ACCEPT

Table 17.2: Summary of the results of applying Goodier's published test to the primary level units

then repeated using the secondary level units in place of the primary level units. The decision to use a 100m boundary annulus was made because this was the size applied by Goodier in her study, and it has no other significance in these experiments. (The results of these experiments are summarised in Table 17.3).

When the full sample of primary level units and site-locations is considered the test indicates that the number of keeills and burial grounds within 100 m of a boundary is higher than the expected value by two standard deviations. However, when the sample is broken down into the two principal sub-sets, or into individual parishes, the association is no longer apparent.

Likewise, with the boundaries of the secondary level units, a significant correlation is detected when the full sample is considered. However, while some association in maintained in Sample Area 1, it disappears in Sample Area 2. However, significant association is not found with the secondary level units of either of the two parishes of Sample Area 1, but is detected in one of the parishes (*i.e.*, Santon) of Sample Area 2 which itself shows no association! To understand how these seemingly contradictory results were produced it is necessary to look at Goodier's approach in a little detail. Goodier derives her theoretical estimate of the expected number of sites to be found within a certain distance from the boundaries of units in the study zone in several steps:

Step 1: She estimates the total length of the boundaries in the study zone. According to Goodier, the estimated mean length of the perimeter of a single irregular polygon will normally be less than six times the square root of its area. This figure was arrived at by the empirical examination of a sample of fifty digitised parish boundaries.

Step 2: the area of the boundary annuli is estimated as the product of the estimated mean perimeter length multiplied by the number of units in the study zone, which is then multiplied by the chosen annulus width, and then divided by two Goodier states that the last division is performed because each boundary segment has been counted twice.

Step 3: Assuming that the theoretical distribution of sites was produced by a Poisson process, the number of sites expected within one of the boundary annuli will depend on the area of the boundary annulus expressed as a fraction of the total area of the unit. In other words, the estimated area of the boundary annuli divided by the total area of the survey zone gives the probability of finding a particular site within a boundary annulus. The number of sites within the boundary annulus will be a random variable with a Binomial distribution.

Step 4: Finally, Goodier's estimate of the number of sites expected within the boundary annuli of a given boundary system (x) is given by the following:

$$x = n * p \pm 2.58 * \sqrt{(p * n * (1 - p))}$$

where

n = total number of sites in study zone
p = probability

with 99% confidence levels.

Goodier's estimate of the expected range of sites within a boundary annulus is far too small. In fact the stated estimate of area in the study zone within a boundary annulus, used in her test, is actually only half the size it should be. The cause of this extraordinary discrepancy is found in Step 2, where the estimated total area of the boundary annuli is computed. The error is caused by the division operation, which is performed on the pretext that each boundary has been counted twice. In reality, every internal boundary *should be counted twice* because a boundary annulus runs along both edges of each of them (see Fig. 17.2). The effect of the division operation is to half the width of the boundary zone and hence also to half the estimated probability of a random point being selected in this area!

If this division is dropped from the test of her own published data then the expected number of sites within her 100 m boundary annulus, by two standard deviations, changes from 75 ± 21 to 149 ± 28. As her observed value is 128 the test shows no association since it is estimated that the expected value lies between 121 and 177. Bonney's theory is not therefore supported, and Goodier's own subsequent interpretations of the data are invalidated.

This division operation was dropped from the algorithm and the thus modified version of Goodier's test was re-applied to the various Manx data sets as outlined above. Once again, the results are surprising. Taking the sample as a whole the test suggests that there is a 99% probability that the expected number of sites within 100 m of a primary level unit will lie in the range 32.6 to 42.0 (see Table 17.4). The observed value is 31 which is actually *less than* the lower limit of of this range. In other words the test seems to indicate that the site-locations are tending to avoid the primary level unit boundary zones! This result is the complete opposite of the original conclusion. The tests on the primary level units in Sample Area 1 echo this result; however, the results for Sample Area 2 fall into the expected range. A similar outcome is obtained when each parish is considered separately.

The null hypothesis is also accepted in all of the tests using the secondary level units (see Table 17.5). It is concluded that the results from these tests provide no statistical

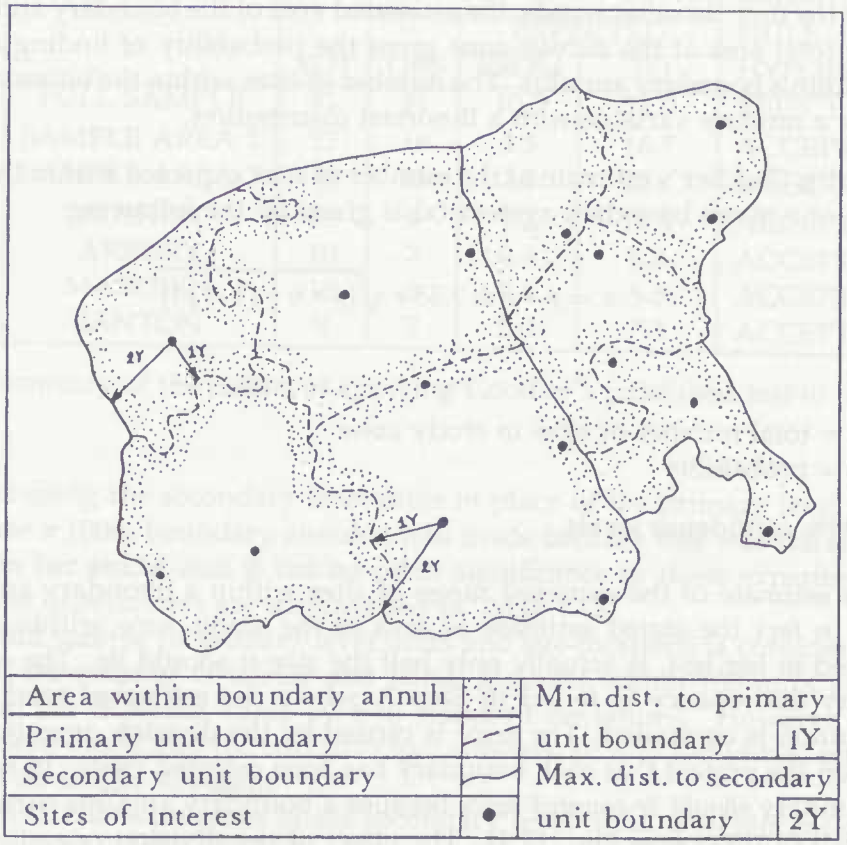

Figure 17.2: The annulus Method

	STUDY AREA	TOT	NUMBER OF SITES IN BOUNDARY ZONE OBS	EXPECTED FROM	TO	ACCEPT or REJECT NULL HYPOTH
PRIMARY UNITS	FULL SAMPLE	41	23	3.9	18.6	REJECT
	SAMPLE AREA 1	23	13	0.8	11.8	REJECT
	SAMPLE AREA 2	18	10	0.1	9.9	REJECT
	RUSHEN	13	7	0.1	7.1	ACCEPT
	ARBORY	10	6	0.0	6.3	ACCEPT
	MAROWN	10	4	0.0	6.6	ACCEPT
	SANTON	8	6	0.0	5.2	REJECT

Table 17.3: Summary of the results of appplying Goodier's published test to the secondary level units

evidence to support the theory that keeills and burial sites display a tendency towards locations near to the land unit boundaries. On the contrary, the results suggest the sites avoided locations near to the boundaries of primary level units.

After making adjustments for the rather fundamental flaw in Goodier's test of boundary association, the test is still equivocal. It is most worrying that although the test suggests that there is a non-random relationship between the sites and boundaries of interest when the full study zone is considered, no such relationship is detectable in any of the sub elements when they are considered individually. Clearly the matter warrants further investigation. The most obvious place to begin is Goodier's method for estimating the area covered by the boundary annuli. The robustness of this estimate may be questioned on the grounds that it is ultimately dependent on the measured lengths of the perimeters of a sample of irregular polygons. It is therefore a variable which is dependent on the resolution of measurement adopted. By way of illustration consider the following: One way to measure the circumference of a leaf is to run a string around its edge and measure the string against a standard rule. Looking at the same leaf under a magnifying lens would reveal that it has serrated edges. If each of the serrations were measured individually, the sum of these lengths would be considerably longer than the length of the string used previously. Similarly, if the leaf was then examined under a powerful scanning electron microscope these serrations would be revealed as possessing yet another level of serration, and the measured length of the leaf's circumference would be increased still further. A simple experiment was devised to throw some light on the robustness of Goodier's method. The procedure was to take the digitised boundaries of the units in the four parishes being considered and compare the actual measured boundary lengths with the estimated value derived from Goodier's formula: $l = 6 * \sqrt{\text{Area of Unit}}$. To make this possible, the exact areas and lengths of the digitised land units were measured, again using purpose-built software. The formula published by Goodier for estimating the circumference of an irregular shape of known area was then applied to each of the units.

Overall, Goodier's estimate is extremely accurate in this example, being out by only 5%. However, the results also revealed that the technique was likely to produce totally misleading estimates with certain shapes of unit. In nearly half the units examined the actual boundary length was greater than the estimated value, which was based on a function derived from Goodier's worst case, and which according to her happened only very rarely in her experiments.

In many instances the method is prone to very significant vagaries in terms of its precision. It seems that the specific function of six times the square root of the area could not be safely applied to other data sets with confidence. It would be necessary to obtain a corresponding function in any new study from a sample of units from the new data set to be analysed.

17.3 A Monte Carlo approach to the problem

It was decided that computer simulation would be a much more reliable method of obtaining the theoretical distribution that was required for comparative purposes. 82,000 simulated site-locations were generated by a Poisson process over the digitised Sample Areas to enable us to measure how closely Goodier's method models the theoretical distribution. The programs to facilitate this were written in a portable sub-set of FORTRAN-77 and were run under the AIX operating system on an IBM 6150 personal computer. The user enters the unit defining the geographical limits of the sample area being studied, and number of sites-locations to be modelled within the sampling area on each run. A seed value for the random number generator and the number of runs to be performed are also entered. All this information is recorded in the results file.

Random coordinates are generated within the range of the maximum and minimum eastings and northings of the smallest box bounding all the units in the Sample Area, so that the points follow a Poisson process. Each coordinate is an observation from a uniform distribution, on the interval minimum to maximum easting or minimum to maximum northing. The easting and northing coordinates are independent. Throughout our experiments the standard IBM RT PC FORTRAN 77 random number generator was used. The program finds both the quarterland and treen level units in which the site lies. In fact, there are certain parts of the Sample Areas which do not contain keeills or rhullicks. The keeill and rhullicks are confined to those areas of the island occupied by the treens and quarterlands and avoid the large expanse of commonland. Such common areas are excluded from the simulations. Any random points which are found to lie within such an area are rejected and a new pair of coordinates will be generated.

The simulated data had the considerable advantage that since they were generated by a Poisson process, they could also be used to provide an estimate of the amount of land that lay within some specified distance from particular boundaries. Since every possible site-location within the study zone had an equal chance of being selected by this process, the proportion of points lying within a certain distance of the boundaries will mirror the proportion of the total area of land which lies within the boundary annuli.

A program was written to read in each of pair of the 82,000 coordinates representing a simulated site-location and then measures The distance between each of the 82,000 simulated site-locations and each of the digitised boundary points delimiting the boundaries of the units in which they are located is measured, and a record is kept of the shortest of these distances. This list of shortest site-to-boundary measurements may be used to test Goodier's estimate. For example, the simulated set of sites within the quarterland and treen level units of Sample Area 1 was used to obtain the probability distribution of sites within 100m of a boundary (Figs. 17.4 & 17.5).

Having already recorded the minimum site-to-boundary distance of each random point corresponding to an actual site of interest in the original simulation runs, it was a simple matter to count the number occasions on each run that a simulated site fell within a boundary annulus, and thereby build up a histogram showing the expected probability distribution of sites inside the boundary zones according to the Poisson model. If Goodier's test is correct, we would expect to find nearly all the simulated distribution within her 99% confidence limits. However, this is plainly not the case, and the results confirm that her method does not accurately model the theoretical distribution.

Consider the distribution of sites within the primary level units of Sample Area 1 (Fig. 17.4). It is known that the observed number of sites lying within 100m of the primary level unit boundaries in that area is sixteen. Using Goodier's published test, this value lies in the upper tail of her expected distribution which suggests that the

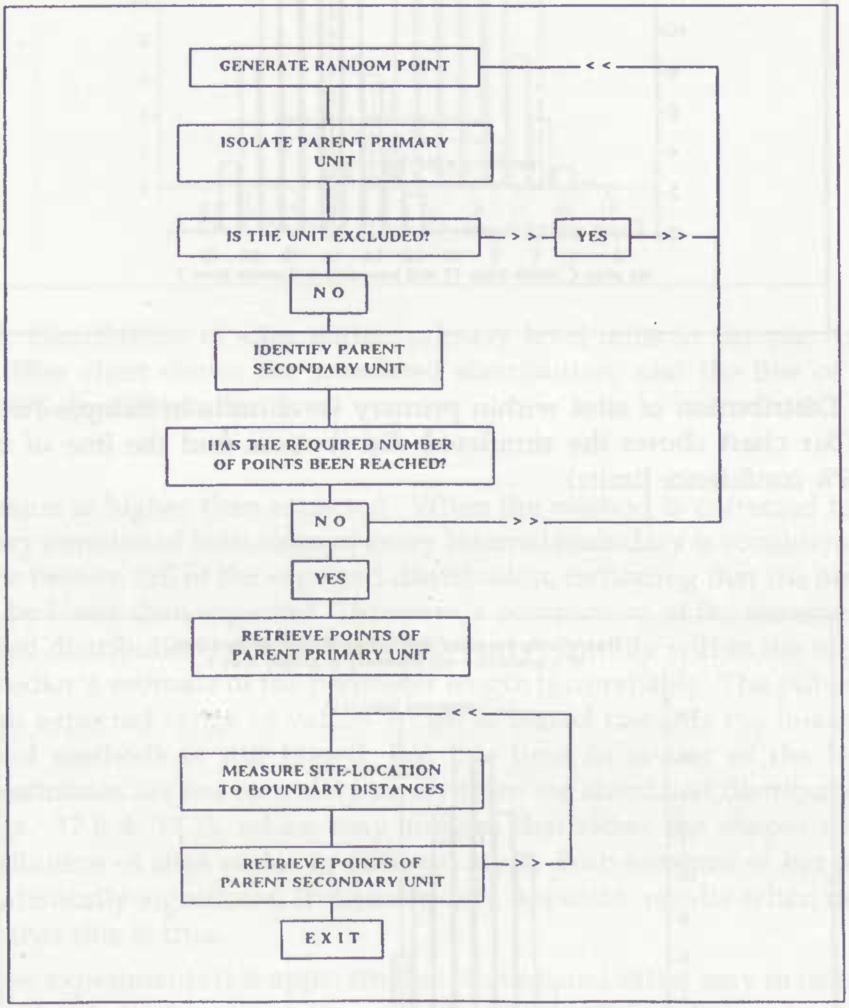

Figure 17.3: Flow chart showing simulation process

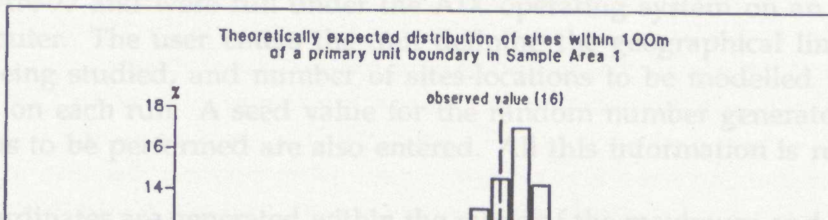

Figure 17.4: Distribution of sites within primary level units in Sample Area 1 boundary annuli (Bar chart shows the simulated distribution, and the line of stars shows Goodier's 99% confidence limits)

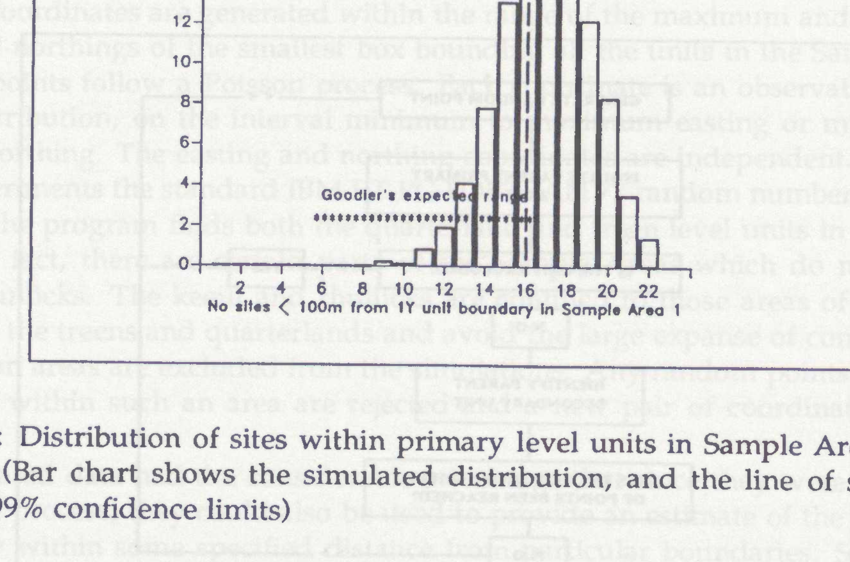

Figure 17.5: Distribution of sites within secondary level units in Sample Area 1 boundary annuli (Bar chart shows the simulated distribution, and the line of stars shows Goodier's 99% confidence limits)

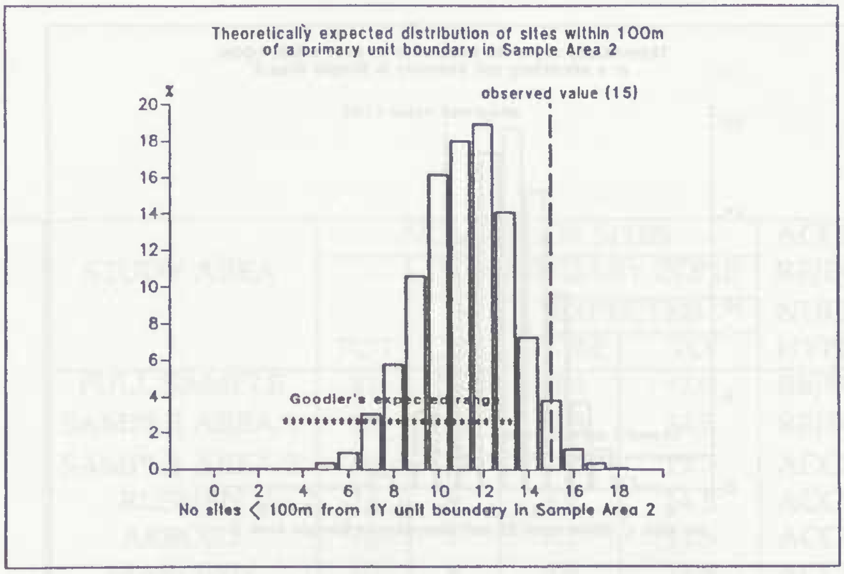

Figure 17.6: Distribution of sites within primary level units in Sample Area 2 boundary annuli (Bar chart shows the simulated distribution, and the line of stars shows Goodier's 99% confidence limits)

observed value is higher than expected. When the method is corrected to ensure that the boundary annulus of both sides of every internal boundary is considered this values falls into the bottom tail of the expected distribution, indicating that the observed value appears to be lower than expected. However, a comparison of the observed value with the simulated distribution reveals that it falls fairly centrally within the expected range. Clearly, Goodier's estimate of the perimeter length is unreliable. The published method produces an expected range of values which is biased towards the lower values, and the corrected methods is still biased, but this time in favour of the higher values. Goodier's estimates are not so widely astray from the simulated distribution in Sample Area 2 (Figs. 17.6 & 17.7), which may suggest that either the shapes of units or the actual distribution of sites varies in different areas. Both versions of her test, however, produce statistically significant, if diametrically opposite, results when in fact it is not at all clear that this is true.

From these experiments it is apparent that the best and safest way to test the observed probability distribution against a theoretically generated distribution must be to ensure that the two distributions are measured in exactly the same fashion using the actual boundaries. However, having gone to all the effort of collecting the site-to-boundary distances in interval form, with each individual measurement having a precise value along a continuous scale, it seems somewhat perverse to discard some of this hard-won data-set by reducing it to the two nominal categories of 'less than' or 'greater than' some arbitrary threshold. Use of the interval data will enable a more precise measurement of how large and how significant the differences are between the observed and the theoretical distributions to be made. For instance, the Kolmogorov-Smirnov test can be applied to such data to provide a measure of *how closely* the observed probabilities correspond to the theoretical probabilities. In order to compare the two

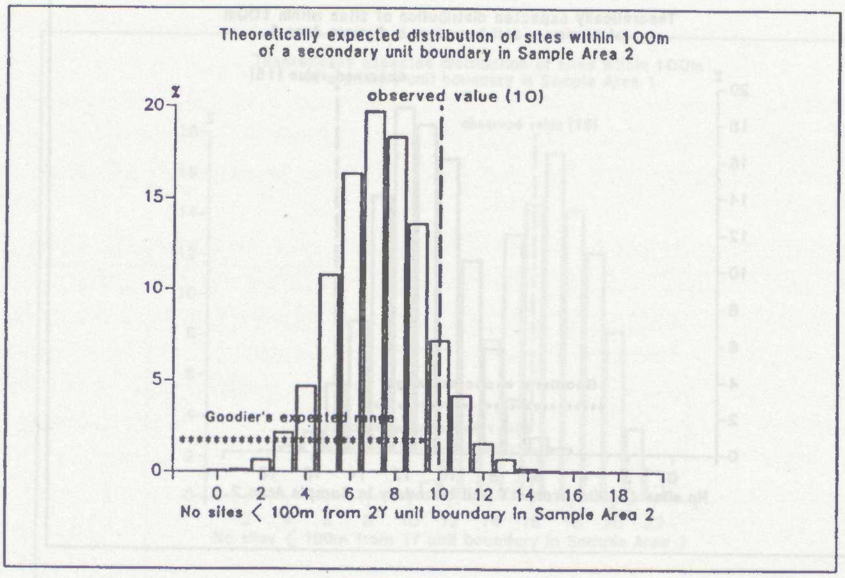

Figure 17.7: Distribution of sites within secondary level units in Sample Area 2 boundary annuli (Bar chart shows the simulated distribution, and the line of stars shows Goodier's 99% confidence limits)

probability distributions, we used the Kolmogorov-Smirnov test[1] No association was found between the sites and the boundaries of either the quarterland or treen level units in Sample Area 1. However, the tests do indicate a slight association between the primary level unit boundaries and sites in Sample Area 2, which is significant at the 15% level (see Table 17.6). There is also a weak association between the secondary level units and the sites in this Sample Area, but this is only significant at the 20% level (see Table 17.7). Our conclusion must be that these test provide no support for the hypothesis that the early chapels and burial grounds in the study zone were located unusually near to the boundaries of the land units in those areas.

17.4 Conclusions

What we have attempted to demonstrate here is that it is both possible and desirable to rigorously define and test hypotheses concerning the relationship of the distribution of various categories of site use sites of interest and the land units in which they lie. It appears to us that simulation methods hold out one of the more reliable methods of modelling the phenomenon under study. Some archaeologists have pointed to so-called boundary associations as possible dating evidence of certain boundaries (*inter alia* Bonney 1966, Bonney 1972, Bonney 1976, Goodier 1983, Goodier 1984), other have suggested that such associations have an important symbolic significance, and may be related to territorial behaviour (e.g., Charles-Edwards 1976). Similar boundary

[1]The Kolmogorov-Smirnov statistic (D) is given by the largest absolute difference between the theoretically expected and the observed cumulative probability distribution. Since the sampling distribution under the null hypothesis is known, these values can be compared with tables of critical values (see Table 17.7). The observed distribution from Sample Area 1 has 23 degrees of freedom, and the observed distribution from Sample Area 2 has 18 degrees of freedom.

	STUDY AREA	NUMBER OF SITES IN BOUNDARY ZONE				ACCEPT or REJECT NULL HYPOTH
		TOT	OBS	EXPECTED FROM	EXPECTED TO	
PRIMARY UNITS	FULL SAMPLE	41	31	32.6	42.0	REJECT
	SAMPLE AREA 1	23	16	17.3	24.5	REJECT
	SAMPLE AREA 2	18	15	13.3	19.7	ACCEPT
	RUSHEN	13	9	8.7	14.5	ACCEPT
	ARBORY	10	7	7.1	11.5	ACCEPT
	MAROWN	10	8	6.6	11.5	ACCEPT
	SANTON	8	7	7.0	11.4	ACCEPT

Table 17.4: Summary of the results of applying the modified test to the primary level units

	STUDY AREA	NUMBER OF SITES IN BOUNDARY ZONE				ACCEPT or REJECT NULL HYPOTH
		TOT	OBS	EXPECTED FROM	EXPECTED TO	
PRIMARY UNITS	FULL SAMPLE	41	23	14.2	30.7	ACCEPT
	SAMPLE AREA 1	23	13	5.8	18.8	ACCEPT
	SAMPLE AREA 2	18	10	4.5	14.4	ACCEPT
	RUSHEN	13	7	2.6	11.8	ACCEPT
	ARBORY	10	6	1.2	9.4	ACCEPT
	MAROWN	10	4	1.9	9.9	ACCEPT
	SANTON	8	6	0.5	7.7	ACCEPT

Table 17.5: Summary of the results of applying the modified test to the secondary level units

OBSERVED		EXPECTED	DIFF
Cum.%	Dist (m)	Poisson	
.0555	2.000	.0029	.0526
.1111	4.243	.0140	.0971
.1666	17.692	.0807	.0859
.2222	23.087	.1054	.1168
.2777	23.431	.1073	.1704
.3333	54.120	.2343	.0990
.3888	57.070	.2458	.1430
.4444	57.428	.2475	.1969
.5555	76.922	.3237	.2318
.6111	130.000	.5094	.1017
.6666	190.515	.6765	.0099
.7222	193.217	.6839	.0383
.7777	221.847	.7497	.0280
.8333	240.832	.7861	.0472
.8888	273.146	.8413	.0475
.9444	285.414	.8577	.0867
1.000	443.373	.9828	.0172

Kolmogorov-Smirnov statistic (D) = 0.2511

Table 17.6: Minimum site-location to secondary level unit boundary distances in study area 2 (Marown & Santon)

	Significance levels				
Degrees of Freedom	0.20	0.15	0.10	0.05	0.01
18	0.244	0.259	0.278	0.309	0.370

Table 17.7: Critical Values of D with 18 degrees of freedom (Source: Ebdon 1979)

OBSERVED		EXPECTED	DIFF
Cum.%	Dist (m)	Poisson	
.0555	2.000	.0047	.0508
.1111	4.243	.0236	.0875
.1666	8.485	.0598	.1068
.2222	17.692	.1321	.0901
.2777	19.105	.1440	.1337
.3333	23.087	.1726	.1607
.3888	23.431	.1755	.2133
.4444	50.961	.3600	.0844
.5000	54.120	.3792	.1208
.5555	55.073	.3853	.1702
.6111	57.070	.3969	.2142
.6666	57.871	.4014	.2652
.7222	73.763	.4936	.2286
.7777	76.922	.5105	.2672
.8333	93.606	.5924	.2409
.8888	193.217	.9046	.0158
.9444	213.103	.9348	.0096
1.000	221.847	.9444	.0556

Kolmogorov-Smirnov statistic (D) = 0.2672

Table 17.8: Minimum site-location to primary level unit boundary distances in study area 2 (Marown & Santon)

associations have been posited for the so-called Bersu round-houses which date from the Iron Age (Reilly & Zambardino 1985, p. 18–20), and the island's ancient and venerated wells are also thought to favour boundary locations (Davies 1956, p. 103). Clearly, it is important to determine whether the stated associations are more apparent than real, if we are to avoid the erection of fallacious theories, or lend credence to our impressionistic interpretations.

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