



UNIVERSITY OF
HOHENHEIM

200 YEARS
1818
2018

Public Participation GIS for Ecosystem Services

PPGIS spatial analysis

Outline September 28



Introduction to spatial analysis

- Kernel density
- Incremental Spatial Autocorrelation
- Bundles of ecosystem services

Evaluation survey

INTRODUCTION TO SPATIAL ANALYSIS

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Analysis methods for PGIS data



Analysing spatial patterns of mapped attributes

- **Intensity/density:** e.g. point & Kernel density surface
- **Clustering:** e.g. incremental spatial autocorrelation
- **Distance/proximity:** e.g. from mapped attribute location and homes
- **Diversity:** e.g. Shannon diversity index
- **Richness**

Nora Fagerholm, 2014

Analysis methods for PGIS data



Analysing spatial relationships

- **Correlation:** e.g. between mapped attributes
- **Overlay:** e.g. of mapping attributes and land cover

Nora Fagerholm, 2014

PRACTICE. Analysing spatial patterns

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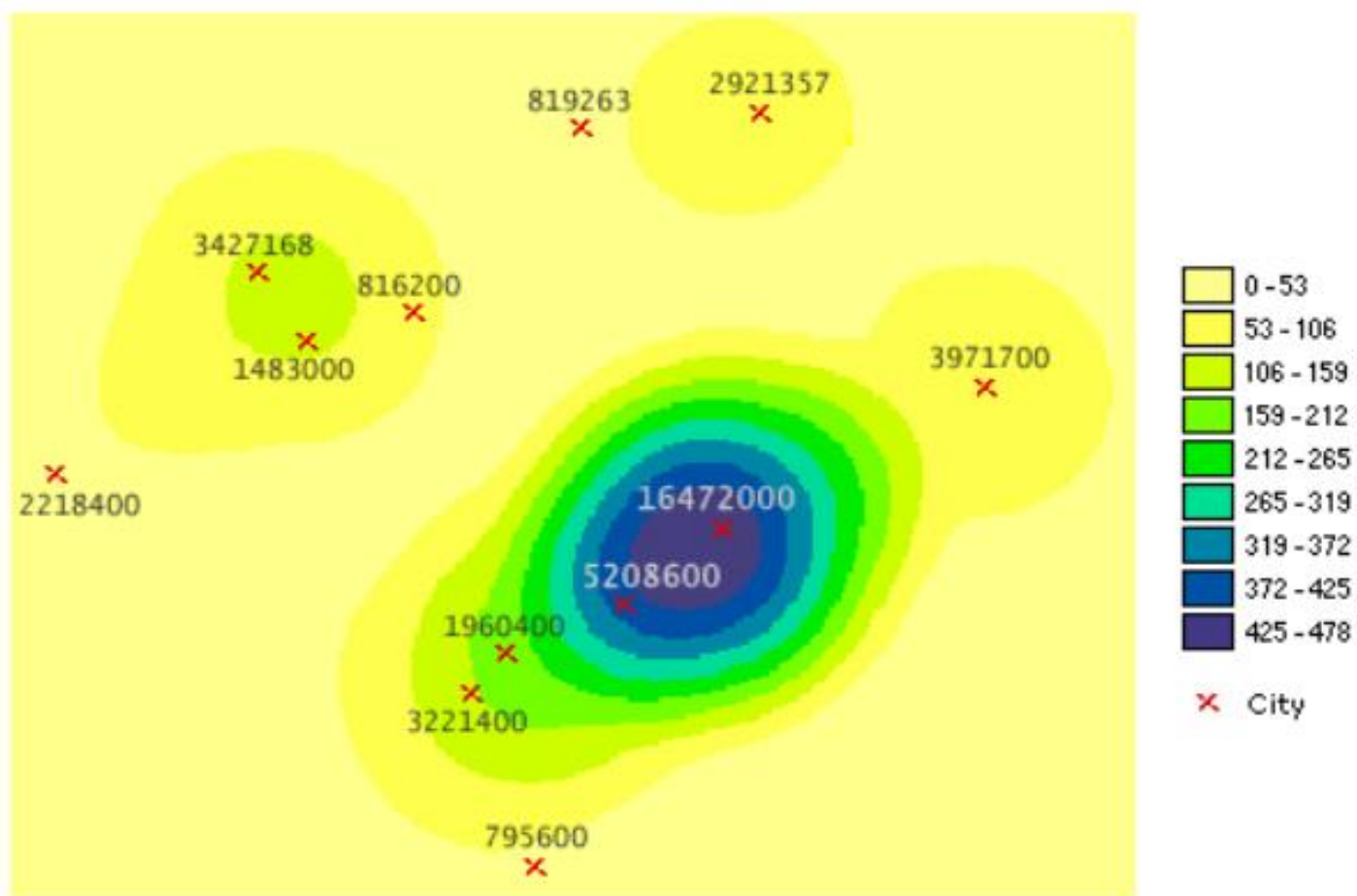


Density analysis



PRACTICE. Analysing spatial patterns

Density analysis



Population density surface example

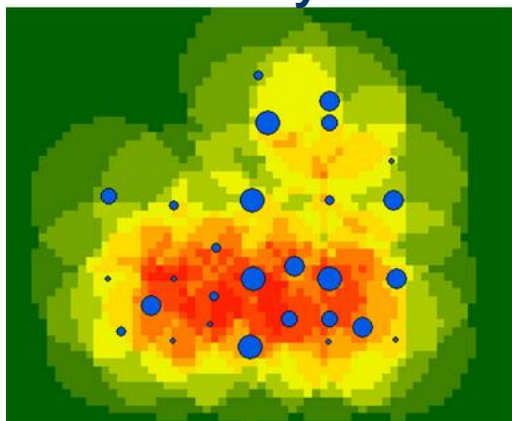
ArcGIS help



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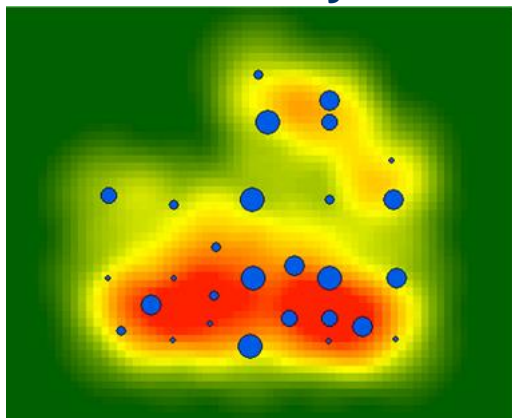
Density analysis

Point density



Points that fall within the search area are summed, then divided by the search area size to get each cell's density value.

Kernel density



The surface value is highest at the location of the point and diminishes with increasing distance from the point.

<https://community.esri.com/thread/122240>

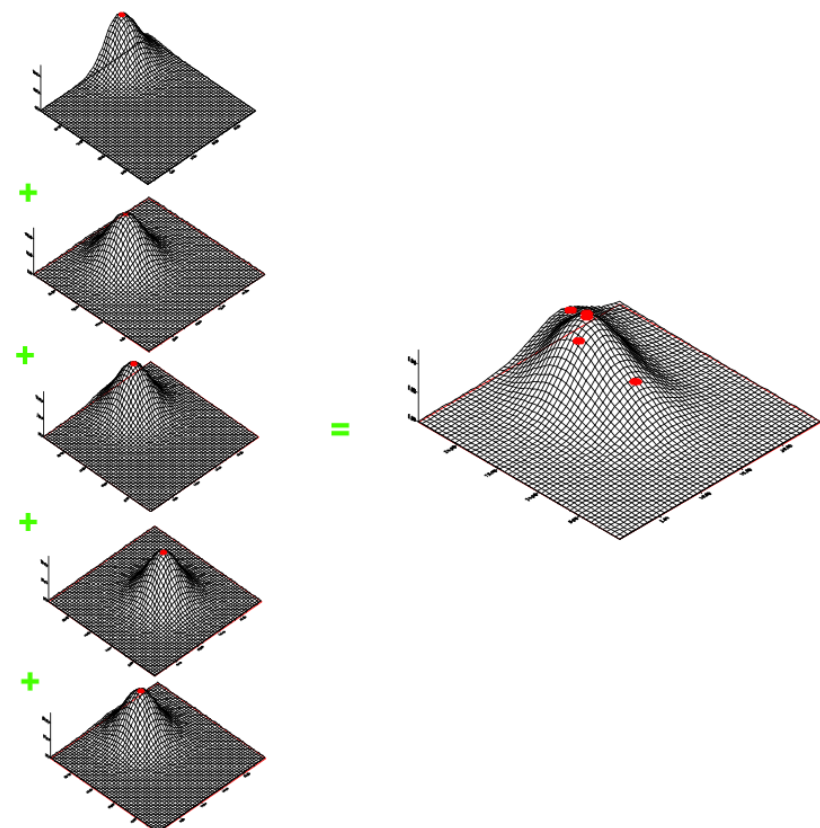


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Density analysis

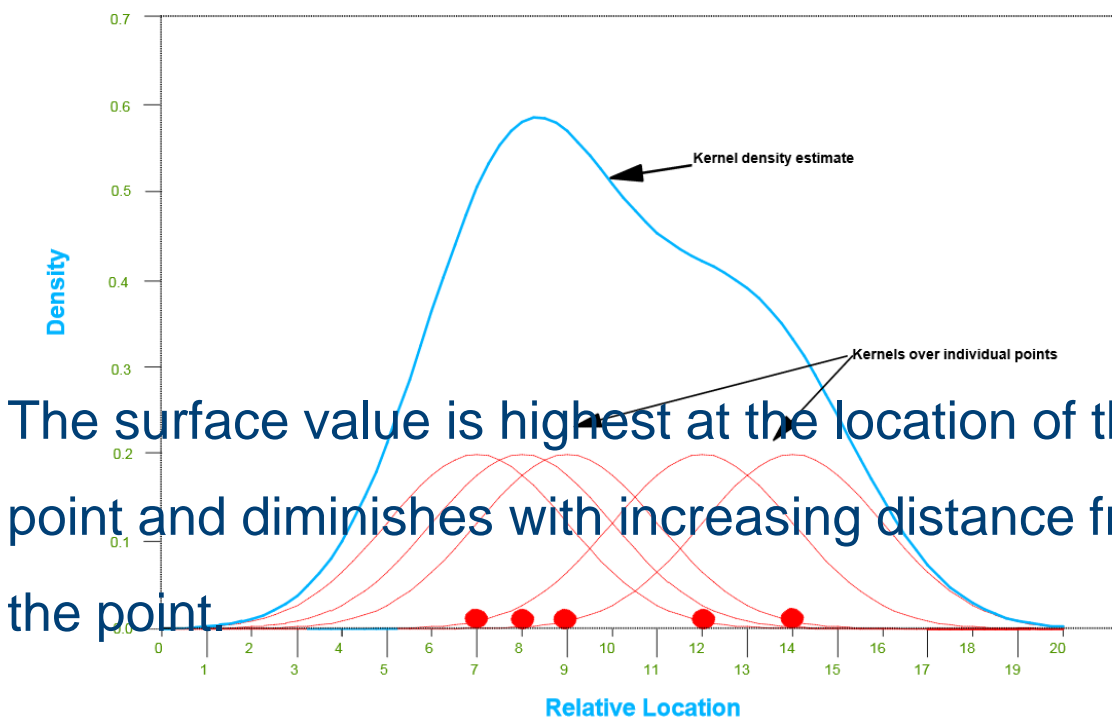
Kernel Density Surfaces

Summing of Normal Kernel Surfaces for 5 Points



Kernel Density Estimate

Summing of Normal Kernel Functions for 5 Points



The surface value is highest at the location of the point and diminishes with increasing distance from the point.

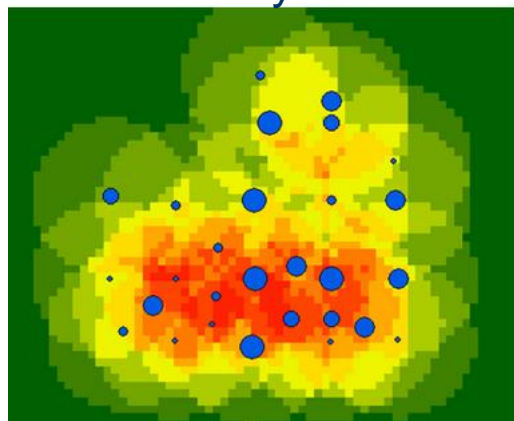
<https://www.icpsr.umich.edu/CrimeStat/files/CrimeStatChapter.8.pdf>



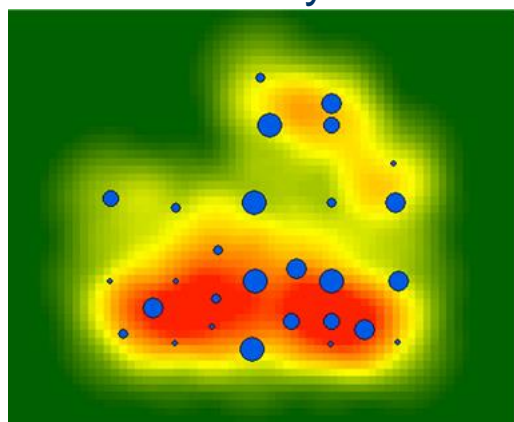
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Density analysis

Point density



Kernel density



The kernel density has a much larger smoothing effect than the point density point.

<https://community.esri.com/thread/122240>

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Density analysis

Population field

Geoprocessing

Kernel Density

Parameters | Environments

* Input point or polyline features

Population field

* Output raster

Output cell size

Search radius

Area units

Output cell values

Method

Square map units

Densities

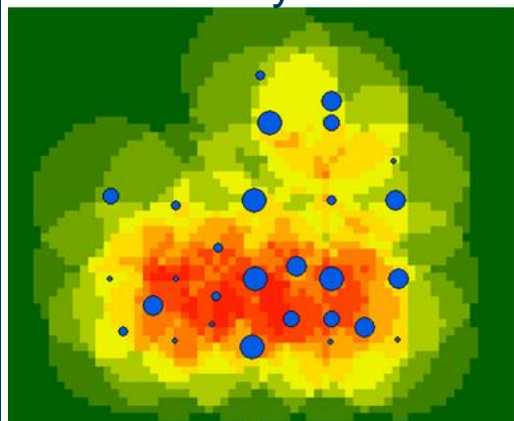
Planar



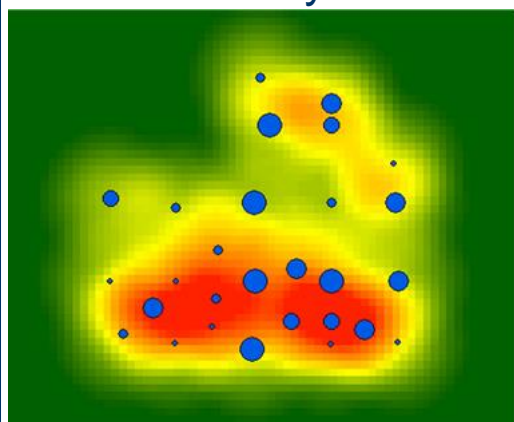
PRACTICE. Analysing spatial patterns

Density analysis

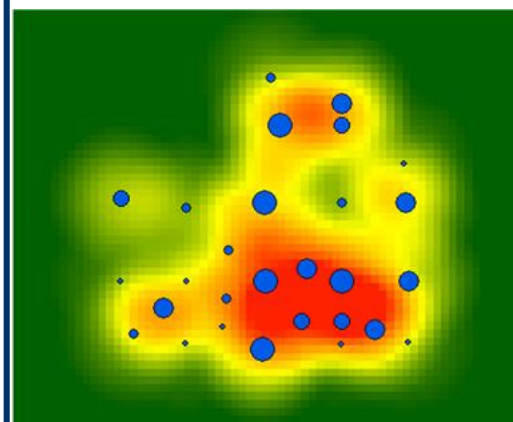
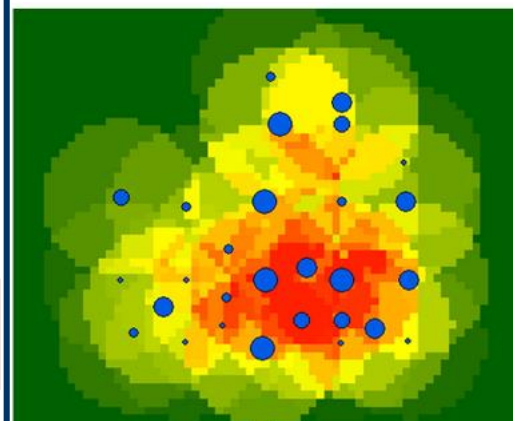
Point density



Kernel density



No population



With population

<https://community.esri.com/thread/122240>

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Density analysis

Cell size

Search radius

Geoprocessing

Kernel Density

Parameters | Environments

* Input point or polyline features

Population field

* Output raster

Output cell size

Search radius

Area units

Square map units

Output cell values

Densities

Method

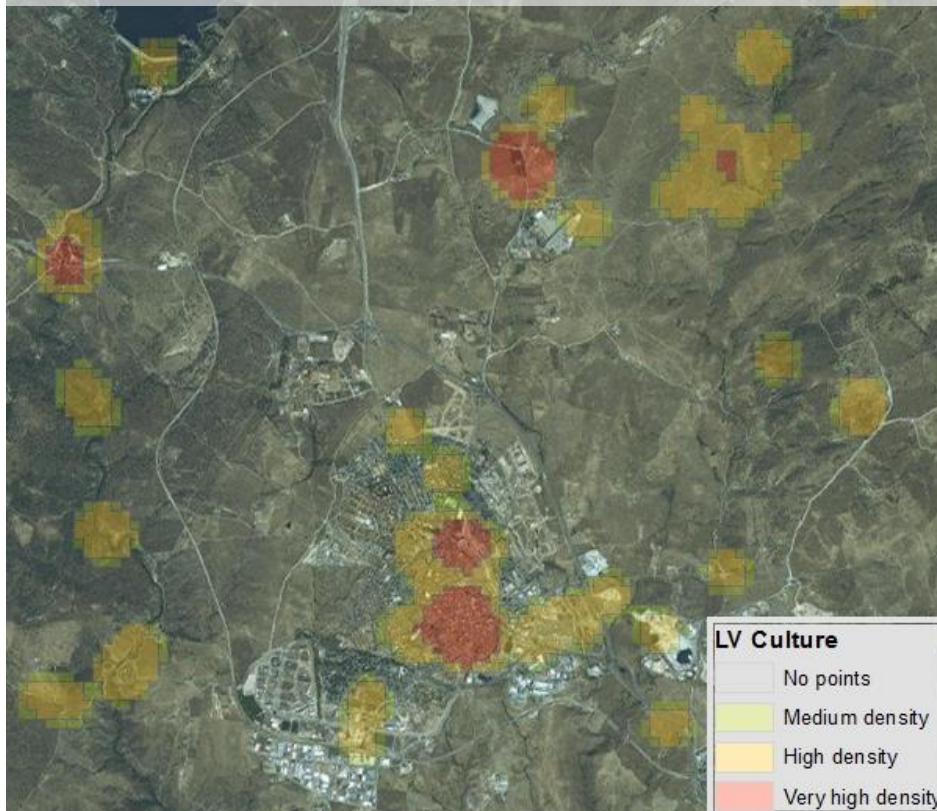
Planar

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Density analysis

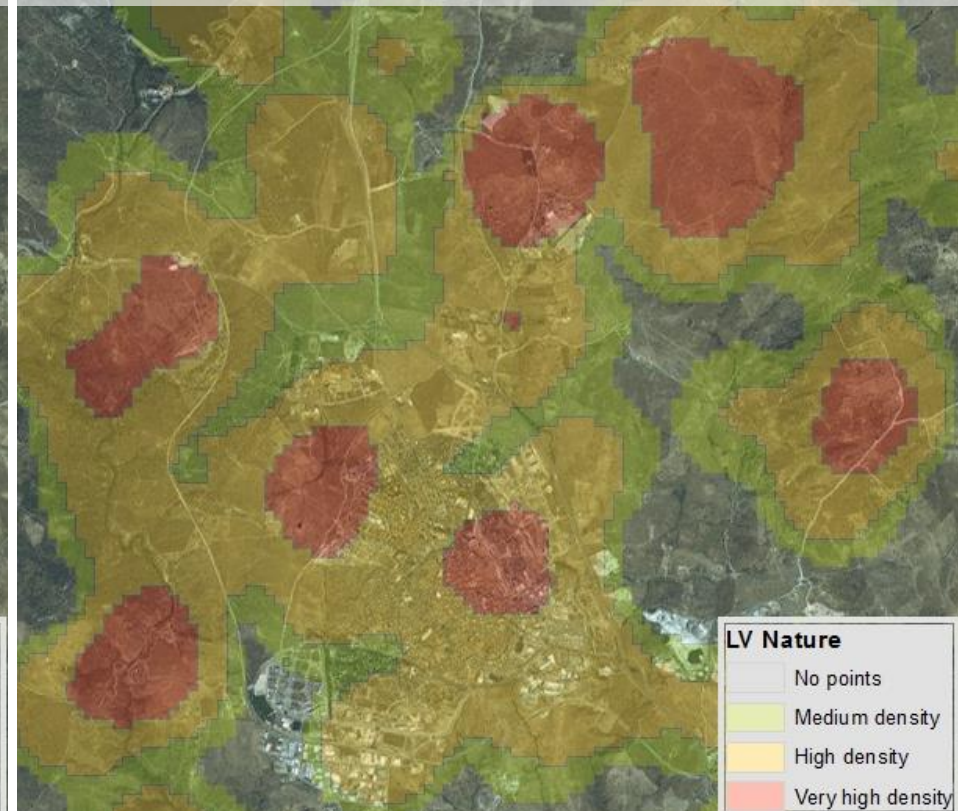
Points mapping cultural heritage **elements**



Radius: 400m

Cell size: 200 m

Points mapping nature protected **areas**



Radius: 800m

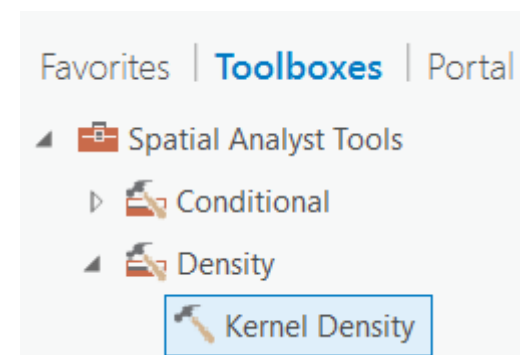
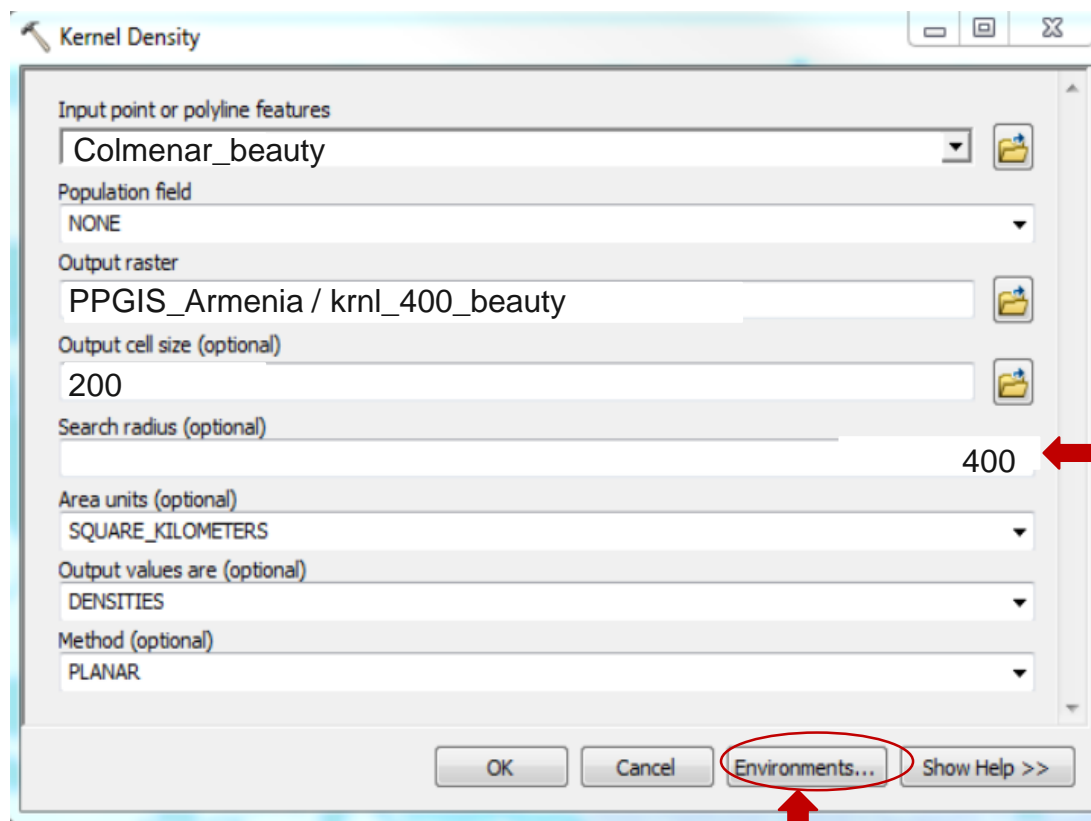
Cell size: 200 m



PRACTICE. Analysing spatial patterns

Exercise. Density analysis

- Open Kernel Density tool
- Drag in the points shapefiles for one of the attributes: e.g. [home_parking](#)



200? 1000?

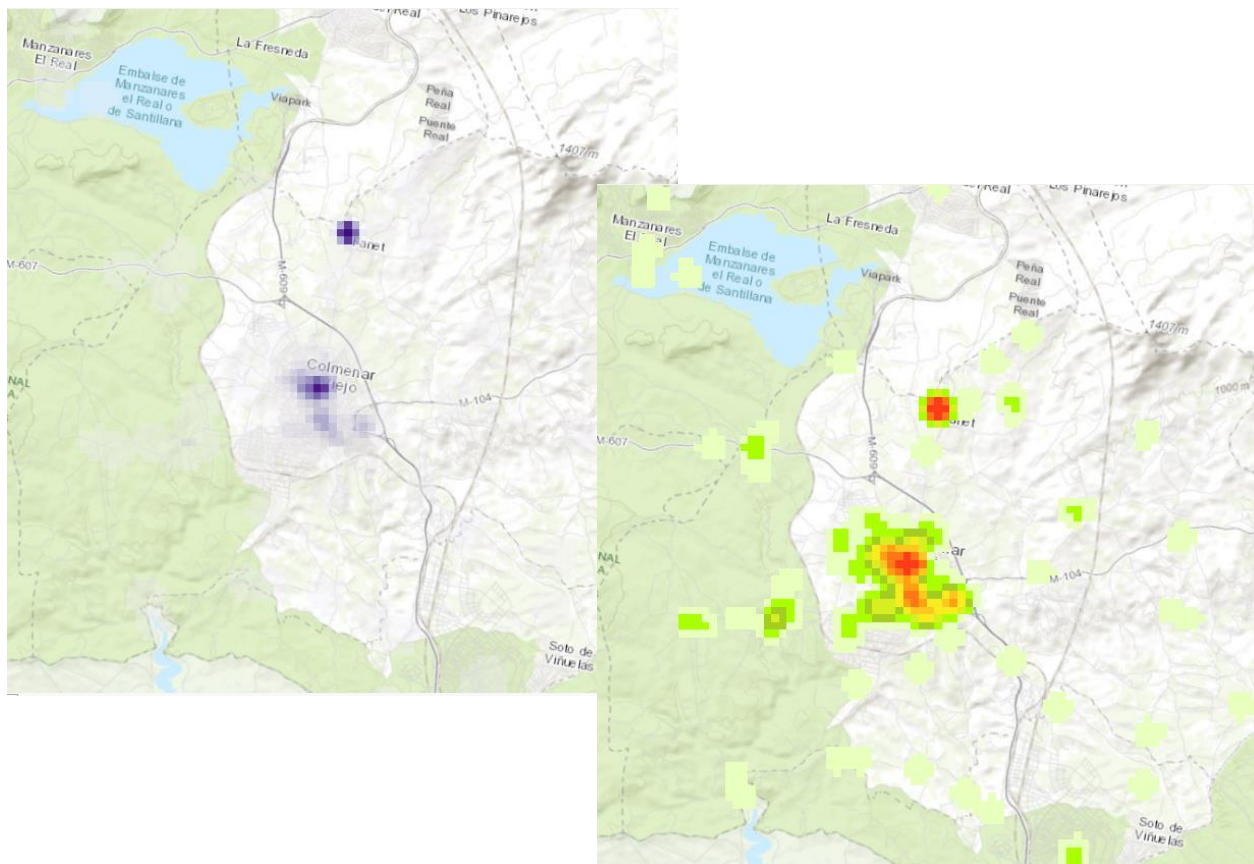
- Set the processing Extent in the Environments: [analysis_extent](#)



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Exercise. Density analysis

- **Visualise** the data in a more descriptive way:
Play with the different parameters in the **Symbology**



Symbology - Krnl_nature_1000

Krnl_nature_1000

Primary symbology
Classify

Field: No fields

Normalization: No fields

Method: Natural Breaks (Jenks)

Classes: 6

Color scheme: [Color gradient bar]

Nodata: [Checkered box]

Class breaks Options

Color	Upper value	Label
[White]	≤ 0,369391108494179	≤0,369391
[Light Green]	≤ 1,31925395890778	≤1,319254
[Yellow-Green]	≤ 2,7968183928845	≤2,796818
[Yellow]	≤ 5,01316504384957	≤5,013165
[Orange]	≤ 8,75984628714766	≤8,759846
[Red]	< 13,4563903808594	<13,45639



PRACTICE. Analysing spatial patterns

Exercise. Density analysis

- Add a basemap of Yerevan and observe which are the areas with a higher and lower density of points

The image displays three sequential screenshots of the ArcGIS interface:

- Left Screenshot:** The 'Add Data' dialog box is open, showing the file explorer view. The 'Look in' field is set to 'Home - Documents\ArcGIS'. The 'GIS Servers' folder is selected in the tree view. The 'Name' field contains 'GIS Servers' and the 'Show of type' is set to 'Datasets, Layers and Results'. The 'Add' button is highlighted.
- Middle Screenshot:** The 'Add Data' dialog box is open, showing the 'GIS Servers' folder. The 'Add WMS Server' option is selected in the list of server types. The 'Name' field contains 'Add WMS Server' and the 'Show of type' is set to 'Datasets, Layers and Results'.
- Right Screenshot:** The 'Add WMS Server' dialog box is open. The 'URL' field is set to 'http://'. The 'Examples' field shows two sample URLs. The 'Version' is set to 'Default version'. The 'Server Layers' section is empty, with a 'Get Layers' button. The 'Account (Optional)' section has 'User' and 'Password' fields, with the 'Save Password' checkbox checked. The 'OK' and 'Cancel' buttons are at the bottom.



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Exercise. Density analysis

- What differences do you perceive when trying with different radius sizes?
- What is the data telling you?
- Compare and discuss with the other members of your group

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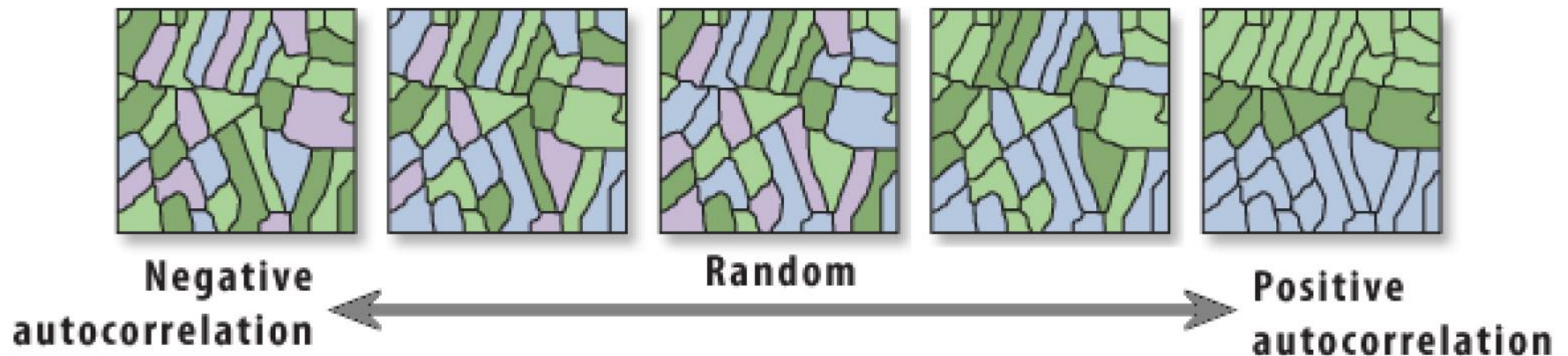
Spatial autocorrelation



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Spatial autocorrelation

Spatial phenomena tend to possess order and structure in space



Spatial autocorrelation is actually the same phenomenon as spatial clustering

- Positive spatial autocorrelation >> observations are spatially clustered
- Negative spatial autocorrelation >> dispersed spatial pattern



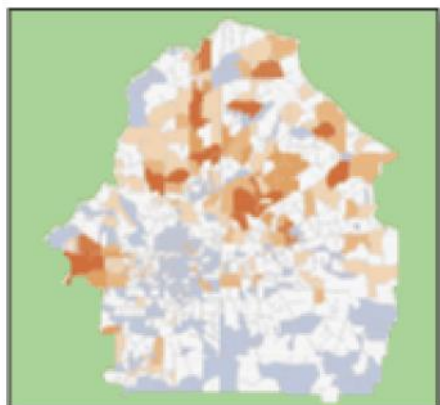
PRACTICE. Analysing spatial patterns

Spatial autocorrelation. Spatial cluster analysis

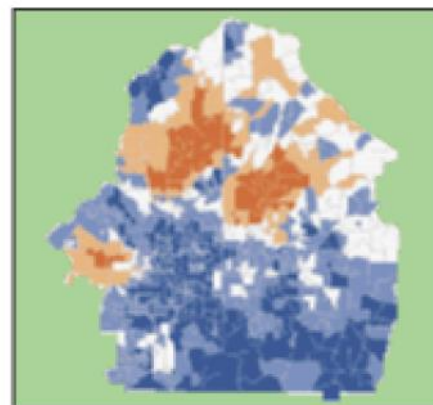
Detects unusual concentrations or non-randomness of events in space

Two types of spatial cluster analysis:

- Global clustering throughout the study region (statistical parameter)
- Local clustering in specific locations (map)



INPUT



Gi* Z SCORES



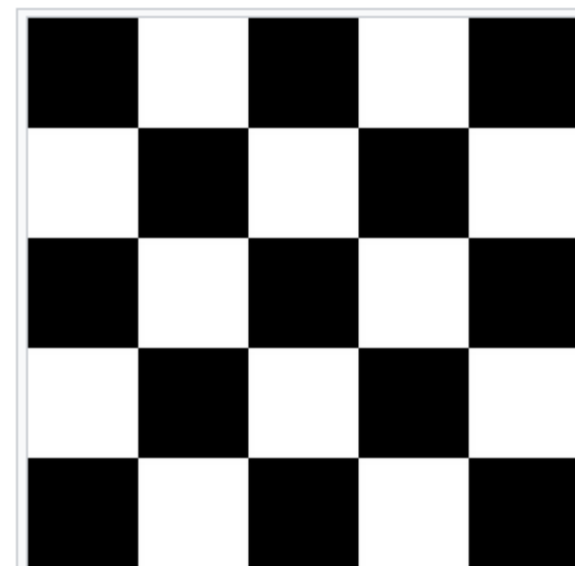
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Spatial autocorrelation. Global spatial cluster

Statistical parameter indicating level of clustering in the whole area

Moran's I estimates the overall degree of spatial autocorrelation of a dataset

- Index value -1 (dispersed) / +1 (clustered)
- Z score evaluates significance of index value $< -1,96$ / $> 1,96$
- P value indicates probability of rejecting complete spatial randomness (CSR)
- Distance band: neighbouring feature outside critical influence on the computation

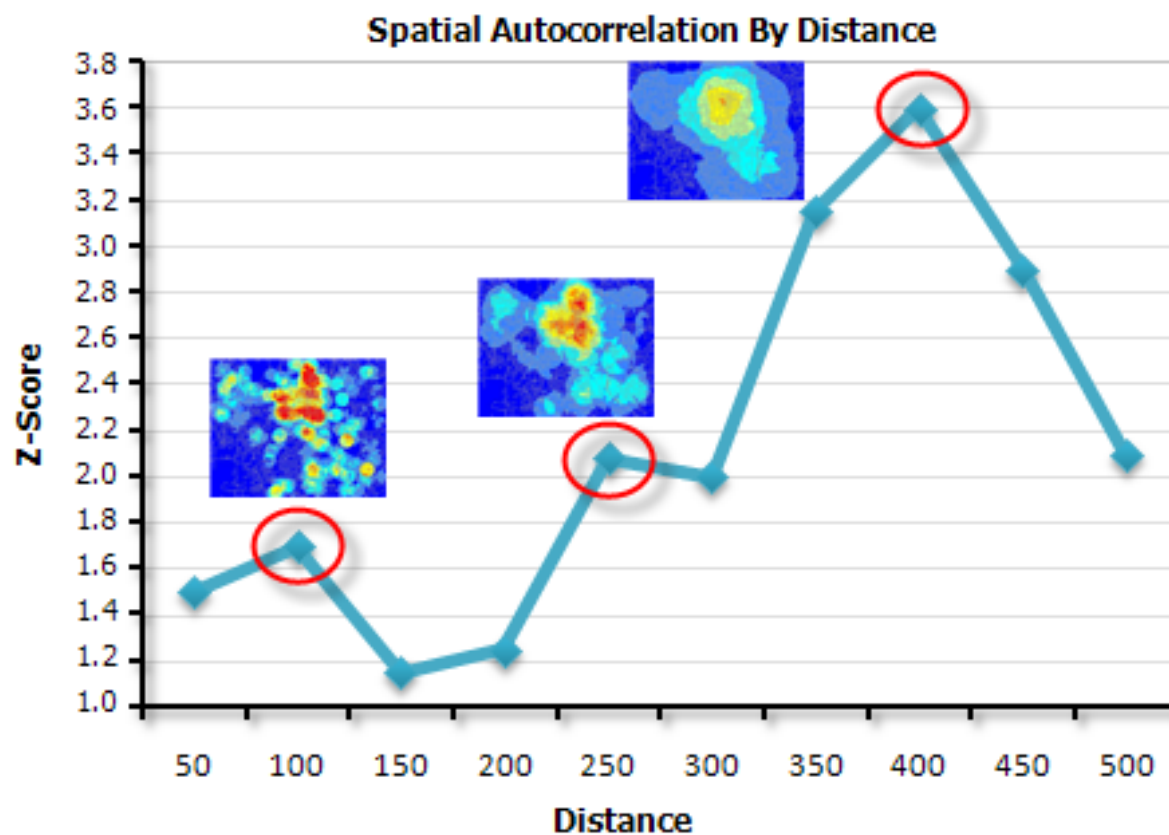




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Spatial autocorrelation. Incremental spatial autocorrelation (ISA)

- Moran's I for a series of increasing distances



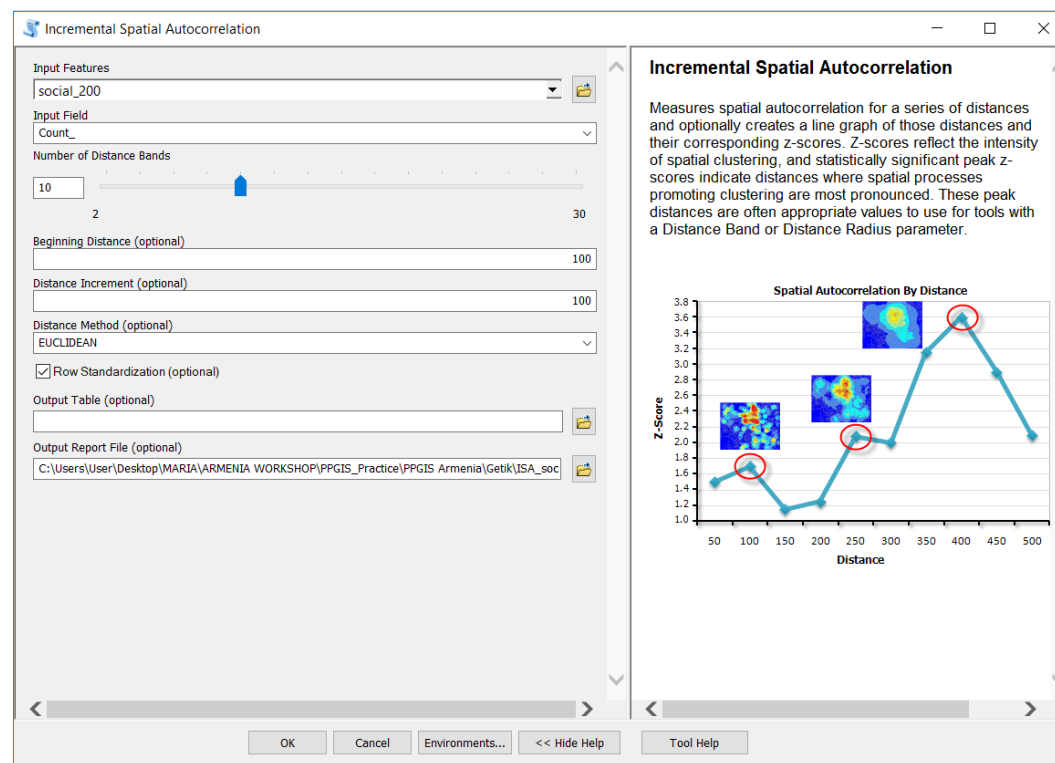
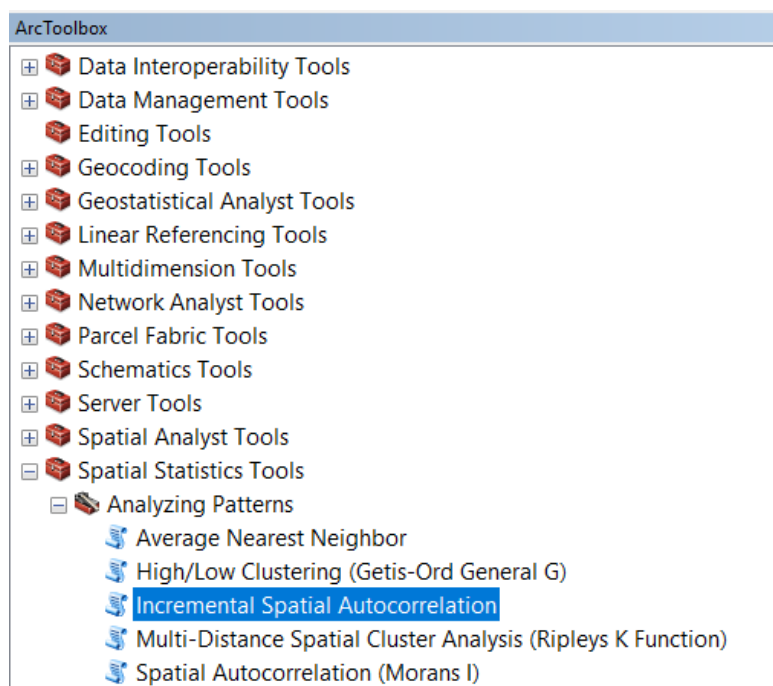
GIS help



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Exercise. Incremental Spatial Autocorrelation (ISA)

- Open the ISA tool in the toolbox
- Introduce the following parameters





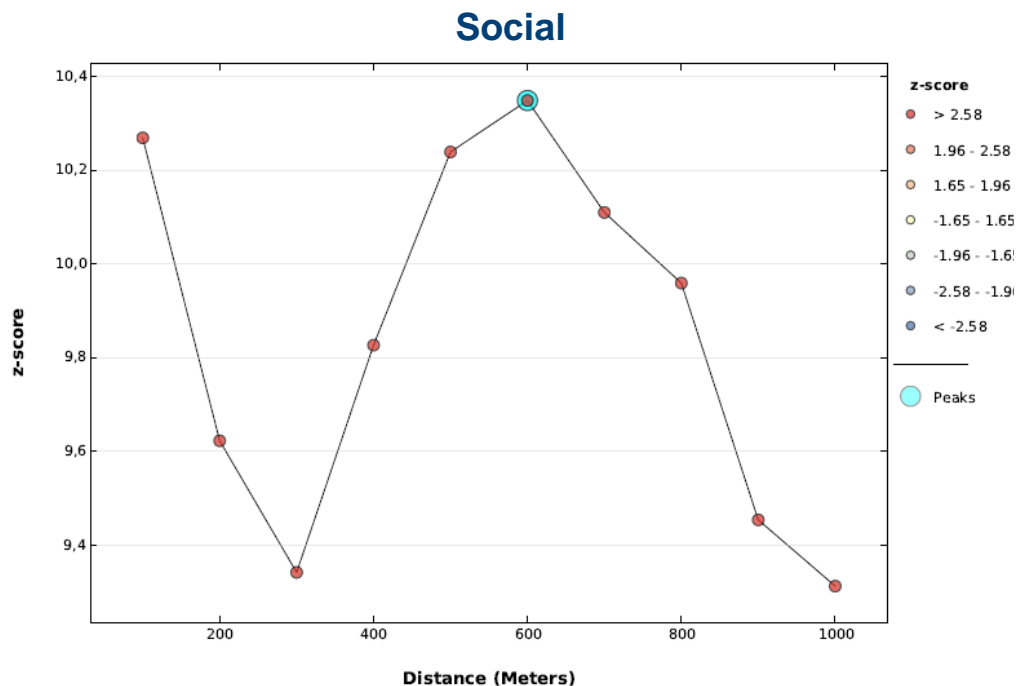
PRACTICE. Analysing spatial patterns

Exercise. Incremental Spatial Autocorrelation (ISA)

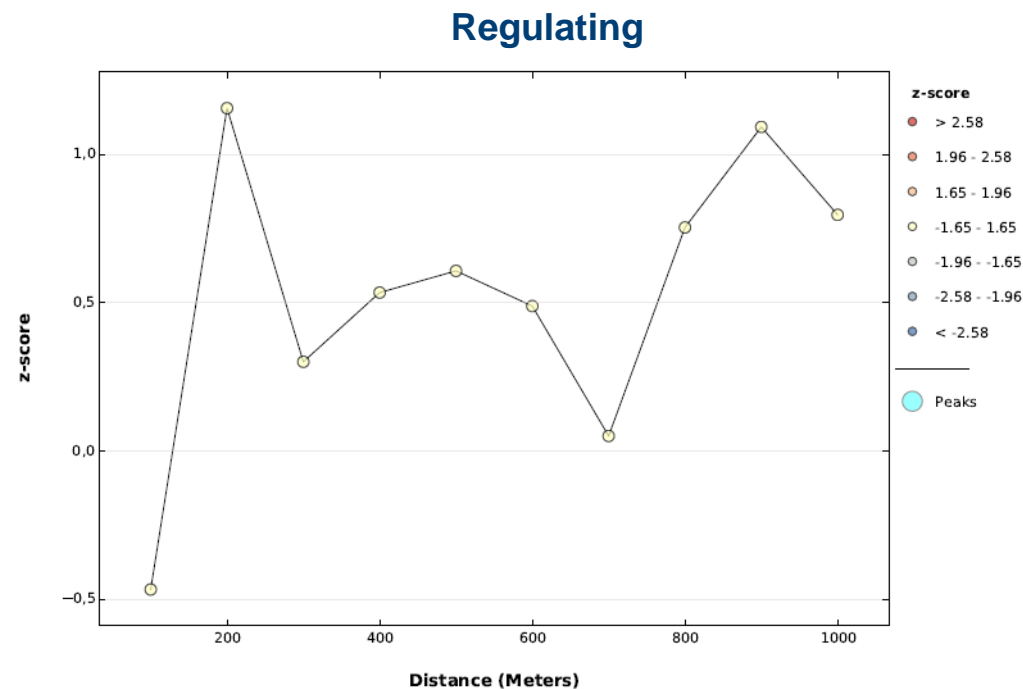
Interpret the results:

- Is there spatial autocorrelation ?
- At which distance are the spatial processes promoting clustering most pronounced?

Spatial Autocorrelation by Distance



Spatial Autocorrelation by Distance





Spatial bundles

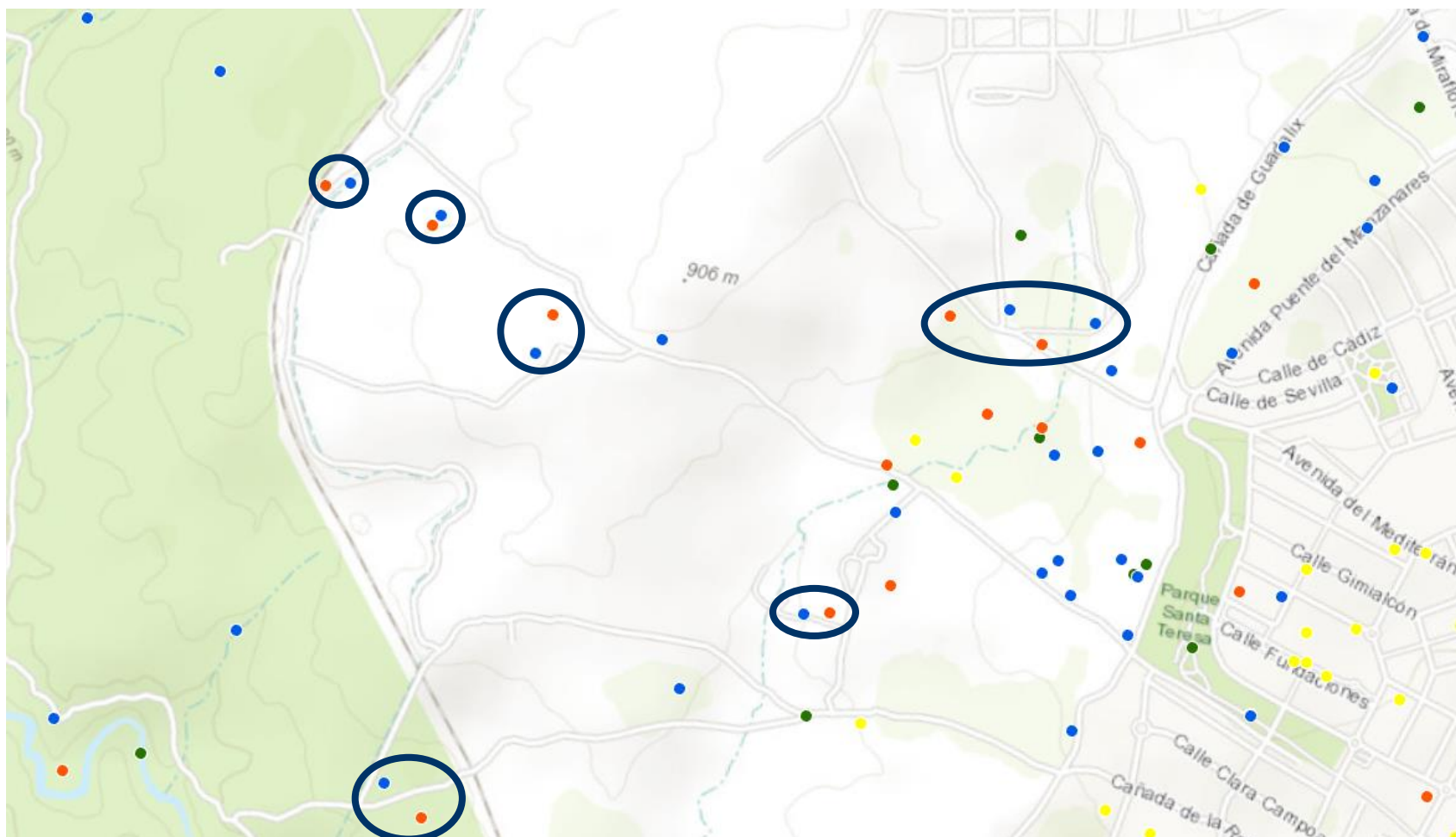


PRACTICE. Analysing spatial relationships

Spatial bundles

Spatial coexistence of different landscape services

- Inspiration
- Beauty
- Nature
- Society

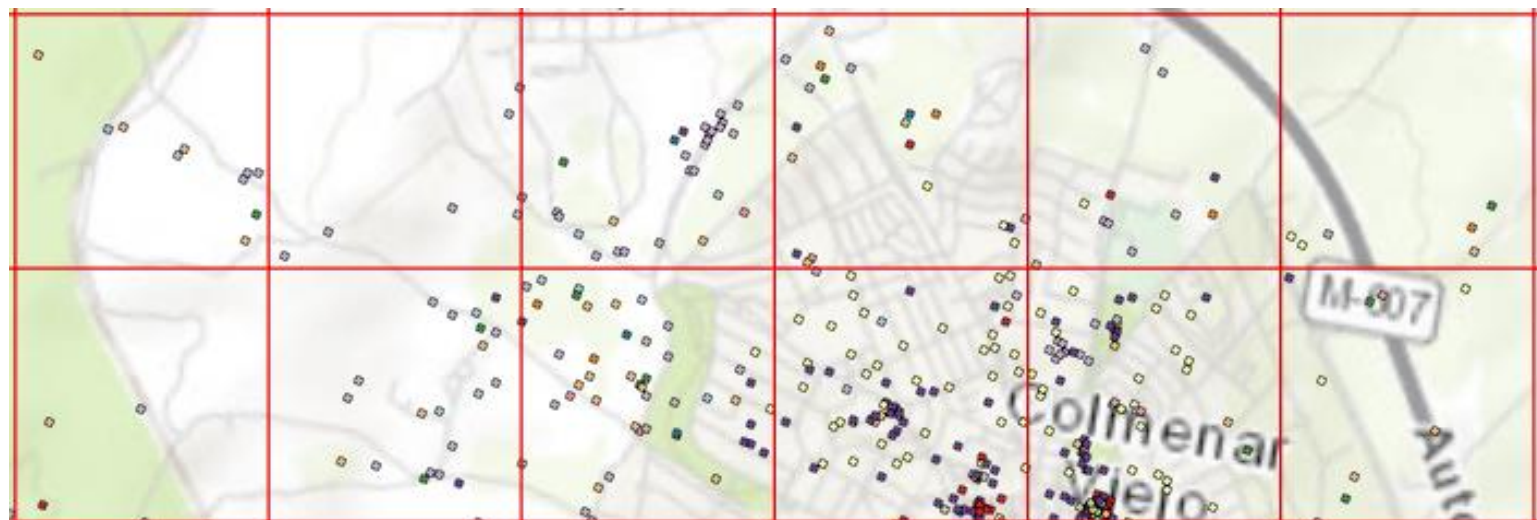




PRACTICE. Analysing spatial relationships

Spatial bundles

1. Aggregate point data into polygon grid data
 - Create fishnet grid
 - Cells with combinations of different types of points
2. Identify recurrent combinations
 - Bivariate correlation



PRACTICE. Analysing spatial relationships



Spatial bundles

Fishnet cell sizes!





PRACTICE. Analysing spatial relationships

Spatial bundles

- Bivariate correlation

ID CELL	Feelings	Regulating	Culture	Nature	Existence	Products	Beauty	Harvest	Walking	Society
445	0	0	0	1	0	0	2	0	1	0
446	0	0	0	0	0	0	1	0	0	0
449	0	0	0	0	0	0	0	0	1	0
452	0	0	0	0	0	0	1	0	1	0
455	0	0	1	0	0	0	0	0	1	3
487	0	1	1	4	0	0	3	0	2	0
488	0	0	0	0	0	0	3	0	4	0
489	0	0	0	0	0	0	0	0	1	0
491	1	0	0	1	0	0	2	0	0	0
492	0	0	0	0	0	0	0	0	1	0

PRACTICE. Analysing spatial relationships



Spatial bundles

- Bivariate correlation

Correlation coefficient (Spearman-Rho)

	Feelings	Regulating	Culture	Nature	Existence	Products	Beauty	Harvest	Walking	Society
Feelings	1,000	,296**	,445**	,392**	,393**	,126*	,453**	,273**	,424**	,355**
Regulating		1,000	,278**	,420**	,307**	,001	,332**	,174**	,311**	,211**
Culture			1,000	,272**	,321**	,196**	,350**	,325**	,263**	,416**
Nature				1,000	,345**	,015	,388**	,208**	,301**	,260**
Existence					1,000	,165**	,329**	,260**	,278**	,296**
Products						1,000	-,008	,161**	,108*	,263**

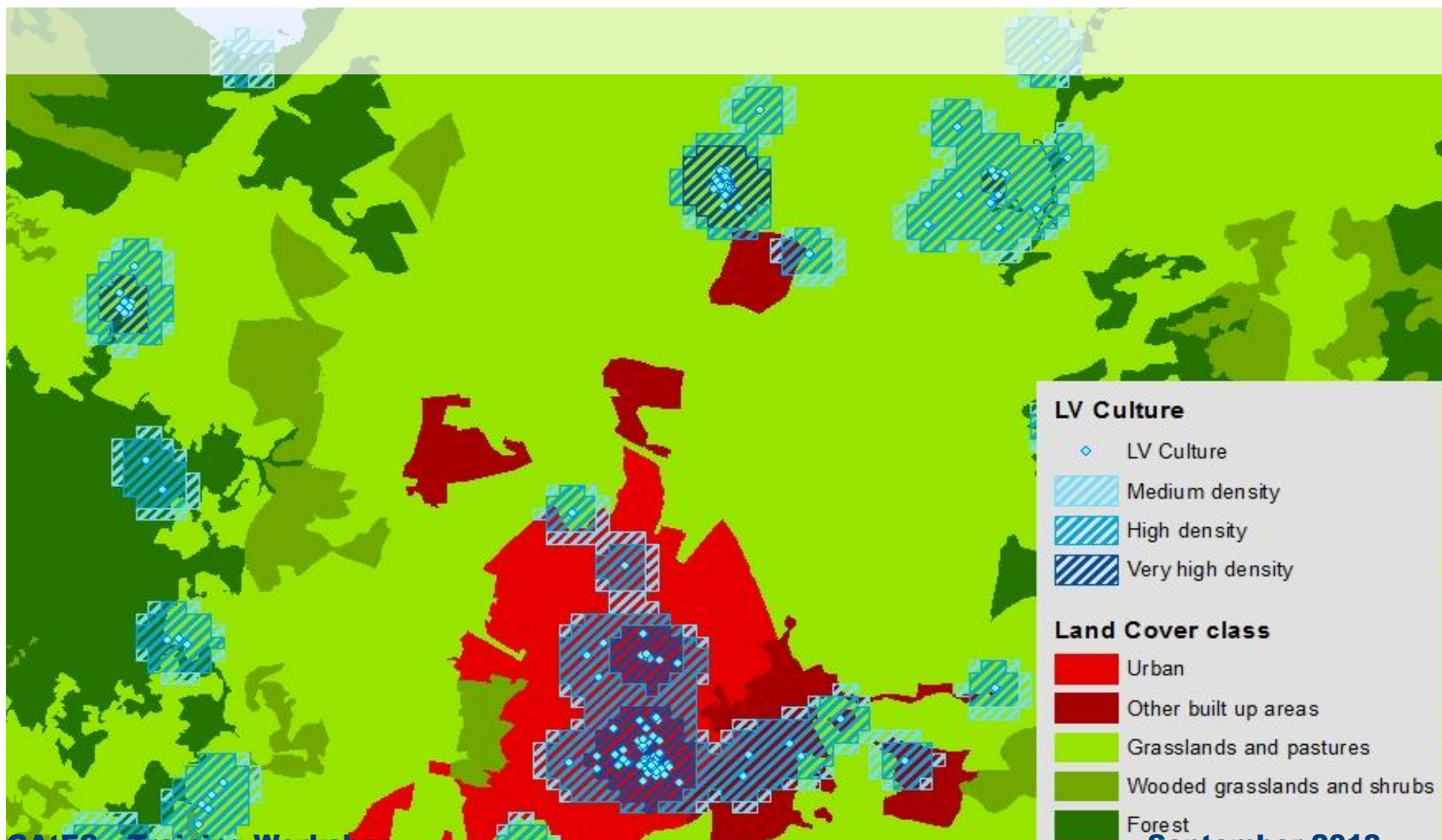
** $p < 0,01$

* $p < 0,05$



PRACTICE. Analysing spatial patterns

Overlay kernel density classes with land cover classes





References

Teaching material:

UTU Department of Geography and Geology 2014, Nora Fagerholm

For kernel analysis:

Brown, G., 2004. Mapping spatial attributes in survey research for natural resource management: methods and applications. *Soc. Nat. Resour.* 18, 17–39.

Scolozzi, R., Schirpke, U., Detassis, C., Abdullah, S., Gretter, A., 2014. Mapping alpine landscape values and related threats as perceived by tourists. *Landscape Res*, <http://dx.doi.org/10.1080/01426397.2014.902921>.

Fagerholm, N., Käyhkö, N., Ndumbaro, F., Khamis, M., 2012. Community stakeholders' knowledge in landscape assessments—mapping indicators for landscape services. *Ecol. Indic.* 18, 421–433.

<https://www.icpsr.umich.edu/CrimeStat/files/CrimeStatChapter.8.pdf>

For Incremental Spatial Autocorrelation analysis:

Getis A (2010) Spatial Autocorrelation. In: Fischer MM, Getis A (eds) *Handbook of applied spatial analysis software tools, methods and applications*. Springer, Berlin, pp 255–278



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For spatial bundles analysis:

Martin-Lopez, B., I. Iniesta-Arandia, M. Garcia-Llorente, I. Palomo, I. Casado-Arzuaga, et al. 2012. Uncovering ecosystem service bundles through social preferences. PLoS ONE 7: e38970.

Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Policy 33, 118–129.

Fagerholm N, Oteros-Rozas E, Raymond CM, Torralba M, Moreno G, Plieninger T (2016) Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS. Appl Geogr 74:30–46

Fagerholm N, Kayhko N, Ndumbaro F, Khamis M (2012) Community stakeholders' knowledge in landscape assessments—mapping indicators for landscape services. Ecol Indic 18:421–433



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Other references:

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Raymond, C.M., B.A. Bryan, D.H. MacDonald, A. Cast, S. Strathearn, A. Grandgirard & T. Kalivas (2009). Mapping community values for natural capital and ecosystem services. *Ecological Economics* 68, 1301–1315.

Sherrouse, B.C., J.M. Clement & D.J. Semmens (2011). A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. *Applied Geography* 31, 748–760.