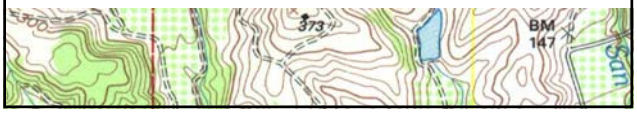
Geography 12: Maps and Spatial Reasoning

Lecture 18: Measuring shape and distribution

Professor Keith Clarke



Feature Types: Objects

Features Collectively: Landscape

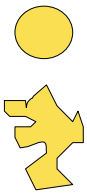
Shape, Distribution, Arrangement and Pattern

- One feature can have shape
- Many features of one type can have a distribution
- Features of different types show arrangements
- One or more features of one or more types can have pattern

Features on maps: Shape

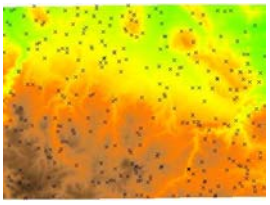
Shape properties

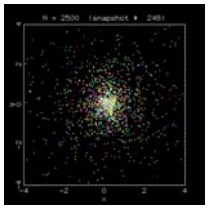
- Natural vs. geometric
- Circular vs. Linear
- Circular vs. Fragmented
- Correspondence to another shape
- How measured?
  - Value should be unique
  - Should be able to get shape from measure



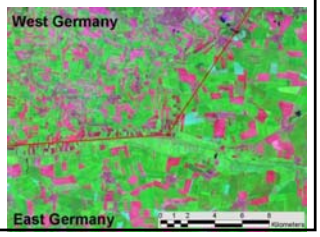
Distribution

- Clustered vs. Dispersed
- Random vs. Ordered





Arrangement



Pattern: repetition

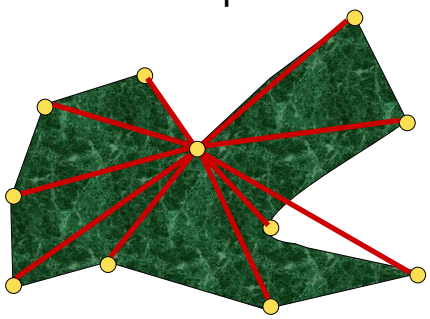
Measurement

- Shape
  - Miller
  - Bunge
  - Boyce-Clark
  - Fourier measures
- Distribution
  - Quadrat analysis
  - Nearest neighbor analysis

Shape Measurement

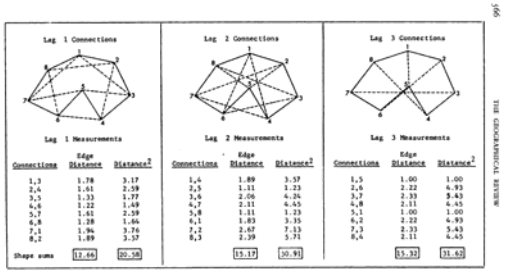
- Miller's measure: covered in lab
- Book explains Boyce-Clark radial shape method
- Will cover Bunge's method here
- Set of distance measurements taken between systematically places vertices on the perimeter of the shape in question
- Originally applied to 97 Mexican community outlines
- Can compare shapes of different sizes by making all their lengths the same (scale to 1.0)

A shape



Bunge's Shape Measure

- Select vertices on shape
- Take shortest straight-line distance between different pairs of vertices
- Pick a start point and a direction (e.g. clockwise)
- Repeat for all start points
- Then repeat skipping one, two, three, etc points at a time
- Values are unique for any specific shape



Lag 1 Connections

Lag 1 Measurements

Connections	Edge Distance	Distance²
1,3	1.78	3.17
2,4	1.61	2.59
3,5	1.33	1.77
4,6	1.22	1.49
5,7	1.61	2.59
6,8	1.28	1.66
7,1	1.96	3.76
8,2	1.89	3.57
Shape sums	13.66	20.50

Lag 2 Connections

Lag 2 Measurements

Connections	Edge Distance	Distance²
1,4	1.89	3.57
2,5	1.11	1.23
3,6	2.06	4.24
4,7	2.11	4.45
5,8	1.11	1.23
6,1	1.83	3.35
7,2	2.67	7.13
8,3	2.39	5.71
	15.17	30.91

Lag 3 Connections

Lag 3 Measurements

Connections	Edge Distance	Distance²
1,5	1.00	1.00
2,6	2.22	6.93
3,7	2.33	5.43
4,8	2.11	6.45
5,1	1.00	1.00
6,2	2.22	6.93
7,3	2.33	5.43
8,4	2.11	6.45
	15.32	31.62

FIG. 1—The connecting method of measuring shape, after Bunge (see text footnote 16 for reference). The six shape sums equal the shape index.

1966 GEOGRAPHICAL REVIEW

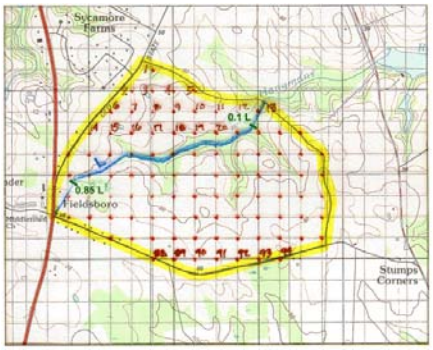
Problems with shape measures

- Shape can vary by scale and projection!
- Many violate the one shape one number rule
- All violate the number to shape rule
- Many simply compare one shape to another, e.g. a circle
- Shape is often multi-dimensional (Bunge)
- But, many measures work well!
- Often use shape correspondence

Distribution: Quadrat Analysis

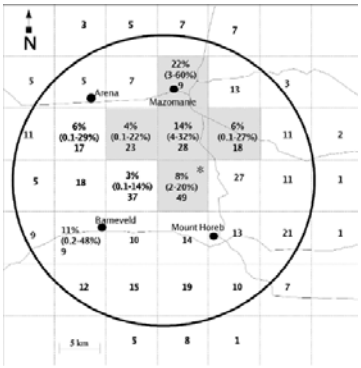
- Popular in biology and ecology
- Divide area into squares or rectangles
- Count points or features in each cell
- Can then compare actual counts to what would be expected if points were located at random, or evenly
- Uses mean and variance measures

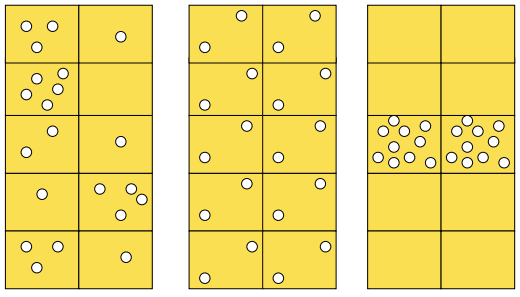
FEMA Flood frequency estimation: Sample elevations



Spatial distribution of chronic wasting disease in White-tailed Deer sampled in Wisconsin (February-April 2002). Locations for sampled deer were recorded by using the Wisconsin Public Land Survey System; analysis was conducted on pooled 4X4 sections (41 km2), as indicated by the dashed grid lines. Prevalence, 95% confidence limits (CI), and sample size for each quadrat are indicated, as well as sample size only for quadrats in which positive deer were not detected. A cluster of higher than expected prevalence was detected in the north-central region of the sampling area indicated by shading (prevalence 9.4%, 95% CI 5.0% to 16.0%, n=127). The asterisk indicates the quadrat in which the three initial positive deer were found.

USGS National Wildlife Health Center





Random

3	1
5	0
2	1
1	3
3	1

Quadrat #	Number of Points Per Quadrat	x^2
1	3	9
2	1	1
3	5	25
4	0	0
5	2	4
6	1	1
7	1	1
8	3	9
9	3	9
10	1	1
	20	60
Variance	2.222	
Mean	2.000	
Var/Mean	1.111	

Uniform

2	2
2	2
2	2
2	2
2	2

Quadrat #	Number of Points Per Quadrat	x^2
1	2	4
2	2	4
3	2	4
4	2	4
5	2	4
6	2	4
7	2	4
8	2	4
9	2	4
10	2	4
	20	40
Variance	0.000	
Mean	2.000	
Var/Mean	0.000	

Clustered

0	0
0	0
10	10
0	0
0	0

Quadrat #	Number of Points Per Quadrat	x^2
1	0	0
2	0	0
3	0	0
4	0	0
5	10	100
6	10	100
7	0	0
8	0	0
9	0	0
10	0	0
	20	200
Variance	17.778	
Mean	2.000	
Var/Mean	8.889	

$$N = number\_of\_quadrats = 10$$

$$Variance = \frac{\sum x^2 - [(\sum x)^2 / N]}{N - 1}$$

$$Variance - mean - ratio = \frac{\text{variance}}{\text{mean}}$$

Quadrat Analysis

- A random distribution would indicate that that the variance and mean are the same.
- Therefore, we would expect a variance-mean ratio around 1
- Values other than 1 would indicate a non-random distribution

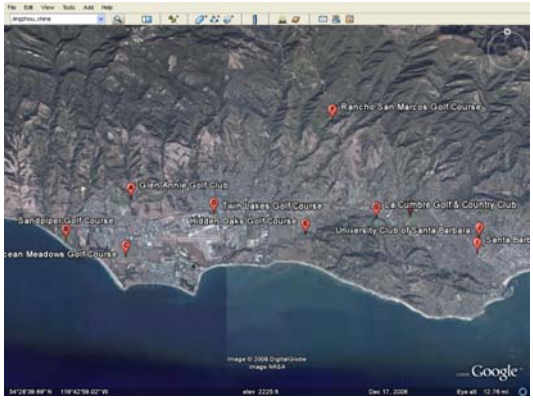
Strengths

- Kilometer grids printed on every quadrangle map!
- Easy to do in GIS
- Gives a good indication of distribution

Weakness of Quadrat Analysis

- Quadrat size and orientation bias
- If the quadrats are too small, they may contain only a couple of points. If they are too large, they may contain too many points
- Some have suggested that quadrat size should be twice the size of the mean area per point
- Or, test different sizes (or orientations) to determine the effects of each test on the results
- Actually a measure of dispersion, not really pattern, because it uses density of points, and not their arrangement
- Results in a single measure, variations within the region are not recognized

Practical example



Summary

- Shapes of individual features can be compared
- Distributions can be quantified, using quadrat analysis
- Other methods, such as NNS still to come