THE PREFERRED ORIENTATION OF IROQUOIAN LONGHOUSES IN ONTARIO

G. B. NORCLIFFE and C. E. HEIDENREICH

INTRODUCTION

Archaeology is one of a number of disciplines which include amongst their tasks the job of reconstructing how extinct systems and organizations functioned, using only fragmentary information. In essence the problem is to make statements about processes using formal evidence. Pleistocene geomorphologists, for instance, use evidence relating to cirques, drumlins and a variety of other observable landforms in theorizing about the flow of ice sheets and glaciers (Evans, 1972). Likewise archaeologists are able to re-approximate the workings of extinct societies using formal evidence together with argument by analogy (for example, with comparable present-day societies) and some sound intuition.

This paper is concerned with the preferred orientation of Ontario Iroquois longhouses. By applying inferential statistics developed to analyze azimuthal data, we are able to identify a marked orientational preference: the results indicate that it is highly improbable that the observed orientation in the sample we used occurred by chance. In searching for an explanation of why this significant orientation preference is found, a variety of climatic data relating to wind direction was examined. The coincidence between certain types of wind conditions and the preferred orientation of longhouses lead us to suggest, albeit tentatively, that longhouses were oriented mainly NW-SE or NNW-SSE on account of the greater thermal efficiency gained from this layout.

THE DATA

Every effort was made to gather as large a sample of longhouse data as possible from the published and unpublished literature. Not all the unpublished sources could be tracked down, but the authors are fairly confident that their sample of 96 longhouses and portions of longhouses is fairly representative of existing information. Since, for the purposes of this study, only the orientation of the longhouse was important, it was possible to include data on partially excavated longhouses.

A glance at Figure 1 shows that the study sample is heavily biased in favour of sites from the Late Ontario Iroquois sequence. The Middle Ontario Iroquois sequence is represented by one site and the Early Ontario Iroquois sequence by three sites. Furthermore, the sites are best represented in the historic Huron area (Map 1). This chronological and areal bias is inevitable because, until recently, archaeological activities have tended to focus on the development of the Huron sequence. A decision was made to include the underrepresented areas when the authors discovered that their inclusion made little difference to the results. The underrepresented chronological sequences were included to suggest speculative trends in the data.

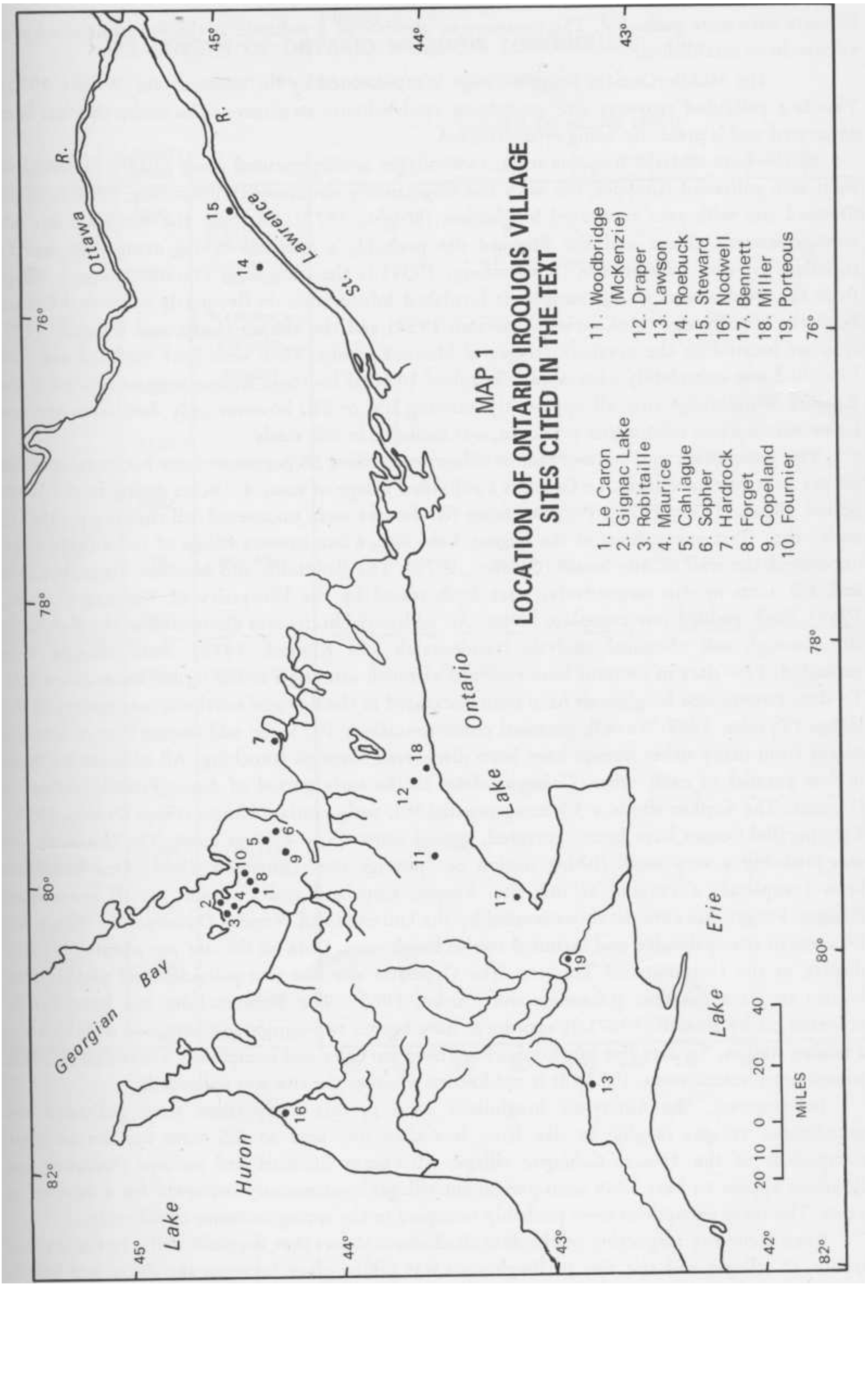
The Early Ontario Iroquois stage is represented by 17 longhouses from the Porteous (Noble and Kenyon, 1972), Miller (Kenyon, 1968) and Bennett (Wright and Anderson, 1969) sites (Figure 1). All three sites appear to have been semi-permanent villages occupied during the entire season. Of the 17 houses, the ones from the Miller and Porteous sites and three from the Bennett site were completely excavated. In size the sites ranged from the Miller site at 1.2 acres and the Porteous site at 1.3 acres to the Bennett site at 2.5 to 3 acres. Both the Miller and

Figure 1.

CHRONOLOGICAL ORDERING OF SITES USED IN THE STUDY.

STAGE	APPROX. DATE	HISTORIC HURON AREA	TORONTO AREA	HISTORIC NEUTRAL AREA	EASTERN ONTARIO	WESTERN ONTARIO
LATE ONTARIO IROQUOIS	1650	LE CARON (5) GIGNAC LAKE (1) ROBITAILLE (2) MAURICE (1)				
	1600	CAHIAGUE (21) SOPHER (2) HARDROCK (1)				
	1550		WOODBRIDGE (1)	LAWSON (4)		
	1500	FORGET (12) COPELAND (4) FOURNIER (5)	DRAPER (1)		ROEBUCK (5) STEWARD (2)	
	1450					
MIDDLE ONTARIO IROQUOIS	1400					
	1350					NODWELL (12)
	1300					
EARLY ONTARIO IROQUOIS	1250			BENNETT (7)		
	1200					
	1150					
	1100		MILLER (9)			
	1050					
	1000			PORTEOUS (1)		

Note: Numbers in brackets after the site name indicate the number of houses that furnished data for the study. Chronologies are based on individual site reports and Wright (1966).


MAP 1
LOCATION OF ONTARIO IROQUOIS VILLAGE SITES CITED IN THE TEXT
1. Le Caron
2. Gignac Lake
3. Robitaille
4. Maurice
5. Cahiague
6. Sopher
7. Hardrock
8. Forget
9. Copeland
10. Fournier
11. Woodbridge (McKenzie)
12. Draper
13. Lawson
14. Roebuck
15. Steward
16. Nodwell
17. Bennett
18. Miller
19. Porteous
Lake Huron
Georgian Bay
Ottawa R.
St. Lawrence R.
Lake Ontario
Lake Erie
20 10 0 20 40
MILES
45°
44°
43°
42°
82°
80°
78°
76°

Bennett sites were palisaded. The presence or absence of a palisade at the Porteous site has as yet not been established.

The Middle Ontario Iroquois stage is represented by the Nodwell site (Wright, 1971). This is a palisaded two-acre site containing twelve house structures. The entire site has been excavated and is presently being reconstructed.

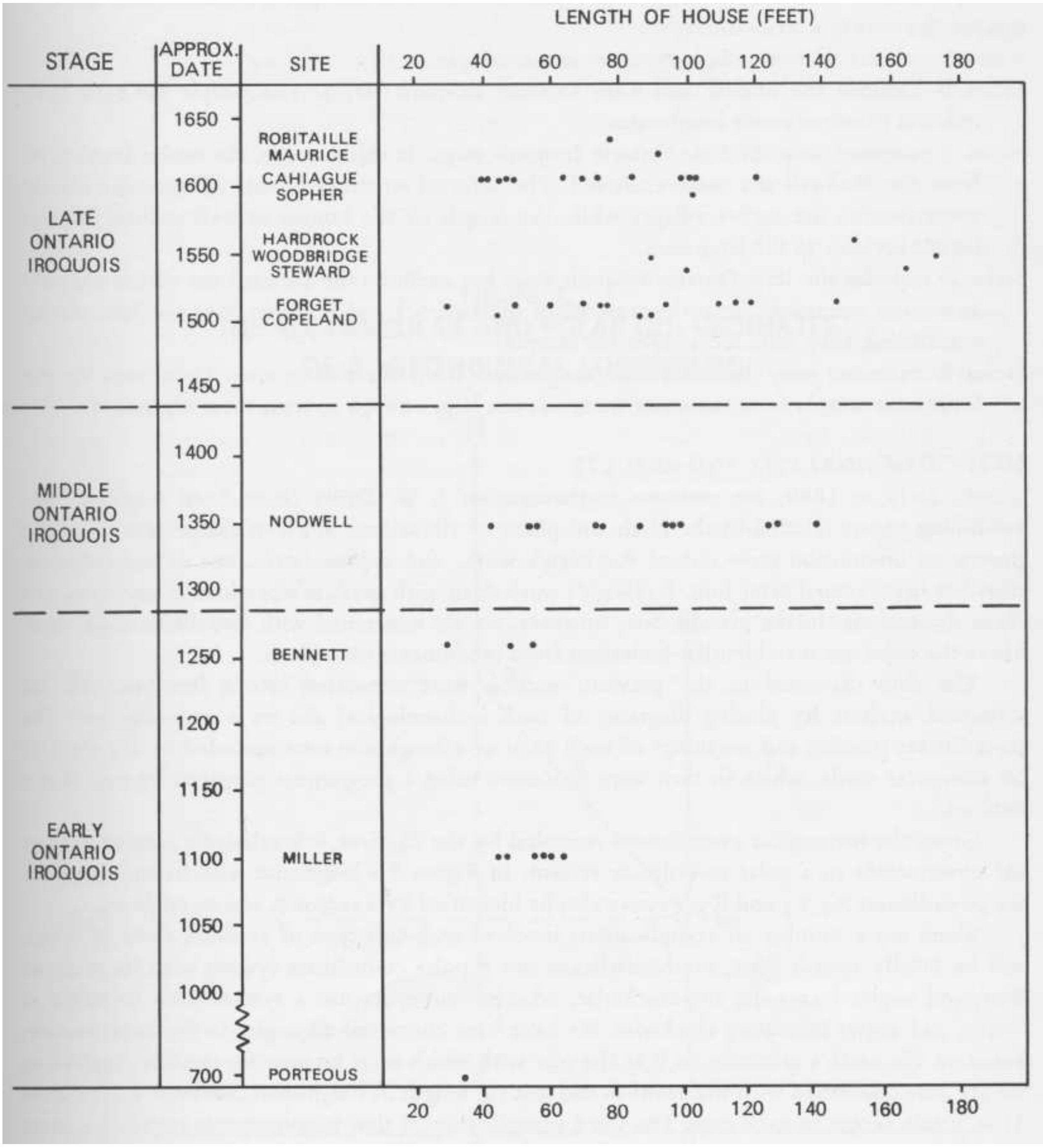
In the Late Ontario Iroquois stage, two villages are represented from eastern Ontario; the eight-acre palisaded Roebuck site with five fragmentary structures (Wintemberg, 1936) and the Steward site with two excavated longhouses (Wright, 1972). Of these the Roebuck site is a semi-permanent village and the Steward site probably a seasonal fishing camp. The heavily fortified five-acre Lawson site (Wintemberg, 1939) is the only Late Ontario Iroquois village from the Neutral area in our sample. It furnished information on five partly excavated houses. Both the Woodbridge (McKenzie) (Emerson, 1954) and the Draper (Latta and Konrad, 1972) sites are located on the northern fringes of Metro Toronto. They were both fortified and each furnished one completely excavated longhouse. In total fourteen houses were excavated at the 2.5-acre Woodbridge site, all apparently running NW to SE; however only data from the one house whose exact orientation is known, was included in this study.

The pre-contact and contact Huron villages comprised 56 per cent of our house sample and 68 per cent of our villages. Le Caron is a palisaded village of some 4.7 acres dating to the Jesuit period (Rexe, 1971; 1972). Portions from five houses were uncovered, all running parallel to each other. Test excavations at the Gignac Lake site, a late contact village of some three acres, uncovered the wall of one house (O'Brien, 1972). The Robitaille and Maurice sites, about six and 1.5 acres in size respectively, were both tested by the University of Toronto (Tyyska, 1969). Each yielded one complete house. An additional house was discovered at the Robitaille site through soil chemical analysis (Heidenreich and Konrad, 1973). Both villages were palisaded. Few sites in Ontario have received as much attention as *Cahiague* (Warminster site). To date twenty-one longhouses have been excavated in the 8.5-acre northern component of the village (Tyyska, 1968; Russell, personal communication, 1973). In addition, a host of bits and pieces from many other houses have been discovered through trenching. All of these are more or less parallel to each other. *Cahiague* dates to the early period of direct French contact in Huronia. The Sopher site is a 3.7-acre, unpalisaded, early contact Huron village (Noble, 1968). Two parallel houses have been excavated, spaced some 35 to 40 feet apart. The Hardrock site was probably a very small fishing station or "portage site" (Emerson, 1954). One house has been completely excavated at this site. Forget, Copeland and Fournier are all pre-contact villages. Forget was completely excavated by the University of Western Ontario. The village was 1.8 acres in size, palisaded and included twelve longhouses. Data on the site was obtained from a display at the University of Toronto. The Copeland site was also palisaded and yielded four houses to its excavators (Channen and Clarke, 1965). The Fournier site has been briefly reported on by Russell (1967). It appears to have been a two-component site, one of which was a fishing station. To date five longhouses have been partially and completely excavated (Russell, personal communication, 1973). It is not known whether the site was palisaded.

In summary, the ninety-six longhouses used in this study come from palisaded and unpalisaded villages ranging in size from less than one acre to 8.5 acres for the northern component of the 15-acre *Cahiague* village. All except Steward and perhaps Hardrock and Fournier appear to have been semi-permanent villages continuously occupied for a number of years. The three exceptions were probably occupied in the spring, summer or fall only.

Even a cursory inspection of the data cited above shows that dramatic shifts in the internal layout of villages and the size of longhouses was taking place between the Early and Middle

Figure 2.
THE LENGTH OF ONTARIO IROQUOIS LONGHOUSES.
(Each dot represents one longhouse)



Iroquois stages (Figure 2). This observation, as well as changes in the internal layout of the longhouses has been discussed by Noble (1968:268-269; 1969:18-19). The cause of these changes, Noble reasons, is linked to changes in Iroquoian social and political structure that took place sometime around 1300 A.D. Because of these changes a decision was made to analyze the data in a series of steps:

Series A includes all ninety-six longhouses in our sample.

Series B includes the Middle and Late Ontario Iroquois stages. The sample has now been reduced to seventy-nine longhouses.

Series C examines only the Late Ontario Iroquois stage. In other words, the twelve longhouses from the Nodwell site were excluded. The internal structure of this village more closely approximates the earlier villages while the length of the houses as well as their internal layout is closer to the later ones.

Series D includes the Late Ontario Iroquois stage but excludes the Steward site which was only seasonally occupied. Since the seasonality of Hardrock and Fournier have not been clearly established, they were included in the sample.

Series E examines only the fifty-four longhouses from the Huron area. Unfortunately the longhouse sample from the other areas was not large enough to treat these separately.

METHOD OF ANALYSIS AND RESULTS

As early as 1880, the eminent mathematician J. W. Strutt (later Lord Rayleigh) was publishing papers relating to the pitch and phase of vibrations: much of the present statistical theory on orientation grew out of Rayleigh's work, and appropriately, one of the statistical tests has been named after him. Rayleigh's work dealt with random vibrations in one, two, and three dimensions. In the present case, however, we are concerned with two-dimensional data, hence the objective is to identify deviations from randomness on a plane.

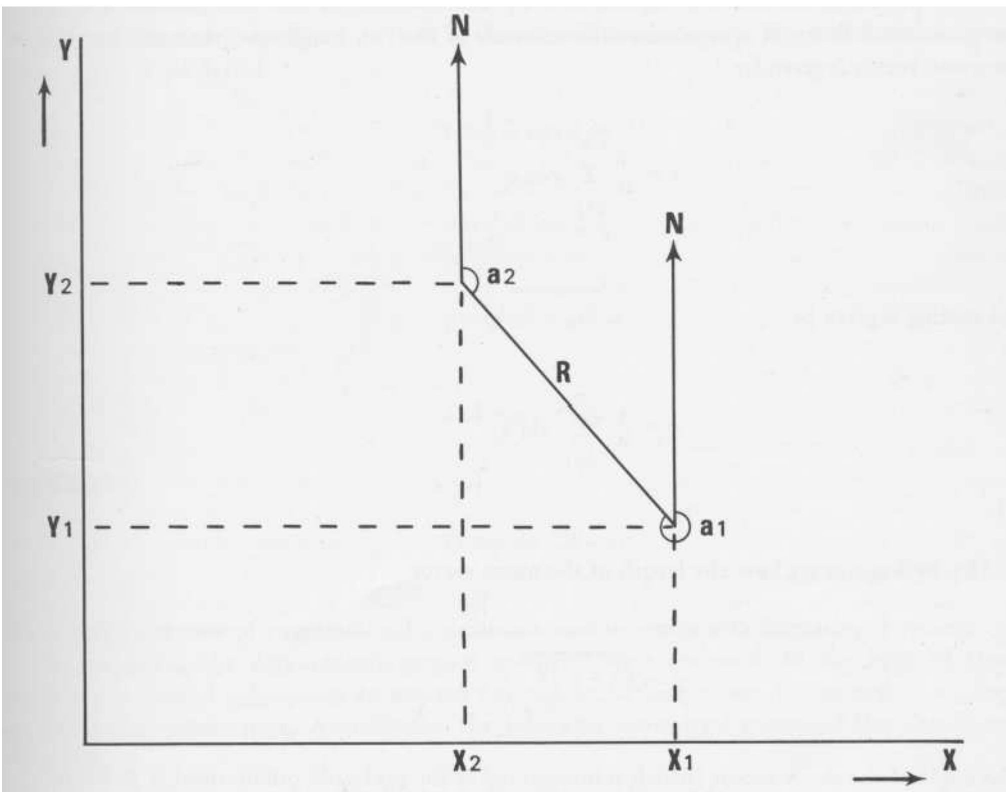
The data discussed in the previous section were converted into a form suitable for statistical analysis by placing diagrams of each archaeological site on a map digitizer. The co-ordinates (easting and northing) of both ends of a longhouse were recorded by the digitizer on computer cards, which in turn were processed using a programme prepared by one of the authors.

Given the rectangular co-ordinates recorded by the digitizer, it is relatively easy to convert the observations to a polar co-ordinate system. In Figure 3 a longhouse with its ends given by the co-ordinates X_1 Y_1 and X_2 Y_2 may also be identified by a vector R and an angle a_l.

There are a number of complications involved with this type of analysis, three of which will be briefly noted. First, mathematicians use a polar co-ordinate system with its origin at East, and angles increasing anti-clockwise, whereas surveyors use a system with its origin at North, and angles increasing clockwise. We have here converted all angles to the latter system, based on the earth's graticule, as it is the one with which most laymen are familiar. Second, as we are here concerned with the azimuth and not the length of longhouses, we treat R (in Figure 3) as a unit vector in each case. The third complication is that trigonometric routines in most computer languages require their arguments to be given in radians rather than degrees, hence it was necessary to convert angles into radians for processing and then back to degrees for interpretation.

The data processing gave rise to several sets of angles based on the earth's grid system. One further processing step was required before statistical analysis was possible. It is clear that for each longhouse there are two possible angles. This stems from the fact that, to use the jargon, longhouses lack a "source" and a "sink." Hence whereas an ornithologist may say that a pigeon

Figure 3.
THE RECTANGULAR AND POLAR CO-ORDINATES OF A HYPOTHETICAL LONGHOUSE.



flew from a release point (source) towards the horizon (sink) at an angle of, say, 250^0, an archaeologist cannot say that a longhouse began at one end and ended at the other: the reverse may be equally true. In Figure 3, the longhouse could be characterized by two angles, either a_1 (320°) or by a_2 (140°). A similar problem is faced by stratigraphers in studying the orientation of pebbles: a pebble oriented to the east is also oriented to the west. If both angles are recorded, then one ends up with a central symmetric distribution where any 180^0 segment is the mirror image of the other. Clearly, angles are only unique over a 180^0 arc, hence it is necessary to use the following simple manipulation proposed by Krumbein (1939). Any angle exceeding 180° is reduced by 180°, so that in Figure 3, the angle would be $320° - 180^0 = 140°$. The resulting angles are then doubled to restore them to a range 0 - 360°, this being necessary for the purposes of statistical analysis. This method is known, logically enough, as "the doubling of angles."

The first type of statistical test we applied were chi square tests, comparing the observed azimuths to a uniform distribution. These tests were performed by classifying the data into twelve arcs each of 30^0. The results permit one to make statements as to whether the azimuths are or are not uniformly distributed, but they do *not* identify the preferred orientation.

The preferred direction is represented by the azimuth of the mean vector which was computed as follows. If a_i represents the azimuth of the i th longhouse, then the northing of the mean vector is given by

$$x = \frac{1}{n} \sum_{i=1}^{n} \cos a_i$$

the easting is given by

$$y = \frac{1}{n} \sum_{i=1}^{n} \sin a_i$$

and by Pythagoras we have the length of the mean vector

$$r = \sqrt{x^2 + y^2}$$

The angle of the mean vector (which is interpreted as the preferred orientation) is θ where

$$\cos \theta = \frac{x}{r} \text{ or } \theta = \cos^{-1} \frac{x}{r}$$

Bearing in mind that we are dealing with a central symmetric distribution and that all the angles have been doubled, then we must halve θ to obtain the two preferred orientations, 1/2 θ and 1/2 θ +180°

The significance of this finding can be determined using the test named after Rayleigh. One has to compute the quantity z, where

$$z = n r^2$$

and compare this to a set of tables published by Greenwood and Durand (1955).

Two other measures are indicative of the presence of a directional preference. The measure r, as defined above, can be expressed as a percentage to represent the magnitude of the mean vector. The second measure is the mean angular deviation, s, which is given by

$$s = \sqrt{2(1 - r)}$$

This measure is the circular equivalent of the familiar standard deviation and has similar statistical properties.

One final statistic which is of use is the second trigonometric moment (a measure of skewness) G: if we define

$$v = \frac{1}{n} \Sigma \cos 2 a_i$$

$$w = \frac{1}{n} \Sigma \sin 2 a_i$$

$$p = \sqrt{v^2 + w^2}$$

$$\text{and } \cos a = v/p$$

then we have

$$G = p \sin (2\theta - a).$$

G vanishes in the case of a symmetrical distribution, and increases with increasing skewness.

In discussing the data sources, several problems were reviewed. In the light of these problems, it seemed appropriate to analyze not one set of longhouses, but several to see how consistent the results were. Accordingly, the following series were examined (for details, see Figure 1):

Series A: All longhouses listed in Figure 1 (N = 96) - see Figure 4;
Series B: Middle and Late Ontario Iroquois (N = 79) - see Figure 5;
Series C: Late Ontario Iroquois (N = 67) - see Figure 6;
Series D: Late Ontario Iroquois, excluding the Steward site (N = 65) - see Figure 7;
Series E: Huron longhouses (N = 54) - see Figure 8.

The results are summarized in Table 1 and will be commented upon briefly.

TABLE 1

RESULTS OF THE STATISTICAL ANALYSIS OF LONGHOUSE

Series	n	θ	r	s	G	z	X^2
A	96	131 and 311°	.357	65.0	.103	12.3	46.3
B	79	135 and 315°	.463	59.4	.148	16.9	55.8
C	67	134 and 314°	.574	52.9	.214	22.1	73.4
D	65	136 and 316°	.592	51.8	.255	22.7	75.0
E	54	136 and 316°	.588	52.0	.312	18.7	80.5

Note: x^2 is based on comparing the observed to a uniform distribution with 12 sectors, each 30^0: for definitions, see the text.

The most important finding is that the mean vector for all the series is almost exactly NW-SE, and in each case, the results are highly significant both in terms of the deviation from uniformity (measured by x^2) and the strength of the mean vector (z).

As the series progress from A to E, so the definition of the series becomes more stringent. The first series covers all Iroquoian sites in Ontario for which we could trace reliable information. Although the results are unquestionably significant, it is clear that the orientation of Early Ontario Iroquois longhouses in this sample is quite different from the later series, because the seventeen houses are scattered through a wide variety of azimuths with the largest number oriented roughly WNW-ESE.

Dropping the Middle Ontario Iroquois (represented by one site, namely Nodwell) also increases the significance of the results. The Nodwell houses are oriented in a variety of azimuths, and the site appears to differ in its layout from the later sites. By dropping the Nodwell site, the strength of the mean vector rises from .463 to .574, the z value and chi square value rise quite substantially and the mean angular deviation correspondingly declines.

The difference between series C and D is fairly small because only two houses were dropped, namely those for the Steward site. Wright (1972:7) has suggested that the Steward site was probably a summer fishing village, and hence fulfilled a different role to the winter villages.

The final series represents fifty-four Huron longhouses. The difference between Series D and E is quite small, suggesting that the layout in Late Ontario Iroquois villages was quite similar in all areas (it would, of course, need a larger sample to confirm this finding). In Series E, the arcs from 120° to 160° (and 300° to 340° contain thirty-eight, or 70 per cent, of the longhouses; there is, in short, a very marked concentration of Huron longhouses oriented between NW-SE and NNW-SSE.

It was noted earlier that fourteen houses are known to exist at the Woodbridge site, although the orientation of thirteen of these houses could not be pinned down with any exactness other than that they were "parallel." But assuming that these thirteen are exactly parallel to the house for which the orientation is known, then by computing the various statistics including these thirteen houses, the concentration of azimuths in the NW-SE trend becomes even more marked.

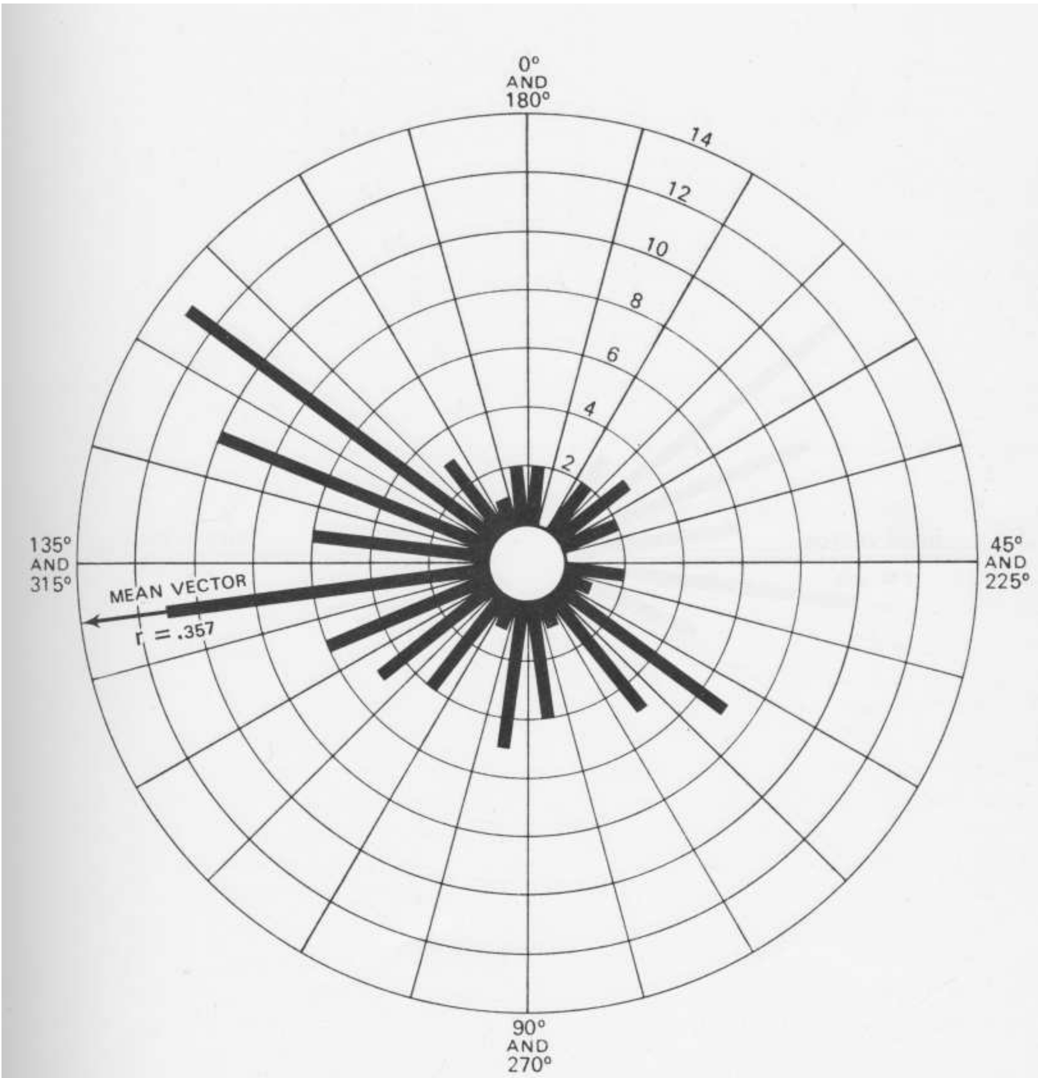


Figure 4. Rose Diagram: Series A (see text)
(Note: Angles are plotted for a range 0°—180°)

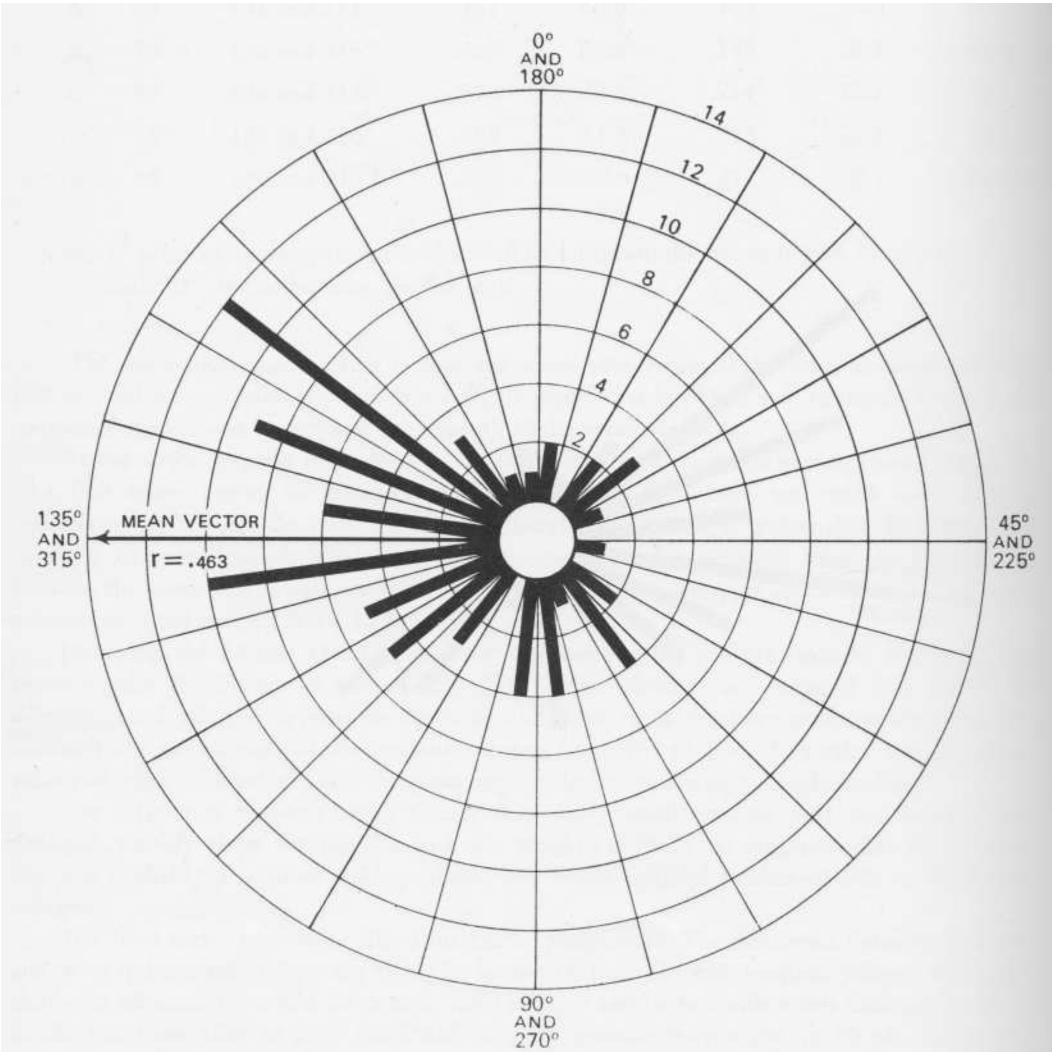


Figure 5. Rose Diagram: Series B (see text)
(Note. Angles are plotted for a range 0^0—180°)

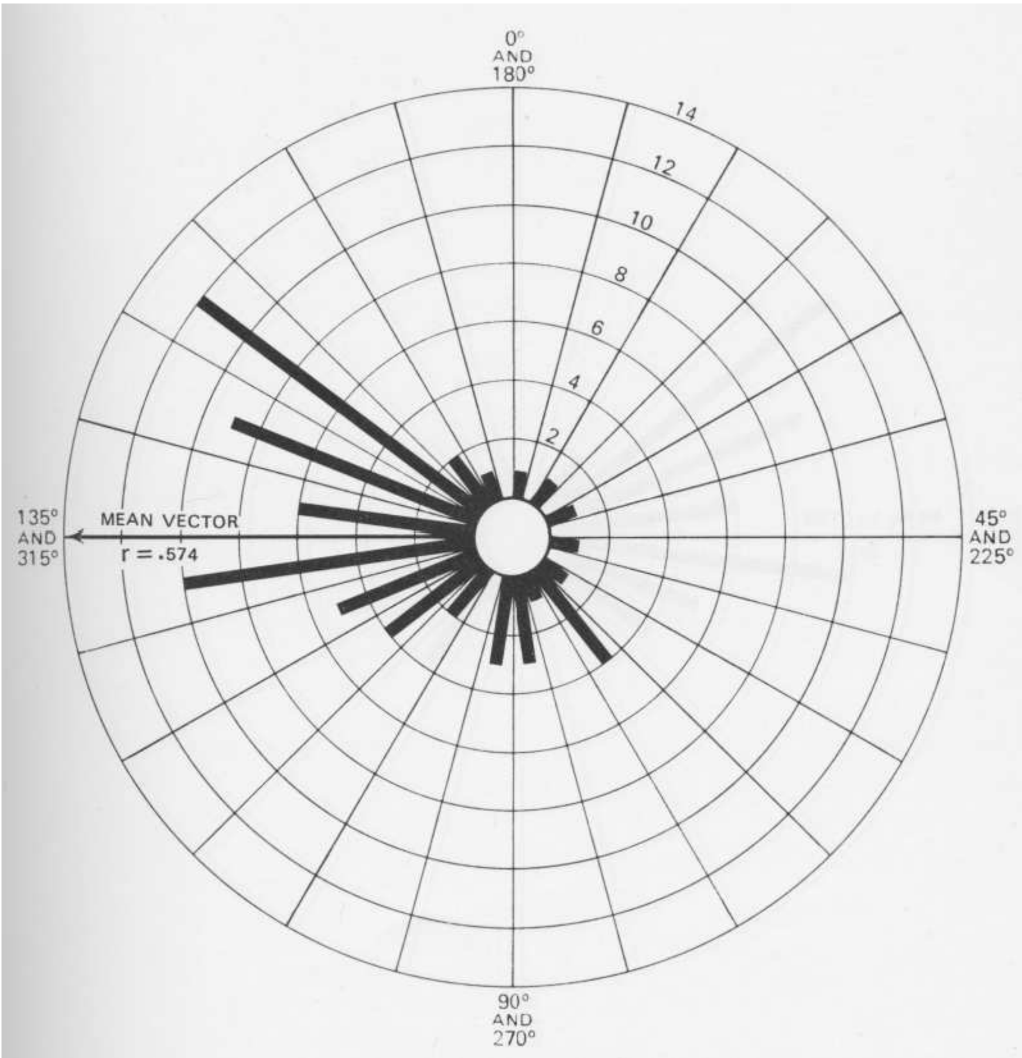


Figure 6 . Rose Diagram: Series C (see text)
(Note: Angles are plotted for a range 0°—180°)

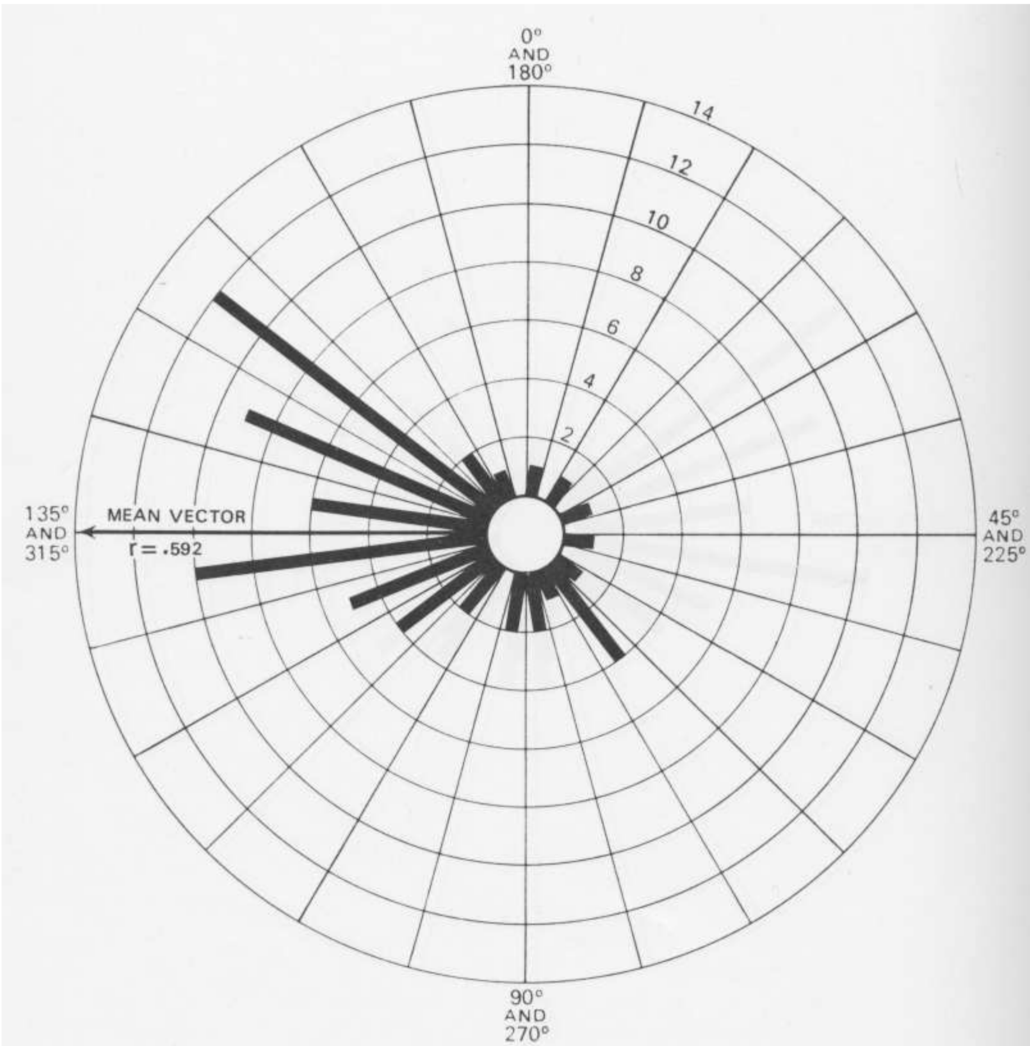


Figure 7. Rose Diagram: Series D (see text)

(Note Angles are plotted for a range 0^0—180°)

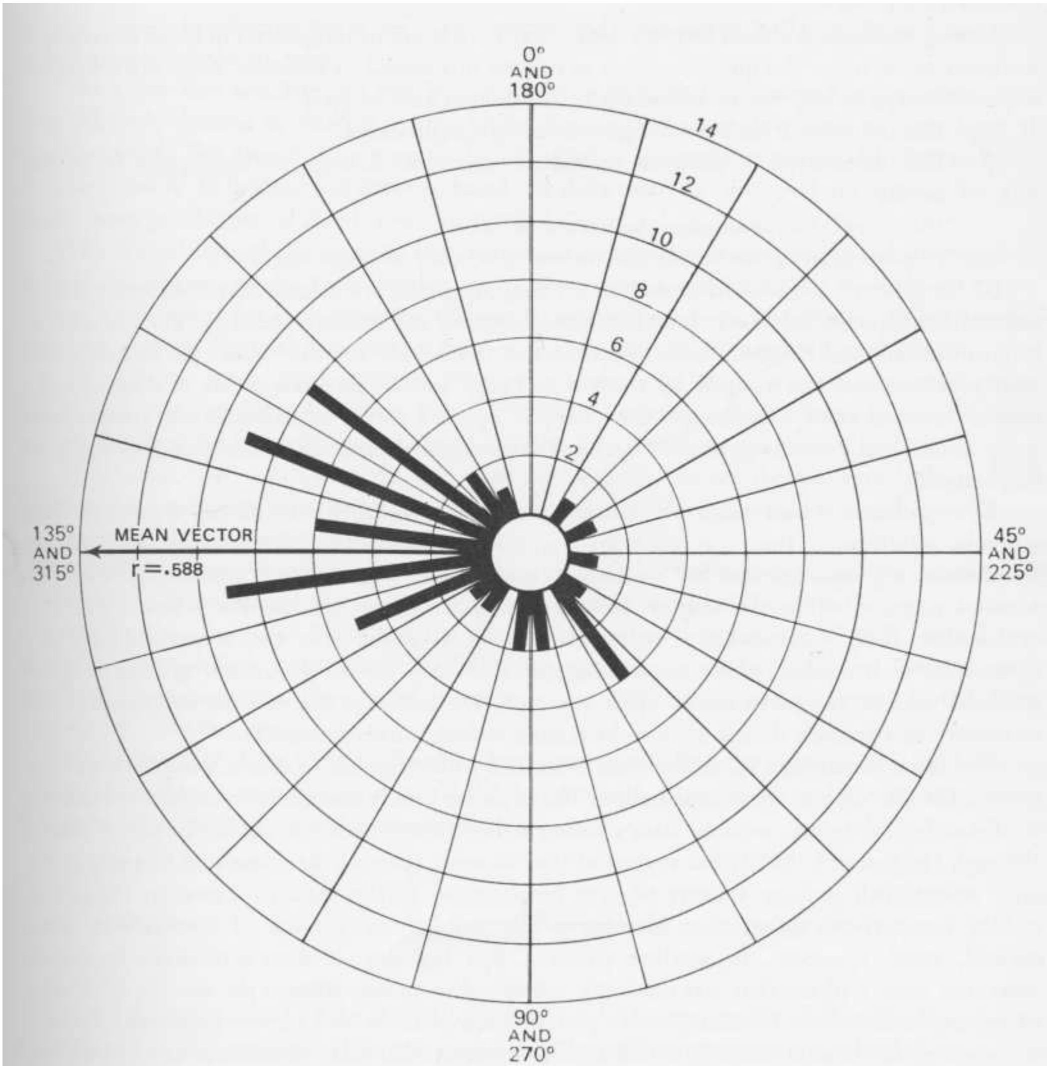


Figure 8. Rose Diagram: Series E (see text)
(Note Angles are plotted for a range 0°—180°)

We have established that in statistical terms, it is exceedingly improbable that Late Ontario Iroquois longhouses are randomly oriented: rather, there appears to be a deliberate concentration of houses oriented either to the NW or NNW, or conversely, to the SE or SSE. We will now explore possible explanations of this arrangement.

INTERPRETATION

Having established almost beyond doubt that Late Iroquois longhouses in Ontario display a preferred orientation, the question arises as to why this should be the case. There are a number of possible hypotheses, four of which will be considered here, namely:

(a) This orientation has some religious/symbolic significance.
(b) This orientation is designed to reduce structural damage to longhouses by strong winds.
(c) This orientation minimizes the hazard of fires.
(d) This orientation maximizes the thermal efficiency of longhouses.

There is a well established precedent for supposing that orientation may have some sort of cultural significance, for this is found in both primitive and modern societies. For instance, in Roman Catholic and Anglo Catholic churches, the "East End" and the "altar" are synonymous. Most primitive societies navigate by the sun and stars and are intensely aware of azimuths; the famous monument of Stonehenge, for example, appears to be an elaborate sun temple with many stones and pointers having a directional and seasonal meaning. Could this also apply to longhouses?

The evidence would seem to indicate that the established orientation does not have symbolic significance: there are too many exceptions. One of the characteristics of structures oriented to a given direction for symbolic reasons is the high level of conformity with the required pattern within the culture area. The number of exceptions found here make this explanation fairly improbable. Furthermore, there is nothing in the seventeenth-century ethno-historic literature which would suggest that any of the Iroquoian groups assigned symbolic value to any particular compass direction. Similarly, the size of a site and the presence or absence of a palisade do not seem to be related to longhouse orientation.

The three remaining hypotheses were examined with reference to recent wind data, and the reasons for this deserve some explanation. The problem is that in seeking to explain orientation in climatological terms, weather data relating to the Huron period is obviously not available, although Heidenreich (1973) has suggested that in most respects the climate of Huronia in the early seventeenth century appears to have been similar to the present. There are dangers in making comparisons to weather data for a different period because of fluctuations, some cyclical, some a periodic, in weather patterns. For instance, Roman settlement in Britain coincided with a phase that was relatively warmer than today, witness the success of Roman viticulture in Southern Britain. Shorter periodicities of seven and eleven years are also well documented in climatic series. It would appear, however, that more confidence can be attached to comparisons for certain specific wind conditions than for temperature data, because wind conditions are associated with air masses whose behaviour is fairly constant over time. In Huron times, gale force winds almost certainly came mainly from the W and SW because, like today, they are associated with the passage of deep depressions. Likewise intensely cold winter winds came and still come from the northerly quarter, and are associated with polar continental air masses. However, the percentage distribution of wind directions may well be more variable so that the comparisons discussed below must be viewed as tentative.

A further problem in selecting a standard for wind data lay in choosing an appropriate norm. The longhouses examined here are dispersed over quite a wide area, yet wind conditions (measured in terms of wind roses) vary locally. The wind roses for Toronto Malton and Toronto Downsview Airports vary in certain respects quite markedly.

The appropriate source for wind data is Volume 5 of the *Climatic Normals,* published by the Meteorological Branch (Canada Department of Transport, 1968). It appears that quite a few of the weather stations have obstructions creating eddies which alter wind direction patterns: Mount Forest is affected by a recently constructed, two-storey building, Downsview by a hangar, and Muskoka by trees.

The norm that was selected was Toronto Malton Airport. This station has two advantages: it is relatively central in relation to the study area and it has unobstructed air flow from all directions with flat terrain. The normals for this station are based on the period 1955 to 1966, inclusive, while individual tabulations based on daily records (prepared specifically for this study) were for the period April, 1960, to April, 1973.

The second hypothesis suggests that longhouse orientation is designed to reduce structural damage by strong winds. Two weather series were used to examine this hypothesis: (i) the average wind speed for each direction (Figure 9) in miles per hour, and (ii) the prevailing wind direction on each day with a maximum wind speed in excess of 30 m.p.h. (Figure 10).

The average wind speed indicates that overall, westerly winds are stronger than easterly winds, and that the three directions from WSW-WNW have the highest average speed. The daily records confirm this westerly tendency and indicate two dominant quarters, W and SW.

It is clear that south-westerly gales 'hit the majority of longhouses broadside on, and western gales tangentially. If wind speed were a potent factor, one would expect longhouses to be oriented approximately west to east.

A difficulty was encountered in attempting to test this finding: the usual two sample test developed by Wheeler and Watson (1964) is not directly applicable because the longhouses are measured over a range of 180^0 and the wind distributions over a range of 360^0. In order to arrive at a probabilistic conclusion, the following method was used: confidence intervals were fitted to longhouse data, these were converted to a 360^0 range, and compared to the mean angle for the weather series.

Using Series D (Late Ontario Iroquois longhouses excluding the Steward site) by doubling of angles we have a mean angle θ of 272^0, the resultant, R, is 38.38, and n = 65. Following Batchelet (1965:31) we have the approximation

$$X = R - \frac{F_{2,2n-2}\ (n-R)}{n-1}$$

where F is found in tables of the F distribution and X is the component of R in the direction of the selected confidence interval (in this case the 95° confidence interval).

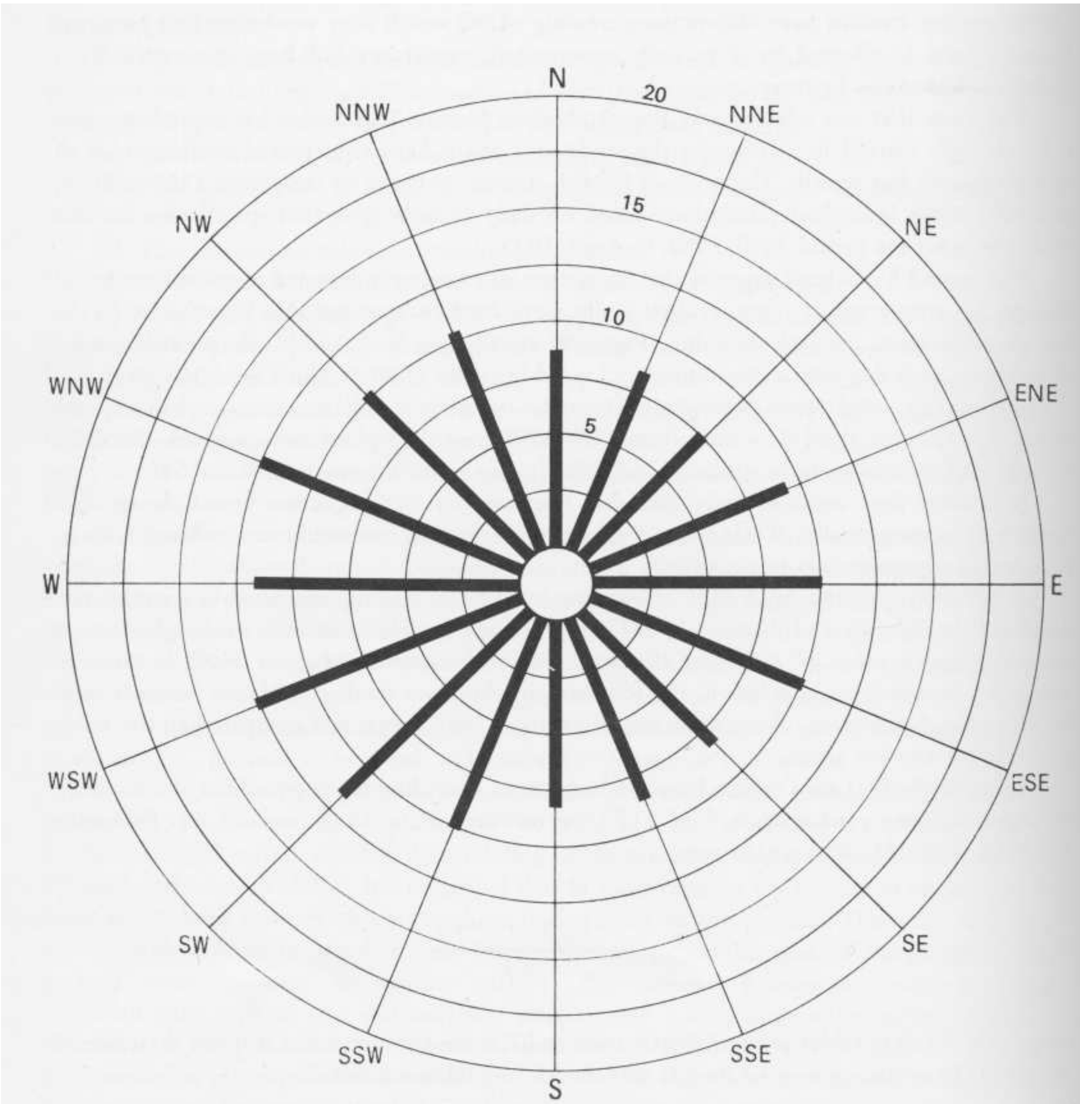


Figure 9, Average Wind Speed (mph) for 1955-1966.

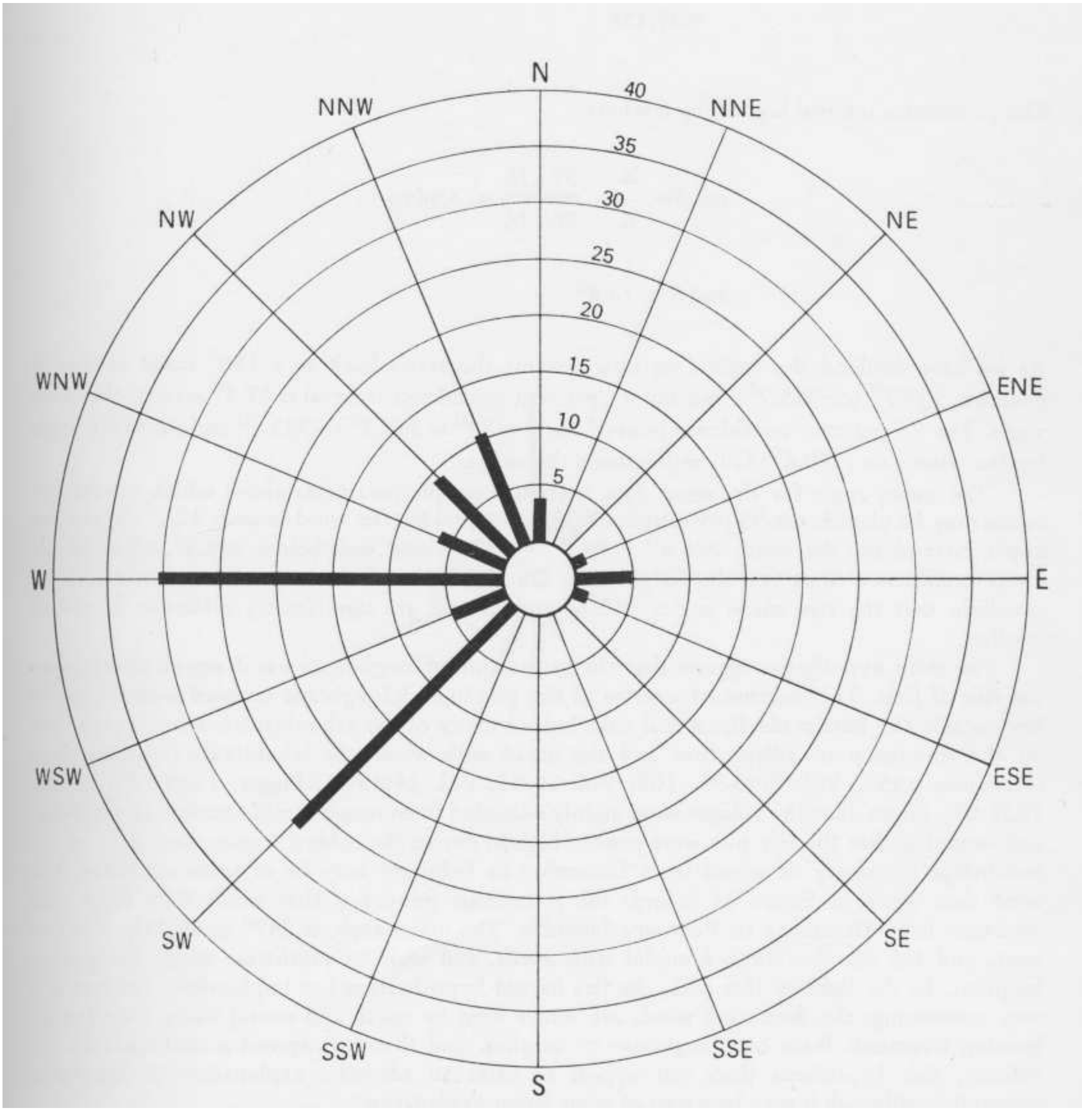


Figure 10. Wind Rose (expressed in percentages) for Days with a Maximum Wind Speed Greater than 30 mph, April 1960—April 1973.

Here

$$X = 38.446 - \frac{3.06\ (65-38.446)}{64}$$

$$= 37.176$$

The confidence interval is given by δ where

$$\cos\delta = \frac{X}{R} = \frac{37.176}{38.446} = +.9670$$

and $\delta = 14.8^{\circ}$

As we have doubled the angles, we now convert the series back to a 180° range so that B becomes 135.7^{0} (or 315.7°) and the 95 per cent confidence interval is ±7.4° around the mean angle. The 95 per cent confidence interval for θ +180° is 308.3° to 323.1° and the mean angle for the wind data (270.6°) falls well outside this range.

The mean angle for the wind data is itself a sample parameter about which confidence limits may be placed: the 95 per cent confidence interval for the wind series is 12.1°, hence the upper interval for the wind, 270.6° + 12.1° = 282.7° and well below 308.3°, which is the lower confidence limit for the longhouses. On the basis of these confidence intervals we conclude that the two mean angles 315.7° and 270.6° are significantly different from one another.

The third hypothesis suggests that the orientation of longhouses was designed to minimize the risk of fires. The location of a series of fire pits in each longhouse coupled with the use of fire outside the huts made fire a real risk. Indeed many of the ethnohistoric sources comment on the frequency of village fires and the dread with which the inhabitants regarded them (Thwaites, 1959, Vol. 8:93-95, 105; Vol. 10:35; Vol. 14:43-45; Biggar, 1929:125; Wrong, 1939:95). Given that the villages were mainly occupied from roughly mid-October to mid-May, and assuming that the fire pits were banked highest during the coldest season, then data on the percentage frequency of winds from December to February may be of some relevance. The wind data given in Figure 11 records the percentage frequency that winds flow from- each direction from December to February inclusive. The mean angle is 287^{0} or slightly north of west, and the distribution is bimodal with north, and west to southwest winds being most frequent. In the light of this data, the fire hazard hypothesis is not implausible, but nor is it very convincing; the dominant winds are either west or north and would likely have fanned burning fragments from one longhouse to another, and therefore spread a conflagration. On balance, this hypothesis does not appear to offer an adequate explanation of longhouse orientation although it may be a part of some larger explanation.

The final hypothesis suggests that the preferred orientation of longhouses maximizes their thermal efficiency. Records indicate that keeping warm during cold periods was not unimportant to the Iroquois: for instance, in winter they slept huddled together around the fire pits, close to each other and to the fires for warmth. The longhouses themselves, with their birch, cedar and elm bark cladding, would not be very well insulated. Insofar as heat loss is a function of the surface area presented to the wind, the loss of heat from a longhouse could be reduced by minimizing the surface area presented to prevailing cold winds.

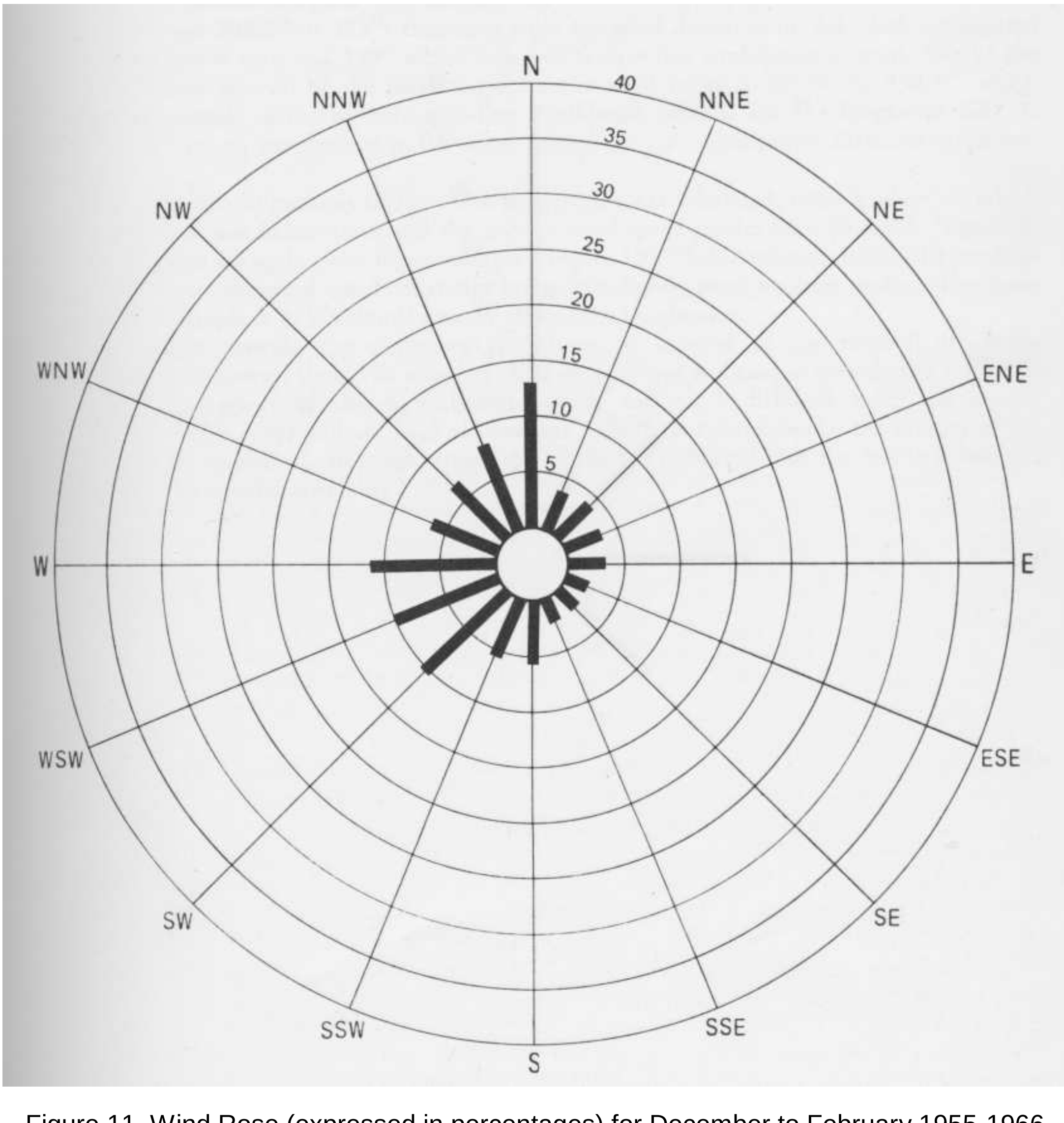


Figure 11. Wind Rose (expressed in percentages) for December to February 1955-1966.

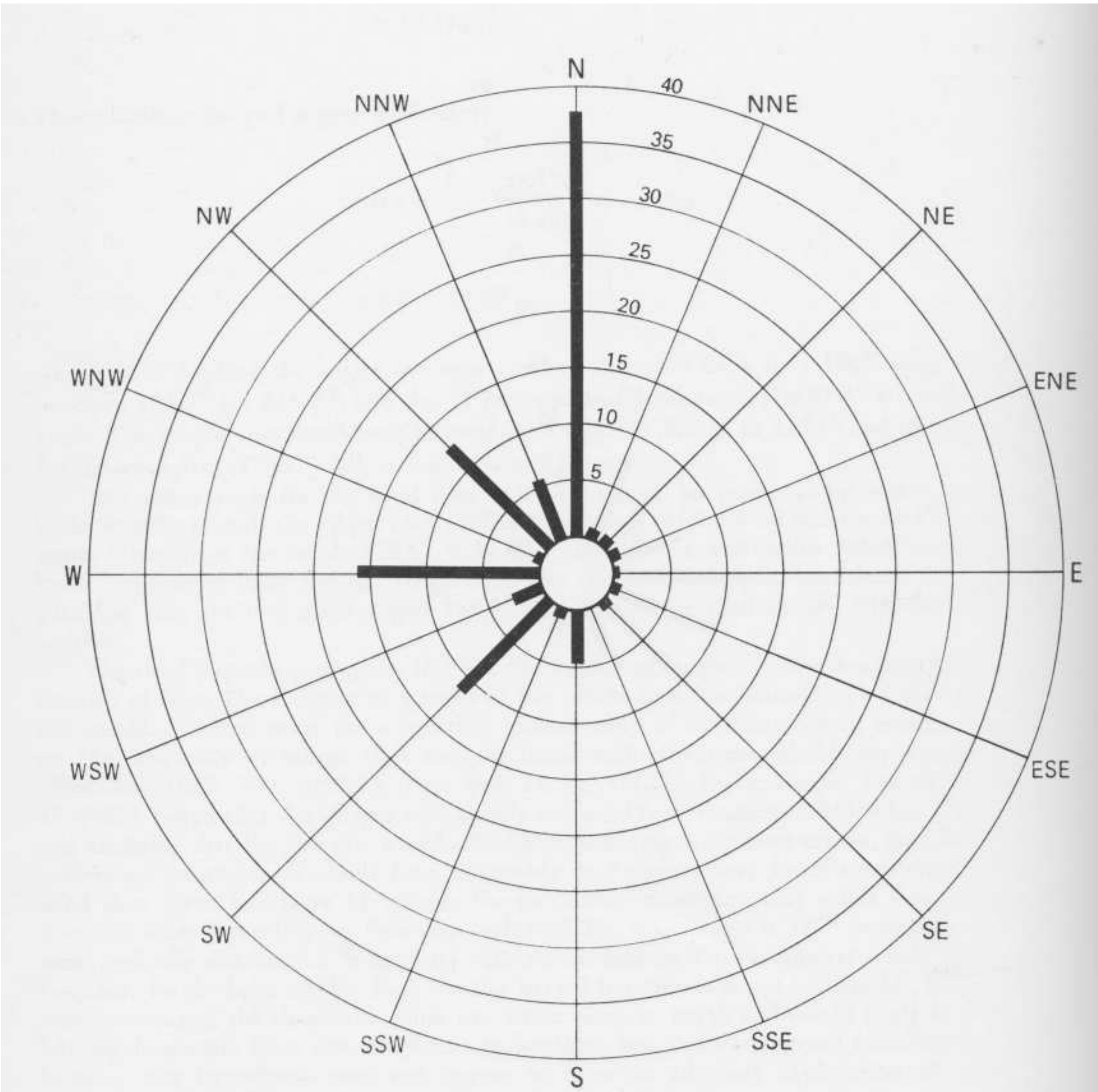


Figure 12. Wind Rose (expressed in percentages) for Days with a Minimum Temperature below 0°F, April 1960—April 1973.

Figure 12 is a rose diagram for days on which the minimum temperature was below zero Fahrenheit between April, 1960 and April, 1973 (figures in the rose diagram are given in percentages). Not surprisingly, the dominant direction is north and the mean angle is 320^0, and very similar to the mean angle of the longhouses.

Again the difference between mean angles is examined using confidence intervals. For Series D (late Ontario Iroquois excluding the Steward site) the 95 per cent confidence interval for θ +180° was 308.3^0 to 323^0: the mean angle for wind direction on days with a minimum temperature below zero was 320^0 which falls well within this confidence interval. The 95 per cent confidence interval of the mean angle for the wind series is 309.9° to 330.1^0, which overlaps extensively with the corresponding confidence interval for the longhouse data. It would seem safe to conclude that the mean angles are not significantly different from one another.

Exploring this hypothesis further, one more series was tabulated, namely, days on which the temperature was below zero, and the average wind speed greater than 10 m.p.h. (figures in the rose diagram are again given in percentages) (Figure 13). This is quite similar to the previous series except that the wind speed constraint brings in a slightly more western bearing. The mean angle for this sample is 315^0, almost exactly that of the longhouses.

The results provide the necessary conditions in support of the thermal efficiency hypothesis. Two caveats should be attached: first we have not and cannot provide the sufficient conditions in support of this hypothesis. Second, and on a different tack, the sample distributions being compared are both skewed and in different ways, hence the validity of the results may be weakened, although Stephens (1962) has indicated that the test is robust for deviations from circular normality.

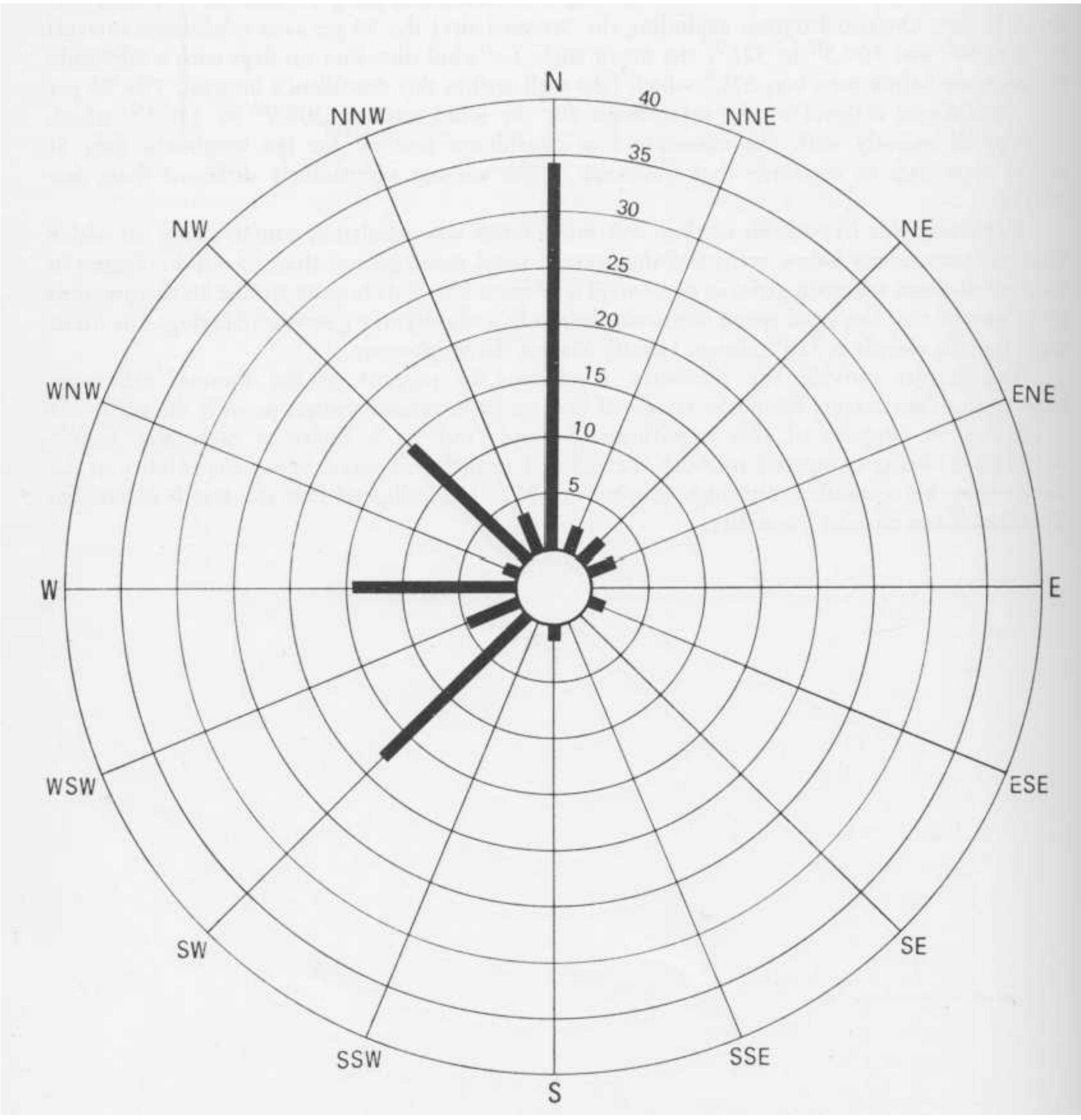


Figure 13. Wind Rose (expressed in percentages) for Days with a Minimum Temperature below 0° F, and an Average Wind Speed Greater than 10 mph, April 1960—April 1973.

CONCLUSIONS AND IMPLICATIONS

In this study. we have attempted to identify the preferred orientation of Iroquoian longhouses in Ontario and have found a strong and significant preference for a NW-SE orientation during the late period. For the early and middle period, the scant information available points to a different village layout lacking this orientational preference. The Steward site appears to be a summer fishing village, and house orientation at this site is also quite different.

In attempting to explain the observed NW-SE preference, four hypotheses were reviewed: does this orientation have symbolic significance? reduce wind damage? minimize damage by fire? maximize thermal efficiency? Comparing the longhouse orientations to present-day wind data (which, it was admitted, must be treated with some reservations) it was found that the most plausible hypothesis involved thermal efficiency. There may well be better explanations, but this is a conclusion we tentatively put forward for others to ponder: the form of late Iroquois villages was deliberate, and was designed to fill a specific function, namely, to keep the occupants as warm as possible on bitterly cold winter days when low temperatures were associated with a large wind chill factor.

Data examined from four sixteenth and seventeenth-century New York Iroquois sites suggests an orientation similar to the late Ontario Iroquois longhouses, thus strengthening an environmental rather than a cultural hypothesis. Difficulty in procuring a large sample of New York Iroquois longhouses precluded the inclusion of such data in this paper, but a comparative study would be illuminating.

It is of interest to compare the orientation of Early Ontario Iroquois longhouses to Late Ontario Iroquois (excluding the Steward site). The relevant two sample parametric test, described by Wheeler and Watson (1964) is based on the following parameters:

SAMPLE 1	SAMPLE 2
Early Ontario Iroquois	Late Ontario Iroquois (excluding Steward)
$x_1 = 2.585$	$x_2 = -38.434$
$y_1 = -5.115$	$y_2 = 0.950$
$n_1 = 17$	$n_2 = 65$
$R_1 = 5.73$	$R_2 = 38.45$
$\theta_1 = 153.2$	$\theta_2 = 271.4$

We have

$$N = n_1 + n_2 = 82$$

$$X = x_1 + x_2 = -35.849$$

$$Y = y_1 + y_2 = -4.165$$

$$R = \sqrt{X^2 + Y^2} = 36.09$$

and the test statistic

$$F = (N-2) \frac{R_1 + R_2 - R}{N - R_1 - R_2} = 17.11$$

The significance of F is ascertained as in the usual F test with 1 and N-2 degrees of freedom. Working at the .01 level we have $F_{1,80} = 6.98$ and the computed value is highly significant. We therefore conclude that the mean orientation of early and late Iroquois are significantly different from one another subject to one caveat: the Rayleigh test applied to the Early Iroquois data is significant only at the .10 level. However taking into account the robust nature of this test (Stephens, 1962), it would appear that considerable confidence can be placed in the above conclusion. This being so, it is suggested that if thermal efficiency was the motive for the observed orientation at the later stage, this may be the product of a cognitive process whereby it became generally observed that occupants of longhouses oriented NW-SE were able to keep warmer when bitterly cold conditions prevailed. Related to this may be the fact that the longhouses were getting larger during the Middle and Late Iroquois stages (Figure 2). A NW-SE orientation would be particularly advantageous for these houses since heat loss from a large longhouse would be greater than from a small one. Once the larger houses were aligned NW-SE it would be most economical in terms of useable village space to place the smaller ones parallel to the larger ones.

Two related issues emerge, one concerned with site excavation, the other with pushing the hypothesis that was accepted to its logical conclusion.

Concerning excavation, it would appear that the most efficient method to explore late Iroquois sites would be to lay trenches or do soil analyses SW-NE, at right angles to the most probable orientation of longhouses (Heidenreich and Konrad, 1973). One thereby should increase the chance of finding the position of longhouses. An exploratory trench laid NW-SE could fall between two longhouses: one could then do a great deal of digging and discover very little.

Having tentatively accepted the thermal efficiency hypothesis, the final step is to push the argument to its limits and see what transpires. Having used the data to identify an orientational preference, one inverts the argument to identify villages that do not conform with the expected layout, and then argues that these villages are different in some way. Earlier villages do not show the NW-SE tendency, and it has been suggested that the preference found in the later stage may be the culmination of a learning process. Hence one possibility is that non-conformist villages are misdated and belong to an earlier period. Another possibility is that non-conformist sites are not winter villages. In this respect, Fournier is of particular interest: the layout of this site differs from the others; only one house is oriented NW-SE, two are oriented due E-W and another two are roughly NNE-SSW. If this speculation were true, then it would strengthen the argument that this type of statistical analysis can serve as a valuable heuristic device for archaeologists.

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