Cornell University
PLSCS/NTRES 6200
Spatial Modelling and Analysis
for agronomic, natural resources, environmental and regional studies

Spring semester 2018
Course information

D G Rossiter
d.g.rossiter@cornell.edu
http://www.css.cornell.edu/faculty/dgr2/

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Orientation to course

1. for whom?
2. objectives
3. instructor
4. method
5. assignments & grading
6. project
7. schedule
8. some key references

For whom?

- **Graduate** and **senior undergraduate** students who want to advance their understanding of geographic information science and technology applied to problems in the agronomic, natural resources, environmental or regional studies sciences;
  - Most labs use the the **R environment** for (spatial) statistical computing and visualization, and the **QGIS** open-source GIS (these will be introduced)
  - Student should have followed an undergraduate-level or introductory graduate-level courses in **GIS theory and practice** (e.g., PLSCS 4200) and **inferential statistics** (e.g., STSCI 3200/BTRY 3020)
  - Helpful but not necessary: remote sensing, computer programming

- Especially useful for students starting a **graduate research project** that uses spatial information in agronomy, soil science, natural resource management, regional science, hydrology, ecology and similar
  - "spatial": information is from **known locations** with **known spatial extent**

Objectives

- **Core competency**: student is able to analyze **complex spatial problems** with **appropriate theory and tools**
- Enhance student skills in processing, analyzing, and visualizing spatial data; with emphasis on **open-source computer programs** and **publically-available data**
- Provide opportunities to analyze **students' own geospatial data** under instructor supervision

Instructor

David G. Rossiter

- Adjunct Associate Professor, PLSCS (7th year)
  - Graduate faculty *Soil & Crop Sciences* ‘Environmental Information Systems’ concentration
  - Graduate faculty *Regional Science* ‘Environmental Studies’ concentration

- Guest Researcher (*Gastmedewerker*), ISRIC–World Soil Information, Wageningen (NL) (4th year)

- Visiting Professor (客座教授), Chinese Academy of Sciences, Soil Science Research Institute Nanjing (中国科学院南京土壤研究所) (6th year)

- Visiting Professor (讲座教授), Nanjing Normal University, School of Geography (南京师范大学地理学学院) (4th year)

- Retired from University of Twente (NL), Faculty of Geoinformation Science & Earth Observation (17 years)

Instruction method

- Graduate-level course, emphasis is on **guided self-instruction**, including critical reading of primary literature, lab. self-paced tutorials
- Lectures are **overviews / orientations** to introduce **fundamental spatial analysis concepts and methods**
  - Each lecture period begins with $\approx$ 20 minutes discussion of an **assigned pre-class reading**, and with Q&A.
- Emphasise ability to read, understand and apply **methods in journal papers**, advanced **textbooks** and **reference** books; necessary in graduate career
- Student **project** allows you to apply ideas and techniques of spatial analysis from this course or elsewhere to your research
- First seven (of 12) labs. are tutorial exercises on **methods** and **computation**; example applications to illustrate these; other lab. periods for project work.

Assignments

- Weeks 2-4, 6–9: seven (**7**) set **lab. exercises**, small hand-in assignment; due before Tues. of following week
- Week 10: **Prelim** = research objective & literature review & **project** flow chart
- (Week 11: spring break)
- Weeks 12–15 four (**4**) short **question sets** based on reading; due before Thursday lecture (to be discussed in class)
- Week 16: **Project** presentations

Grading

- Seven lab. exercise assignments: graded 0–3; 30% of final
- Four question sets: graded 0–3; 20% of final
- Prelim: 5% of final
- Project: 45% of final (breakdown: 80% project, 10% reporting, 10% presentation/discussion)
  - So, project, including prelim, 50% of final grade; set exercises 50%
- Grading on absolute scale; Letter equivalents:

$\geq$ 97.5	A+	$\geq$ 92.5	A	$\geq$ 90.0	A-
$\geq$ 87.5	B+	$\geq$ 82.5	B	$\geq$ 80.0	B-
$\geq$ 77.5	C+	$\geq$ 72.5	C	$\geq$ 70.0	C-
$\geq$ 67.5	D+	$\geq$ 62.5	D	$\geq$ 60.0	D-
< 60.0	F				

Project

- An independent project in which the student applies **spatial analysis** to a **problem of interest** relevant to student's field of study;
  - May work in pairs provided that independent contributions of team members can be evaluated.
- **Spatial analysis** must be prominent;
- Prefer use of **own** data, **similar** obtained from colleague/advisor, or **publically-available** data; little credit for extensive data manipulation (not the main purpose of this course);
- Should be able to complete during allocated lab. time and related self-study time; graded as such;
- Milestones: (1) **brief proposal**: 13-March (week 8 Tuesday) ; (2) **prelim** (literature review / detailed project plan): 10-April (week 12 Tuesday, after hearing comments on proposal presentation during week 10); (3) **report**: ≈18-May (on scheduled exam date, TBD)

Week schedule

Lectures: Tuesday, Thursday 0840–0955 Bradfield 110

Content is equivalent to a 50-minute lecture, this gives more time for review and interaction. We always start with questions and discussion of the key points in the assigned papers, as motivation for the lecture.

Computer laboratory: Tuesday or Wednesday 1325–1625 Bradfield 108

- you can come to one or both labs; if space is limited, priority to those registered for that day
- brief orientation; most time is self-paced with instructor available to answer questions; a few breaks to review key points
- Bradfield 108 always available (card access for enrolled students)

Schedule – lectures

Week 1 Course Intro, naïve analysis; spatial concepts (Th only; 25-Jan)

Week 2 Introduction to spatial modelling; review of GIS concepts (30 Jan, 01 Feb)

Week 3 The R environment; feature-space regression, trend surfaces (06, 08 Feb)

Week 4 Spatial dependence, kriging (ordinary, regression) (13, 15 Feb))

Week 5 Remote sensing as a data source for spatial analysis *guest lecture* (Th only; 22 Feb)

Week 6 Spatial regression (27 Feb, 01 Mar)

Week 7 Data-driven methods: random forests; splines (06, 08 Mar)

Week 8 Area-Based spatial analysis (13, 15 Mar)

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Week 9 Point Pattern analysis (20, 22 Mar)

Week 10 Bayesian approaches (21, 29 Mar)

Week 11 (spring break)

Week 12 Uncertainty, data quality, metadata, simulation (10, 11 Apr)

Week 13 Spatial sampling (17, 20 Apr)

Week 14 Time series; Spatio-temporal analyis (24, 26 Apr)

Week 15 Network analysis (01, 03 May)

Week 16 Summary: the typology revisited (Tu only, 08 May)

Schedule – labs

Week 1 (no lab)

Week 2 open-source GIS (30/31 Jan)

Week 3 The R environment; feature-space regression (06/07 Feb)

Week 4 geostatistics with R/gstat (13/14 Feb)

Week 5 (no lab)

Week 6 Spatial interpolation: R: Generalized least squares, REML (27/28 Feb)

Week 7 empirical methods of spatial prediction: random forests, thin-plate splines (06/07 Mar)

Week 8 Area spatial data analysis: R/spdep and GeoDa (13/14 Mar)

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Week 9 Point-pattern analysis: R/spatstat (20/21 Mar)

Week 10 prelim project presentations (27/28 Mar)

Week 11 (spring break, no lab)

Weeks 12–15 individual project work (instructor available for consultation)

Week 16 student project presentations/discussion (08/09 May)

Key texts/references

Spatial modelling in general

O'Sullivan, D., & Unwin, D. (2010). **Geographic information analysis** (2nd ed). Wiley.
`http://library.books24x7.com.proxy.library.cornell.edu/toc.aspx?site=KD708&bookid=35218`

Ecological modelling

Legendre, P. (2012). **Numerical Ecology** (3rd ed.). San Diego: Elsevier Science & Technology Books.
`http://www.sciencedirect.com.proxy.library.cornell.edu/science/bookseries/01678892/24`

Borcard, D., & SpringerLink (Online service). (2011). **Numerical ecology with R**. New York: Springer.
`http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-1-4419-7976-6`

Statistics review

StatSoft Electronic Statistics Textbook: `https://www.statsoft.com/textbook`

Dalgaard, P. (2008). **Introductory Statistics with R** (2nd ed.). Springer.
`http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-0-387-79054-1`

Spatial analysis in R

Bivand, R., Pebesma, E., & G'şmez-Rubio, V. (2013). **Applied spatial data analysis with R** (2nd ed). New York: Springer.
`http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-1-4614-7618-4`.
Datasets etc. at `http://www.asdar-book.org/`

Kolaczyk, E. D., & Csárdi, G. (2014). **Statistical Analysis of Network Data with R**. Springer. IBSN:978-1-4939-0982-7
`http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-1-4939-0983-4`

General GIS

Burrough, P. A., McDonnell, R., & Lloyd, C. D. (2015). **Principles of geographical information systems** (3rd edition). Oxford‘Ă‘ŕ; New York: Oxford University Press.

Geostatistics

Webster, R., & Oliver, M. A. (2008). **Geostatistics for environmental scientists**. John Wiley & Sons Ltd. http://onlinelibrary.wiley.com.proxy.library.cornell.edu/book/10.1002/9780470517277

Goovaerts, P. (1997). hlGeostatistics for natural resources evaluation. New York; Oxford: Oxford University Press.

Diggle, P. J., & Ribeiro Jr., P. J. (2007). **Model-based geostatistics**. Springer. http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-0-387-48536-2

Krivoruchko, K. (2011). **Spatial statistical data analysis for GIS users**. DVD containing book + data. Redlands: ESRI.

Statistical modelling

Fox, J. (2008). **Applied regression analysis and generalized linear models** (2nd ed.). Los Angeles: Sage.

Fox, J., & Weisberg, S. (2011). **An R companion to applied regression** (2nd ed.). Thousand Oaks, Calif.: SAGE Publications.

Venables, W., & Ripley, B. (2002). **Modern Applied Statistics with S**. Fourth Edition. Springer. http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-0-387-21706-2

Hosmer, D. W., & Lemeshow, S. (2013). **Applied logistic regression** (3rd ed.). Wiley-Interscience Publication. http://onlinelibrary.wiley.com.proxy.library.cornell.edu/book/10.1002/9781118548387

Machine learning

Hastie, T., Tibshirani, R., & Friedman, J. H. (2009). **The elements of statistical learning data mining, inference, and prediction** (2nd ed). New York: Springer. http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-0-387-84858-7

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). **An introduction to statistical learning: with applications in R**. New York: Springer. http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F978-1-4614-7138-7 (A simplified version of Hastie *et al.* 2009).

Land surface modelling

Hengl, T., & Reuter, H. I. (Eds.). (2009). **Geomorphometry: concept, software, applications**. Developments in soil science 33. http://www.sciencedirect.com.proxy.library.cornell.edu/science/bookseries/01662481/33

Spatial sampling

de Gruijter, J., Brus, D. J., Bierkens, M. F. P., & Knotters, M. (2006). **Sampling for Natural Resource Monitoring**. Springer.
`http://link.springer.com.proxy.library.cornell.edu/book/10.1007%2F3-540-33161-1`