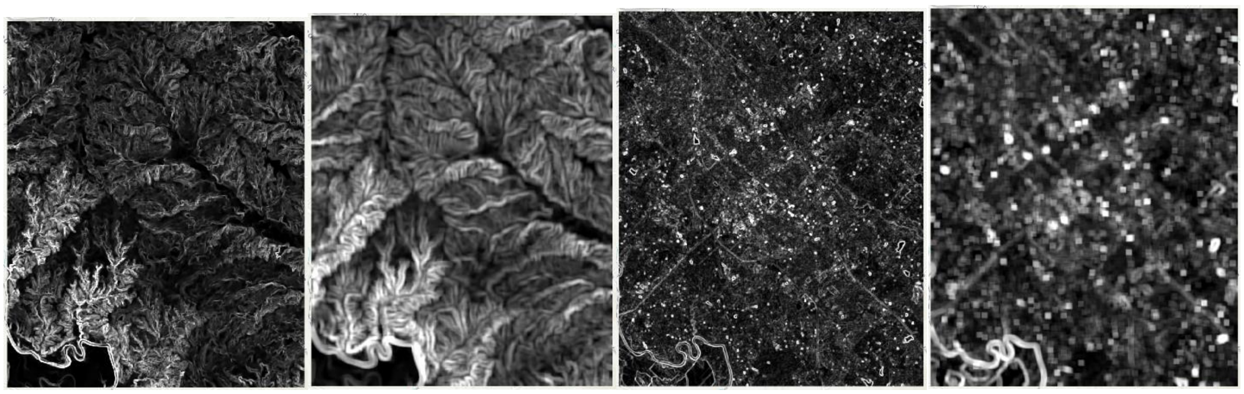
Madyson Bradford

GEOG 475

6 March 2021

GEOG 475 Lab II

Spatial Statistical Metrics



Left to right: DEM Stdev 3x3, DEM stdev 11x11, Landsat8 Stdev 3x3, Landsat8 Stdev 11x11.

What information is generated when the metric is used on the spectral data? What does it effectively highlight? Does the nature of the information change when you utilize the metric over a larger area?

When focal statistics to get standard deviation with multiple neighborhood sizes is used on the spectral data, each respective window calculates to give you a visual representation of standard deviation across the geographic area. This metric highlights the variability in satellite image's topography, where lighter areas represent higher standard deviation and therefore a more complex topography and darker areas represent a lower standard deviation with a subsequently less complex topographical layout. The nature of this information changes when you utilize the metric over a larger area because the metric is scale dependent, so a change is scale could change the standard deviation of the area drastically. Depending on the complexity or homogeneity of the topography, the information extracted could either have a higher or lower standard deviation respectively.

Speculate on what you think this information could be used for (e.g., a particular application, mapping, assessing the landscape)?

This information could potentially be used to observe the process of succession, or recovery after disturbance of a landscape. After anthropogenic forces like agriculture effectively make a landscape more homogenous, from this base point of low complexity you could track (over time) the slow recovery of the area. As more vegetation and possibly wildlife return to the area, the standard deviation would increase as complexity increases. This pairs this first order statistic with a temporal analysis, making it more reliable and allows for a higher level of information extraction.

What information is generated when the metric is used on the DEM? What does it effectively highlight? Does the nature of the information change when you utilize the metric over a larger area?

When this metric is used on the DEM, a visual representation of the degree relief displacement is generated. This information effectively highlights the degree of topographical variation in elevation values, lighter colours being higher standard deviation values and darker values indicating areas of low standard deviation and lower topographic variability in elevation. Overall variation in elevation within the DEM is represented through this metric. The nature of the information does change over a larger area, just like the previous satellite image. As the area increases, more values are taken into the neighborhood calculations and the standard deviation is affected by the introduction of more values, since those values could be higher or lower, or even outliers that greatly affects the outlier-sensitive standard deviation.

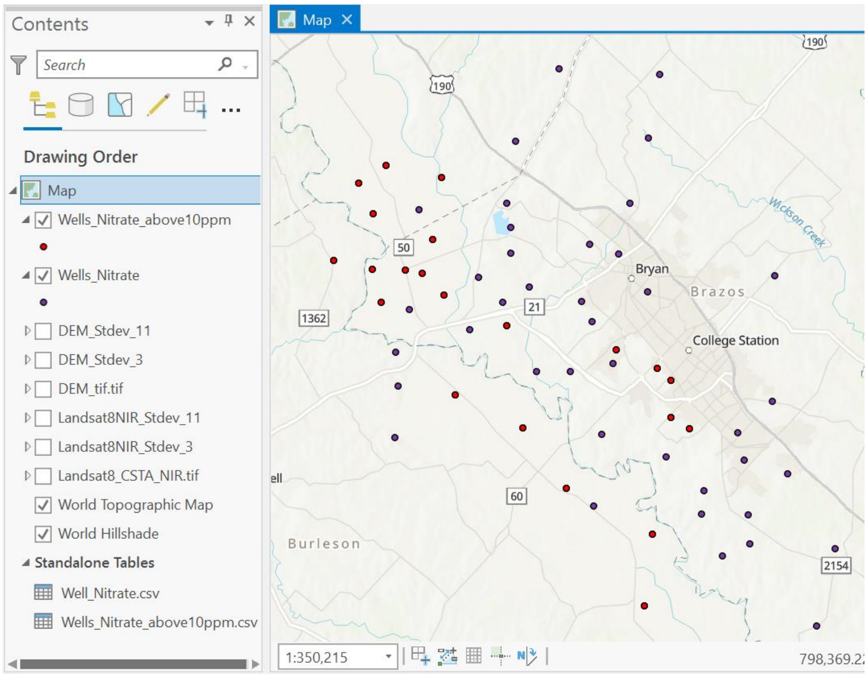
Theoretically, what topographic property should the metric characterize? Can you provide any evidence for your answer?

Theoretically this metric should characterize topographic complexity, like differences in elevation or surface roughness. This is evident in how when a surface is anymore short of complete homogeneity, there is going to be a standard deviation which suggests some level of spatial complexity.

Speculate on what you think this information could be used for (e.g., a particular application, mapping, assessing the landscape)?

This information could be used when trying to map how mountainous terrain is in a particular area, or especially the presence of a basin. The lower standard deviation areas, appearing darker, would do a great job of representing the extent of a basin or sub-basin in an area with high relief displacement. The lower and more homogenous elevation in the basin would incur a lower standard deviation, so the information extracted would clearly confirm a basin which could subsequently be catalogued and mapped.

Point Distance and Variability Metrics



	A	B	C	D	E	F	G	H	I	J	K
1	OID_	NITRATEp	X (m)	Y (m)	X mean (m)	Y mean (m)	Distance (m)	Average Distance (km)	X (x-mean)^2 (m)	Y (y-mean)^2 (m)	Std Dist (km)
2	1	25	753922	3389240	747110.5323	3391075.484	7054.437876	12.86320986	46396092.23	3369001.514	14.05232839
3	2	13	754986	3388280			8356.89669		62022991.49	7814730.794	
4	3	9	750517	3389600			3712.287061		11604022.19	2177053.034	
5	4	11	750803	3390650			3716.901176		13634317.72	181036.6343	
6	5	20	754994	3385420			9702.245217		62149062.98	31984499.27	

***Above**: All Well Points Calculations in excel; **Below**: Well Selection >= 10ppm Calculations in excel.*

	A	B	C	D	E	F	G	H	I	J	K
1	OID_	NITRATEp	X (m)	Y (m)	X mean (m)	Y mean (m)	DIST (m)	Average Distance (km)	X (x-mean)^2 (m)	Y (y-mean)^2 (m)	Std Distance (km)
2	1	25	753922	3389240	741862.3636	3391758.182	12198.5176	11.302615	145434830.1	6341240.585	12.45241416
3	2	13	754986	3388280			13418.0685		172229832.4	12097750.03	
4	3	11	750803	3390650			8950.75504		79934979.24	1228067.345	

Describe the water-well location pattern across Brazos County using the metrics that you generated.

The mean location of the point pattern for water-well locations across Brazos County is the mean center of the point distribution when every point is considered. From this point the average distance is used to measure the compactness of the spatial distribution, and this distribution's average distance of 12.86 km suggests relatively compact distribution, considering the entire area is about 52 km across at its widest. The 14.05km standard distance characterizes the dispersion of the point pattern, which is relatively compact since its close to the average distance.

Describe the water-well location pattern for contaminated wells across Brazos County. Compare and contrast the total distribution pattern versus the contaminated pattern.

The water-well location pattern for contaminated wells is relatively close close-knit, considering the small average distance. This is very similar to the overall distribution of the contaminated pattern, which is surprising with such a small subset. The contaminated pattern is almost an average of the overall well pattern, with distances only varying 1-2km less than the total pattern. The contaminated pattern also appears less directionally dependent than the whole well pattern, but this is likely due to the smaller number of points.

Does the contamination pattern reflect any potential sources of pollution (hint: examine the satellite imagery and examine the land use patterns)?

The contamination pattern reflects sources of pollution from agricultural areas. The satellite imagery of the area suggests that these water wells are in and around farms, where agricultural runoff from pesticides and fertilizers would be high. This runoff is likely what is contaminating the wells and causing high levels of chemical concentrations in the area. This land use activity is commonly associated with increased pollution, and is the most likely culprit for this distribution.

Other Shape Metrics

OBJECTID *	SHAPE *	Perimeter	Area	MaxLength	ORIG_FID	MBG_Width	MBG_Length	MBG_Orientation	Shape_Length
1	Polygon Z	15143.33	18112320	<Null>	1	5498.232591	5498.282409	165.662149	21993.030061
2	Polygon Z	12877.61	10364490	<Null>	2	3729.140466	3729.140466	0.962864	14916.561865
3	Polygon Z	49115.07	112985200	<Null>	3	14232.632255	21293.72184	88.528055	71052.708166
4	Polygon Z	21572.08	16419110	<Null>	5	2223.303578	10442.110306	48.964655	25330.827768
5	Polygon Z	42021.14	111645800	<Null>	6	13656.719262	17673.97159	40.985825	62661.381661

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	OID_	Perimeter	Area	MaxLength	ORIG_FID	MBG_Width	MBG_Length	MBG_Orientation	Shape_Length	Shape_Area	Shape Index (S1)	Shape Compactness (S2)	Shape Elongation Index (S3)	Shape Fractal Dimension Index (S4)
2	Circle	15143.335	18112316		1	5498.23259	5498.28241	165.6621487	21993.03006	30230835.7	0.000836079	7.525052607	0.873625138	1.151897633
3	Square	12877.6113	10364489		2	3729.14047	3729.14047	0.962863935	14916.56187	13906488.6	0.001242474	9.360952676	0.974384522	1.171636307
4	Triangle	49115.0742	1.13E+08		3	14232.6323	21293.7218	88.52805539	71052.70817	303065712	0.000434704	3.129738447	0.563409771	1.165081894
5	Elongated	21572.0781	16419113		5	2223.30358	10442.1103	48.96465485	25330.82777	23215981.2	0.001313839	1.891310258	0.43797744	1.201297836
6	Complex	42021.1445	1.12E+08		6	13656.7193	17673.9716	40.98582471	62661.38166	241368468	0.000376379	4.489145618	0.674764457	1.148995637

Is the shape index sensitive to variations in the *size* of a polygon, given each shape?

The shape index is sensitive to variations in the size of the polygon. As the size of the polygon increases, the shape index decreases. The sensitivity of the shape index to variations in polygon size occur because the shape index is a ratio of perimeter to area, so there will always be a change if area increases or decreases.

Is the shape compactness index sensitive to variations in the *size* of the polygon, given each shape? Based upon your analysis, how would you define the term *compactness*, and what does it really represent?

The shape compactness index is sensitive to the size of the polygon, given each shape. As the each shape gets smaller, the compactness index increases since compactness is the ratio of an area of a shape to a matching circle with the same perimeter. The compactness represents the degree of actual topological space is contained within an object.

Is the shape-elongation index sensitive to variations in the *size* of a polygon, given variations in the maximum and minimum lengths? Is it sensitive to directional variations?

The shape-elongation index is sensitive to the size of the polygon, but given the variation in maximum and minimum lengths, the shape elongation doesn't exactly correlate between the max and the index. The polygon with the longest length does not have the highest degree of elongation, but this could be because it's a circle which may affect the meaning of the index calculation. The elongation index is sensitive to directional variations, since the most directionally dependent polygon has the lowest elongation indices.

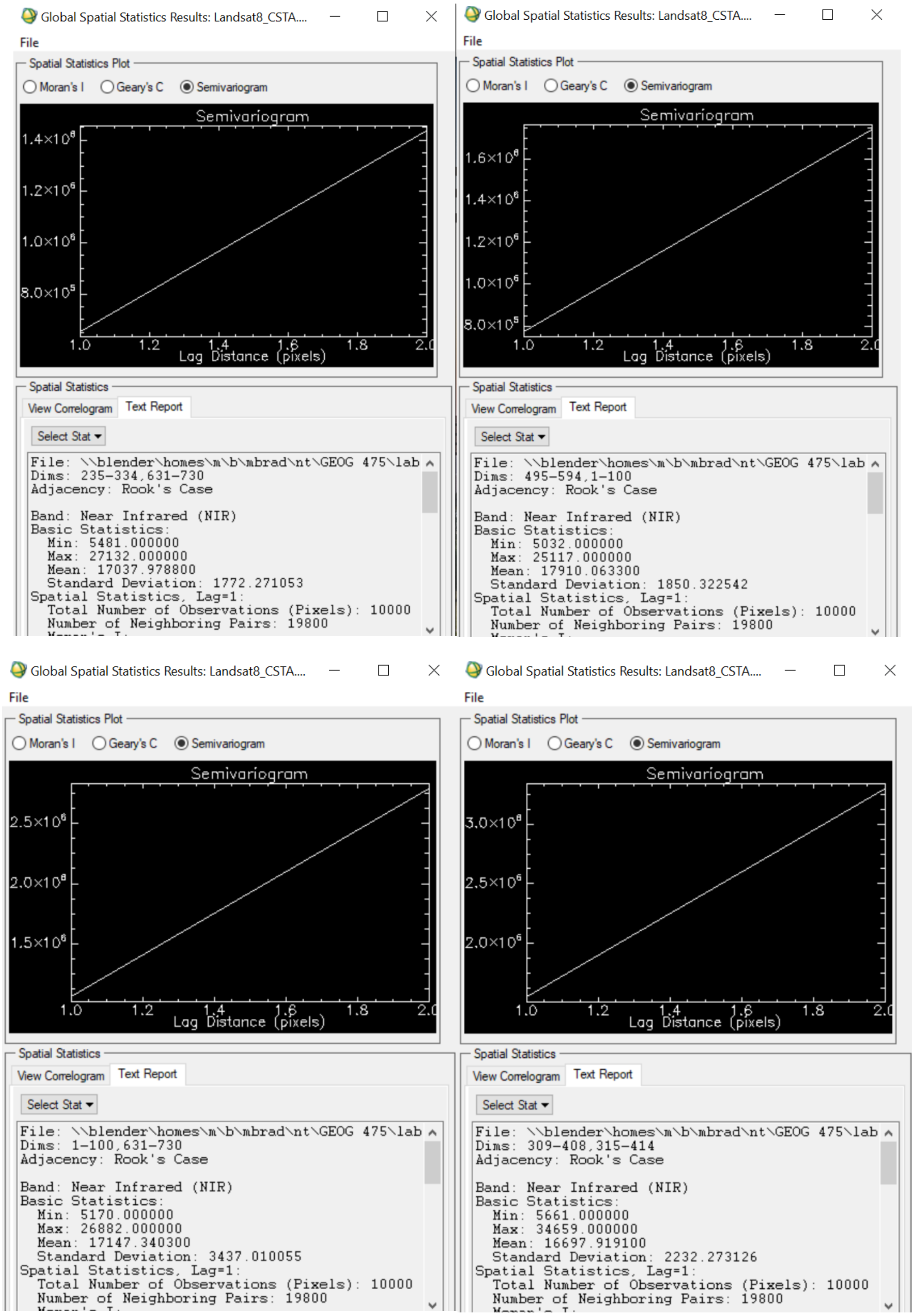
Is the shape fractal-dimension index sensitive to variations in the *size* of a polygon, given each shape? What does the index really characterize? Demonstrate this by generating additional polygons that characterize the concept. Compare and contrast.

The fractal-dimension index is not significantly sensitive to the size of the polygon, considering the lack of variation within that metric between the shapes. The shapes were of widely varying sizes, but the fractal-dimension index only changed slightly between them. This metric is mean to characterize the complexity of the shape, not necessarily the size. This surprised me because the complex polygon I created, according to the metric, has the lowest complexity of the shapes. Other polygons created exhibited the same phenomena, so the metric seems lacking in how useful its characterization of shapes can be.

Based upon your analysis, do you think that any one of these metrics can be used to diagnostically differentiate between geometric and complex shapes?

Even with these metrics, it would be extremely difficult to diagnostically differentiate between geometric and complex shapes. Each metric is affected by multiple variables, so even if a complex analysis is done there can be no way for sure to know whether the shape is complex or just a very large geometric shape. Changing the parameters of a complex shape could yield the same results as a larger or smaller geometric shape with similar parameters.

Spatial Autocorrelation Metrics



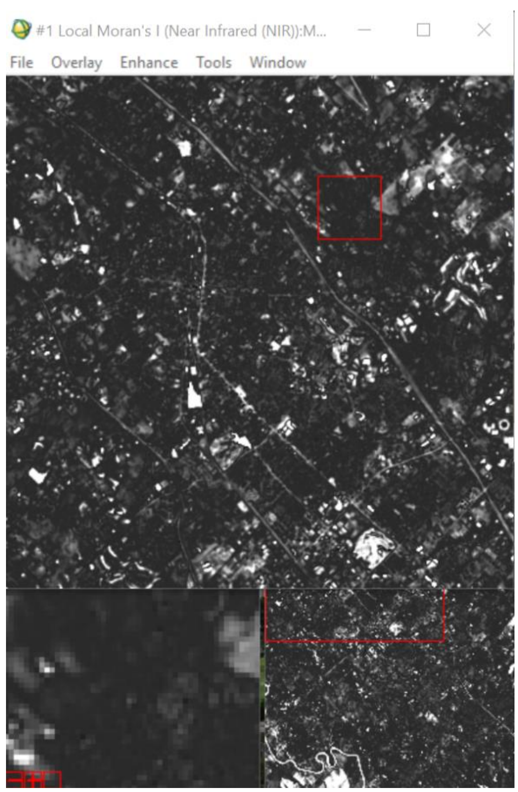
From left to right (top to bottom): least complex to most complex Global Spatial Statistics in 100x100 squares

Did your first two samples (semivariograms) accurately depict relatively high versus relatively low spatial variation in spectral variation? How do you know this? Provide evidence based upon your interpretation of the semivariograms? Was there any significant scale-dependent variation that is related to structural or environmental conditions, or was the variation relatively constant with scale (lag distance)?

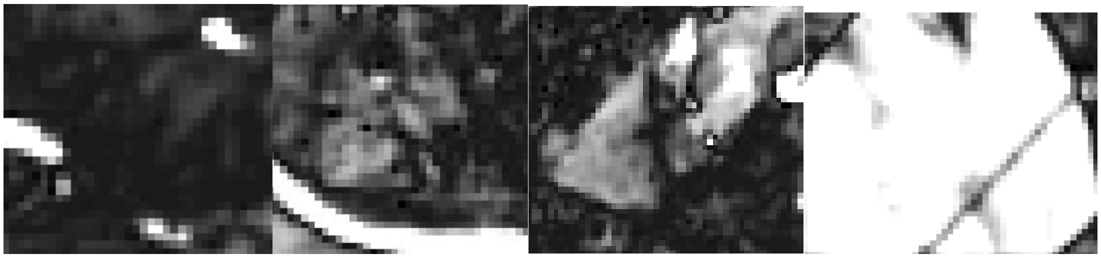
My first two samples (100 x 100) accurately depicted high versus low spatial variation in spectral variation. This is seen in the differences in autocorrelation on the y-axis, and a variation in the lag distance between the two samples. The more complex sample had a wider range of values on the y-axis, showing a significantly higher degree of complexity over the same lag distance. Since variation is scale dependent, the scale was kept consistent between the two samples to ensure a viable comparison, since difference scales cannot be compared as equals. This way structural and environmental conditions were weighted the same for both samples.

Could you find geographic areas with greater or less spatial variability? How did these compare to your initial sample sets?

Geographic areas with greater and less spatial variability were located in my analysis. In comparison, these areas (of the same scale) were comparatively more and less complex than the original samples. The imagery has a wide variety of varying topographical complexity, so there are likely more areas that are even more or less complex than what I located over the same lag distance.



Local Statistics: Moran I of NIR Imagery

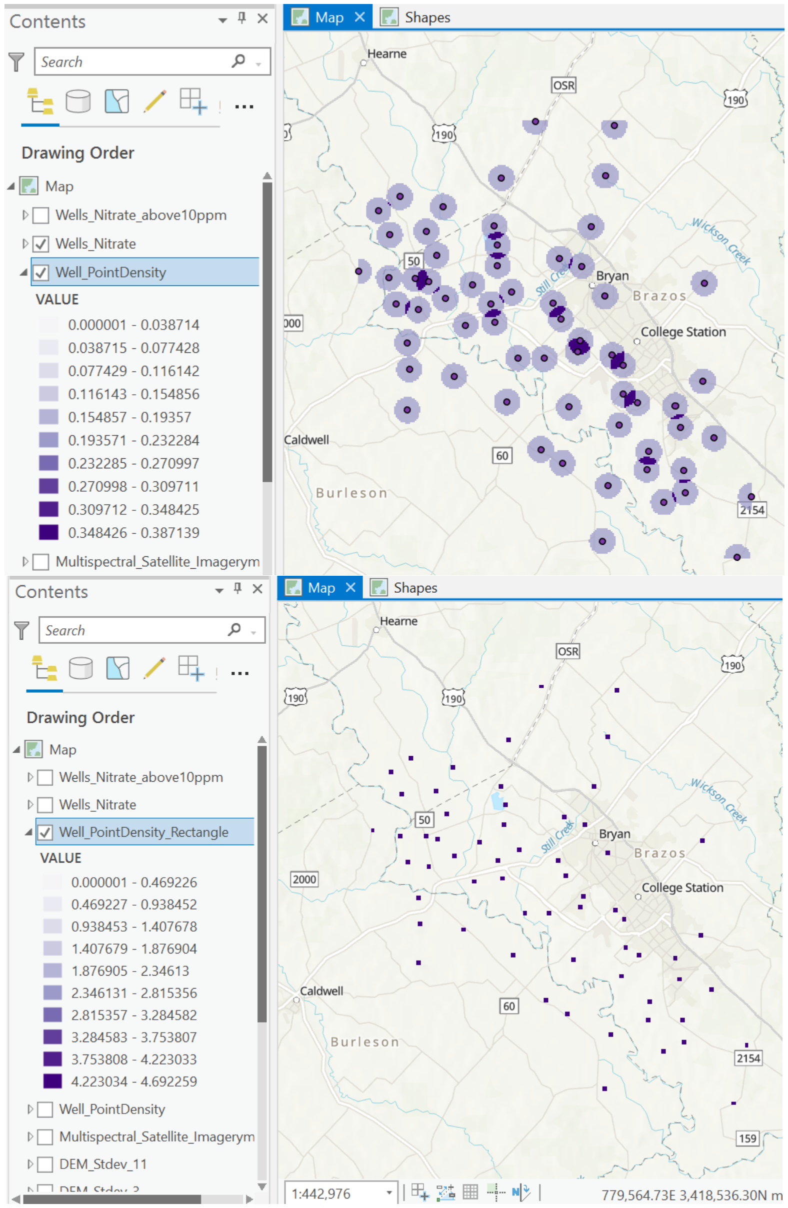


From left to right: Increasing spatial complexity for Local Moran 1 Statistic Comparison

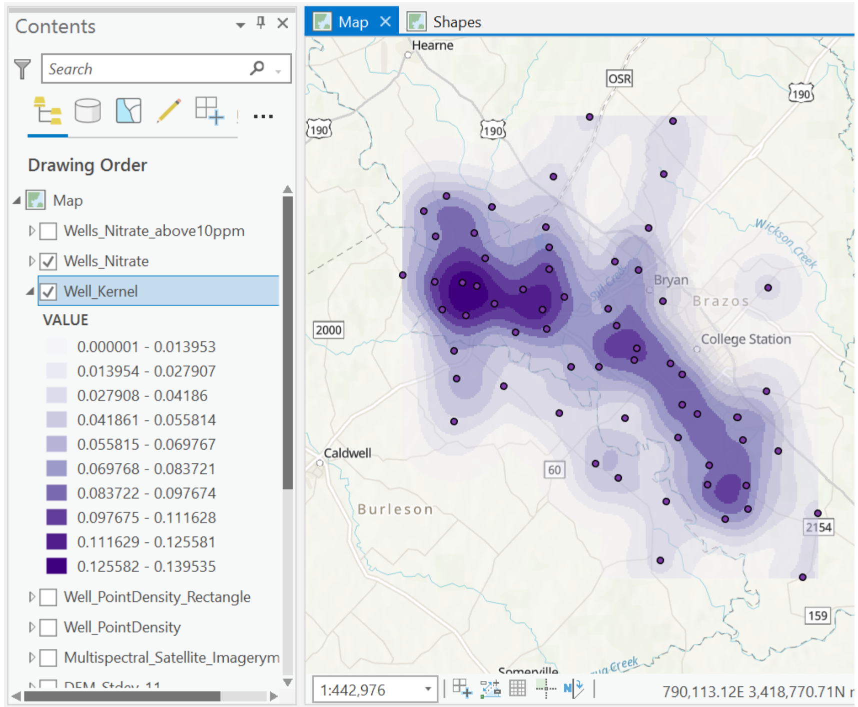
Where you able to obtain a systematic increase in the degree of spatial complexity for your 4 samples (reflectance). Did your Moran's I statistic for each sample validate this? Finally, what environmental conditions cause the higher degree of spatial complexity?

The samples obtained represent a systematic increase in the degree of spatial complexity within the NIR Moran I imagery analysis. From left to right, the reflectance value for the Moran I statistic increased, validating an increasing degree of spatial complexity in the image for each respective sample space. The higher degree of spatial complexity was influenced by environmental conditions such as increased topographical variation, or even increased complexity in the anthropogenic urban space. With greater variation within spatial entities, the reflectance value increased.

Point-Pattern Analysis



Top: Point Density of Wells with Default Parameters; Bottom: Point Density of Wells with Rectangle search with 3 x 3 parameters



Wells Kernel Density with Default Parameters

Compare and contrast the point patterns derived from the point density tool and from different neighborhood shapes. Does the shape of the neighborhood influence the spatial distribution of contamination?

The circle neighborhood shape decreased the point density, exhibited by the large buffer around the points compared to the rectangle neighborhood calculation that was subsequently performed. The circle shape did a better job of characterizing the point density in a clear way, since the rectangles are very difficult to distinguish from the actual well locations. Consequently, the shape of the neighborhood significantly influences the spatial distribution of contamination. With the large circle, the contamination is more clear and widespread than with the rectangle, which badly characterizes (under characterizes) the extent of the contamination.

Compare and contrast the point patterns derived from the kernel density tool and from different kernels and varying search radius. Does the mathematical characteristics of a kernel influence the spatial pattern that is obtained (be sure to keep the radius constant when you compare results)? Does the extent of the kernel influence the point-pattern distribution? How would you determine which kernel and distance to use to accurately depict potential hotspots of groundwater contamination?

The mathematical characteristics of the kernel significantly influences the spatial pattern that is obtained. Depending on the parameters applied, more or less points were weighted in the distribution which changed the overall pattern each time. This was because of outlier influence being increased or decreased within the same radius. The extent of the kernel influences the point-pattern distribution this way by weighing some points as more influential than others. The determination of the kernel and distance to accurately depict potential hotspots of groundwater contamination is heavily affected by the purpose of the analysis, depending on each analyst's own interpretation of the severity of the contamination. Because of this, there is no textbook way to determine the exact parameters that would best characterize the results in every scenario.

Compare and contrast the results from the point density and the kernel density tools? Do they present similar or different point-pattern results?

The point-patterns created by each tool present very different results. The kernel density function performed the most visually useful analysis because the actual distribution is better characterized with the distance-weighted analysis. The point density tool was not nearly as effective as the kernel density in clearly illustrating the spatial variation of the wells, and arguably did a very bad job of providing useful information extraction any better than a buffer tool would. Kernel density was more effective at providing data that could be extracted as useful information.

Finally, interpret your point-pattern analysis results. What do the results suggest about the sources of ground water contamination in Brazos County? Can these patterns be attributed to natural processes or anthropogenic factors? Be specific in terms of what you hypothesize is the cause of the ground water contamination. Be sure to utilize additional spatial data to help verify your interpretation (e.g., satellite imagery or DEM).

The point-pattern analysis results suggest that the sources of ground water contamination in Brazos county is due to anthropogenic factors. The agricultural land use practiced in this area has created a concentration of fertilizers and pesticides that have greatly affected the water well contamination levels. This is not a phenomenon that would occur without the land use farming pattern present in the satellite imagery. Agricultural runoff is the key factor in this ongoing contamination of water wells.