EAS 543: Environmental Spatial Analysis Fall 2019
Instructor: Dr. Silvia Cordero-Sancho

CONTACT INFORMATION:
corderos@umich.edu
Office Hours: Thursday 1:30-4:00 pm Location: ESA Lab (3315 Dana)

First Class Session: October, 24th, 2019
Last Class Session: December 5th, 2019
Class Meets: Thrusdays from 10:00 am to 12:00 pm
Location: 3325 Dana (3rd floor computer lab)

Prerequisites: EAS (NRE) 420 or equivalent; EAS (NRE) 438 or equivalent

CANVAS SITE (EAS 543 001 FA 2019): Class materials (e.g. readings, lectures materials, lab instructions) as well as listings of resources relevant to the class topics (e.g. R-Spatial Resources) can be found on the Canvas site. Additionally, all lab assignments and related feedback will be facilitated through the site.
Deliverables: Weekly lab assignments and a final project.

Class Objectives:
As a result of participating in EAS 543, the students will be able to apply and interpret statistical methods associated with spatial datasets. In addition, the students will strengthen their skills in handling data in the R environment, and specially, the handling and processing of spatial datasets.

Class Goals:
Provide students with the common concepts (*theory*) and practice (*hands-on experience*) employed in spatial data analysis procedures. The class will be taught employing **R**, (a free software, commonly associated with non-spatial statistical analysis). The R environment is a great ecosystem for the creation, handling, manipulation and analysis of spatial data formats.

Course Description
This is a half-semester advanced GIS course focuses on frequently used quantitative methods in spatial analysis using the R programming environment. These methods can help us answer questions such as: *Are the features of interest in my study area spatially clustered or independently distributed?*
How can I interpolate between points to make a spatially continuous map? Is my data spatially autocorrelated? And if so, how does it affect my analysis? What underlying variables best explain or predict the patterns of land cover in my study area?
Course topics include use of R in spatial analysis, spatial point pattern analysis and clustering analysis, assessment of spatial autocorrelation, spatial regression and spatial interpolation. The course emphasizes hands-on lab work. Labs will require additional time to finish outside of the classroom.

Course policies

Attendance: We meet once a week for 2 hours. The class structure allows time for the students and instructor to discuss the class topic and the analytical process. Thus, class assistance and participation will be highly encouraged. Each session has been designed to accommodate a short lecture and a lab session. There will be a lab assignment for each lab. If a student cannot attend a session, it will responsibility of the student to complete the lab materials and assignments associated with the missed session. If you must miss a class, please try to contact the instructor ahead of time. If this is not possible, please be in communication about this as soon as possible.

Accommodations: The instructor will make adjustments to accommodate and support individual student needs, including those with hearing, visual or other physical impairments or / and learning disabilities. Likewise, if any major incoming religious holiday will interfere with class assistance or class work, the instructors will try make the necessary adjustments for the student(s). *Please, let the instructor know in advance if any of the above conditions apply to you*.

Late/Missing Assignments: If you are aware that you cannot submit your assignment on time (e.g. family emergency) please contact the instructor ahead. Otherwise, assignments are accepted but only for two weeks after the due date. Late assignments will receive 7 points deduction for each late week. This implies that a late lab report which could have been rated *A+* will be graded as a *A-* for the *first* late week or a B+ for the second late week. After two weeks, requested materials will not be accepted.

Academic Honesty: We will adhere to the Rackham Academic and Professional Integrity Policy. Please refer to https://rackham.umich.edu/academic-policies/section8/

Grading:

- Labs (n=6, **36%**) *Weekly*
- R-Spatial Cheat Sheet (n=6, **24%**) Weekly
- *Group Project & Presentation (**40%**) By 12/05/2019

(**See Group Project description at the end of this document*)

Grade Calculation:

Percentage	Letter Grade	Percentage	Letter Grade
97.0 - 100	**A+**	75.5 - 79.4	C+
91.0 - 96.9	**A**	71.0 - 75.4	C
89.5 - 90.9	**A-**	69.5 - 70.9	C-
85.5 - 89.4	**B+**	65.5 - 69.5	D+
81.0 - 85.4	**B**	61.0 - 65.4	D
79.5 - 80.9	**B-**	59.5 - 60.9	D-

Class Calendar

Date	Topic	Lab due date
10/24/2019	1. Spatial data in the R Environment	---
10/31/2019	2. Spatial Point Pattern Analysis	- Lab 1 - Weekly R-Spatial Cheat Sheet (due by 11:59 pm)
11/07/2019	3. SAC/Spatial Clustering Analysis	- Lab 2 _ Weekly R-Spatial Cheat Sheet (due by 11:59 pm)
11/14/2019	4. SAC /Spatial Regression	- Lab 3 - Weekly R-Spatial Cheat Sheet (due by 11:59 pm)
11/21/2019	5. Spatial Logistic Regression	- Lab 4 - Weekly R-Spatial Cheat Sheet (due by 11:59 pm)
11/28/2019	6. Spatial Interpolation	- Lab 5 - Weekly R-Spatial Cheat Sheet (due by 11:59 pm)
12/05/2019	7. Student oral project presentations	- Lab 6 - Weekly R-Spatial Cheat Sheet (due by 11:59 pm)

Class Readings:

Topic	Bibliography & Other Resources
Spatial Data in R	**Required Material:** Haining, R., 2003. Spatial data analysis: scientific and policy context, in: Spatial Data Analysis: Theory and Practice. Cambridge University Press, Cambridge, UNITED KINGDOM, pp. 13–88.
	Complementary Material: Pebesma, E.E., 2019. Simple Features in R [WWW Document]. URL https://cran.r-project.org/web/packages/sf/vignettes/sf1.html#what_is_a_feature (accessed 10.4.19). *R & RStudio Cheatsheets (2019-pdf format):* 1)RStudio Keyboard, 2)Shiny, 3) R Markdown, 4) Data Import, 5) Data Transformation (dplyr), 6) Data Visualization (ggplot2), 7) Apply function s with 'plurr', 8) String manipulation 'stringr', 9) Dates and times with 'lubridate', 10) Package Development, 11) Deep Learning with 'Keras', 12) Data Science in Spark with Keras, 13) Data Science in Spark with Sparklyr, 14) Tidy evaluation with rlang, 15) caret package, 16) sf package, 17) cartography package. *R-Packages Documentation (online vignettes & reference manuals)* *Package 'sf'* Vignettes: https://cran.r-project.org/web/packages/sf/vignettes/sf1.html#what_is_a_feature Manual: https://cran.r-project.org/web/packages/sf/sf.pdf *Package 'tmap'* Vignettes: https://cran.r-project.org/web/packages/tmap/vignettes/tmap-getstarted.html Manual: https://cran.r-project.org/web/packages/tmap/tmap.pdf *Package 'dplyr'* Vignettes: https://cran.r-project.org/web/packages/dplyr/vignettes/dplyr.html Manual: https://cran.r-project.org/web/packages/dplyr/dplyr.pdf *Textbooks:* Bivand, R., 2013. Applied spatial data analysis with R, Second Edition. ed. Springer, New York. Other online resources see CANVAS Page: Spatial Data in R (online resources)

Topic	Bibliography & Other Resources
Spatial Point Pattern Analysis	**Required Material:** Law, R., Illian, J., Burslem, D.F.R.P., Gratzer, G., Gunatilleke, C.V.S., Gunatilleke, I. a. U.N., 2009. Ecological information from spatial patterns of plants: insights from point process theory. Journal of Ecology 97, 616–628. https://doi.org/10.1111/j.1365-2745.2009.01510.x
	Complementary Material: Funwi-Gabga, N., Mateu, J., 2011. Understanding the nesting spatial behaviour of gorillas in the Kagwene Sanctuary, Cameroon. Stoch Environ Res Risk Assess 26, 793–811. https://doi.org/10.1007/s00477-011-0541-1 Perry, G.L.W., Miller, B.P., Enright, N.J., 2006. A comparison of methods for the statistical analysis of spatial point patterns in plant ecology. Plant Ecology 187, 59–82. https://doi.org/10.2307/20146996 Velázquez, E., Martínez, I., Getzin, S., Moloney, K.A., Wiegand, T., 2016. An evaluation of the state of spatial point pattern analysis in ecology. Ecography 39, 1042–1055. https://doi.org/10.1111/ecog.01579 *R-Packages Documentation (online vignettes & reference manuals)* *Package 'spatstat'* Vignettes: https://cran.r-project.org/web/packages/spatstat/vignettes/getstart.pdf Manual: https://cran.r-project.org/web/packages/spatstat/spatstat.pdf *Package 'maptools'* Manual: https://cran.r-project.org/web/packages/maptools/maptools.pdf Online resources: *Spatsat website:* http://spatstat.org/ *Programita (*SPPA software*):* http://programita.org/ *Textbooks:* Baddeley, A., Rubak, E., Turner, R., 2015. Spatial Point Patterns: Methodology and Applications with R. Chapman and Hall/CRC. Illian, D.J., Penttinen, P.A., Stoyan, D.H., Stoyan, D., 2008. Statistical Analysis and Modelling of Spatial Point Patterns, 1st ed. Wiley & Sons, West Sussex, England.
Spatial Clustering (LISA)	**Required Material:** Anselin, L., 1995. Local Indicators of Spatial Association—LISA. Geographical Analysis 27, 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

Topic	Bibliography & Other Resources
Spatial Clustering (continuation…)	Bivand, R., 2013. Chapter 9: Modelling Areal Data, in: Applied Spatial Data Analysis with R. Springer, New York, pp. 263-288. Ord, J.K., Getis, A., 1995. Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. Geographical Analysis 27, 286–306. https://doi.org/10.1111/j.1538-4632.1995.tb00912.x
	Complementary Material: *R-Packages Documentation (online vignettes & reference manuals)* *Package 'spdep'* *Vignette:* https://cran.r-project.org/web/packages/spdep/vignettes/CO69.html Manual: https://cran.r-project.org/web/packages/spdep/spdep.pdf Geoda Sofware: https://geodacenter.github.io/ Anselin, L., Syabri, I., Kho, Y., 2006. GeoDa: An Introduction to Spatial Data Analysis. Geographical Analysis 38, 5–22. https://doi.org/10.1111/j.0016-7363.2005.00671.x
Spatial Regression	**Required Material:** Bivand, R., 2013. Chapter 9: Modelling Areal Data, in: Applied Spatial Data Analysis with R. Springer, New York, pp. 288-318.
	Complementary Material: *R-Packages Documentation (online vignettes & reference manuals)* *Package 'spdep'* *Vignette:* https://cran.r-project.org/web/packages/spdep/vignettes/CO69.html Manual: https://cran.r-project.org/web/packages/spdep/spdep.pdf *Package 'visreg'* *Vignette:* https://cran.r-project.org/web/packages/visreg/vignettes/quick-start.html *Manual:* https://cran.r-project.org/web/packages/visreg/visreg.pdf *Package 'usdm'* *Manual:* https://cran.r-project.org/web/packages/usdm/usdm.pdf Geoda Sofware: https://geodacenter.github.io/ Anselin, L., Syabri, I., Kho, Y., 2006. GeoDa: An Introduction to Spatial Data Analysis. Geographical Analysis 38, 5–22. https://doi.org/10.1111/j.0016-7363.2005.00671.x

Topic	Bibliography & Other Resources
Spatial Logistic Regression	**Required Material:** Baddeley, A., Berman, M., Fisher, N.I., Hardegen, A., Milne, R.K., Schuhmacher, D., Shah, R., Turner, R., 2010. Spatial logistic regression and change-of-support in Poisson point processes. Electron. J. Statist. 4, 1151–1201. https://doi.org/10.1214/10-EJS581 Overmars, K.P., de Koning, G.H.J., Veldkamp, A., 2003. Spatial autocorrelation in multi-scale land use models. Ecological Modelling 164, 257–270. https://doi.org/10.1016/S0304-3800(03)00070-X
	Complementary Material: Cardille, J.A., Ventura, S.J., Turner, M.G., 2001. Environmental and Social Factors Influencing Wildfires in the Upper Midwest, United States. Ecological Applications 11, 111–127. https://doi.org/10.2307/3061060 *R-Packages Documentation (online vignettes & reference manuals)* *Package 'spatstat'* Vignettes: https://cran.r-project.org/web/packages/spatstat/vignettes/getstart.pdf Manual: https://cran.r-project.org/web/packages/spatstat/spatstat.pdf *Package 'mgcv'* *Manual:* https://cran.r-project.org/web/packages/mgcv/mgcv.pdf
Spatial Interpolation	**Required Material:** Bivand, R., 2013. Chapter 8: Interpolation and Geostatistics, in: Applied Spatial Data Analysis with R. Springer, New York, pp. 213–256.
	Complementary Material: *R-Packages Documentation (online vignettes & reference manuals)* *Package 'gstat'* *Vignette:* https://cran.r-project.org/web/packages/gstat/vignettes/gstat.pdf Manual: https://cran.r-project.org/web/packages/gstat/gstat.pdf

EAS 543 Environmental Spatial Data Analysis
FALL 2019

Group Project Description

The final project is a group project. The output is a class presentation (20 min) and a Power-Point presentation and must be submitted by December 13th. Considering the current class size (21 students) the students will form 5 teams (4-teams of 4 members and 1 team of 5 members) will select one of the following topics. *Note that group sizes and time will depend on class enrollment*:

- *Working with their own data:* Present preliminary results of analysis conducted with their own data. This is suitable if at least one of the team members has a spatial dataset that could be analyzed with any of the spatial methods reviewed in class. Presentation must include research questions, summary of methods and results and possible conclusions and/or recommendations.

- *R Spatial vs ESRI:* For this class we are relying on freeware software (R-Cran), however, ESRI products have an extensive library of analytical tools. The team must select one of the methods and reproduce the procedure employing ARCGIS Pro (or ArcGIS) analytical toolkits and compare the process and results with the ones obtained in class. Presentation must summarize the findings and provide conclusions or recommendations regarding the advantages or disadvantages (specific for the method) of the use of R vs ESRI products.

- *Literature review:* The methods to be reviewed in class are applied to a wide range of subjects (e.g. ecology, urban planning, epidemiology). Are any of the methods relevant to your own research or area of expertise? The literature review is an opportunity to learn more and share the specific applications of spatial analysis methods in your subject of interest. The presentation must include:
    - The Review of at least 5 papers (max 10).
    - The purpose for the review (e.g. highlight the trends of the use of "X" method in urban planning).
    - The methodology used to conduct the review (e.g. key words, search methods, search constrains).
    - Indicate if there is any "gap" in the literature and which could be interesting research questions to address with the use of spatial analysis methods.

Student groups and project topics must be defined by 11/07/2019. It is highly recommended that at least one member of the group meets with the instructor prior this date to discuss the topic. Meeting could be arranged along class office hours, otherwise, write to instructor to arrange time.