

EEB1250H Spatial Statistics – Fall 2024

Department of Ecology & Evolutionary Biology

Course Instructor

Marie-Josée Fortin (mariejosee.fortin@utoronto.ca)

Location and Time

Lecture: Thursdays from 9:30 (sharp) to 12:00, ESC 2144

Course Description

Ecological processes are inherently spatially structured due to spatial dependence on environmental conditions and spatial autocorrelation of species behaviors. The goal of this course is to provide a broad overview of the various spatial analytical methods available to quantify (geostatistics, network theory, boundary detection), test (restricted randomization), and model (spatial regressions) spatially autocorrelated ecological data. Students will be introduced to concepts of spatial scales and how multiscale analysis can be performed with census and sampled data. Furthermore, specific spatial methods to deal with point pattern data and surface pattern data will be reviewed. A combination of lectures and computer laboratory sessions will be used.

Course Objectives

By the end of the course, graduate students should be able to:

- understand the utility and pitfalls of statistics and their appropriate application to spatially structured data;
- analyse their data with the appropriate statistics and interpret the results adequately;
- read, understand, and critically evaluate papers and their use of spatial statistics.

Topics and Timetable

2024	Topics	Labs
Sept 12–Wk1	<ul style="list-style-type: none"> • Space: scales, sampling, randomization tests • Spatial autocorrelation for population data • Join count statistics 	Homework: Questions, data, and potential analyses, due Sept. 22, 2022
Sept 19–Wk2	<ul style="list-style-type: none"> • Spatial autocorrelation for sample data • Interpolation • Sampling 	Homework DUE Lab 1: Spatial aggregation and autocorrelation
Sept 26–Wk3	<ul style="list-style-type: none"> • Relationship between spatially autocorrelated variables • Mantel test • GLMM • Gravity Model • Spatial regression (CAR/SAR, GWR) • CART 	Lab 2: Spatial relationships
Oct 3–Wk4	<ul style="list-style-type: none"> • Ordinations • Multiscale analysis (wavelet, MEM) 	Lab 1 report DUE
Oct 10–Wk5	<ul style="list-style-type: none"> • Network theory; Connectivity • Spatio-temporal analysis 	
Oct 17–Wk6	<ul style="list-style-type: none"> • Species Distribution Models • Landscape Metrics 	Lab 2 report DUE
Oct 24–Wk7	<ul style="list-style-type: none"> • Boundary detection • Spatial Diversity 	
Oct 31	Reading Week – No class	
Nov 14–Wk8	<ul style="list-style-type: none"> • Student presentations (5 to 10 minutes MAXIMUM) 	Term-paper DUE

Evaluation

1. **Assignment using R** using spatial exploratory data analysis methods (15%)
→ Do not want printout of the figures BUT the statistical and biological interpretations of the results obtained.
2. **Assignment using R** using spatial regression methods (15%)
→ Do not want printout of the figures BUT the statistical and biological interpretations of the results obtained.
3. **Term project = Report** (50%): Write the “methods section” of your potential data analysis explaining which statistics you should use to answer your hypotheses/objectives: Compare at least two different statistical methods stressing the assumptions of each selected statistical methods as well as their pros and their cons from a statistical/methodological perspective and from an ecological/evolutionary/biological perspective.
 - Maximum 6 pages single-spaced (half-page presenting the objectives of the study; half-page presenting the data; 4 pages explaining and comparing the statistical methods; 1 page for the references)
4. **Term project = Presentation** (20%): Each student will present a 10-minute talk summarizing: The objective(s) of their project; The (potential) data to be analysed; The selected methods that should be used to assess/test your hypotheses.

Useful References

- Dale MRT, M-J Fortin. 2014. *Spatial Analysis: A Guide for Ecologists*. 2nd edition. Cambridge Univ Press.
- Borcard D, F Gillet, P Legendre. 2018. *Numerical Ecology with R*. 2nd edition. Springer.
- Fletcher R, M-J Fortin. 2019. 9. *Spatial Ecology and Conservation Modeling: Applications with R*. Springer.
- Crabot J, Clappe S, Dray S, Detry T. 2019. Testing the Mantel statistic with a spatially-constrained permutation procedure. *Methods in Ecology and Evolution* 10:532-540.
- Dale MRT, M-J Fortin. 2010. From graphs to spatial graphs. *Ann. Review of Ecology, Evolution, and Systematics* 41.
- Dale MRT et al. 2002. The conceptual and mathematical relationships among methods for spatial analysis. *Ecography* 25: 558-577.
- Dormann CF et al. 2012 Correlation and process in species distribution models: bridging a dichotomy. *Journal of Biogeography* 39:2119-2131.
- Dray et al. 2012. Community ecology in the age of multivariate multiscale spatial analysis. *Ecol Monog* 82:257-275.
- Elith J, Leathwick JR, Hastie T 2008. A working guide to boosted regression trees. *J of Animal Ecology* 77:802-813.
- Fortin et al. 2012. Spatial statistics, spatial regression, and graph theory in ecology. *Spatial Statistics* 1:100-109.
- Guélat J, Kéry M. 2018. Effects of spatial autocorrelation and imperfect detection on species distribution models. *Methods in Ecology and Evolution* 9:1614-1625.
- Hengl et al. 2018. Random forest as a generic framework for predictive modeling of spatial and spatio-temporal variables. *PeerJ* 6:e5518.
- Kim D. 2021. Predicting the magnitude of residual spatial autocorrelation in geographical ecology. *Ecography* 44(7):1121-1130.
- Melles et al. 2009. Disentangling habitat and social drivers of nesting patterns in songbirds. *Land. Ecol.* 24:519-531.
- Ploton et al. 2020. Spatial validation reveals poor predictive performance of large-scale ecological mapping models. *Nature Communications* 11(4540).
- Rommel TK, M-J Fortin. 2013. Categorical, class-focused map patterns: Characterization and comparison. *Landscape Ecology* 28: 1587-1599.
- Roberts et al. 2017. Cross-validation strategies for data with temporal, spatial, hierarchical, or phylogenetic structure. *Ecography* 40(8):913-929.
- Ruppert et al. 2010. Environmental mediation of Atlantic cod on fish community composition: an application of multivariate regression tree analysis to exploited marine ecosystems. *Mar. Ecol. Progress Series* 411:189-201.
- Ruppert et al. 2018. Human activities as a driver of spatial variation in the trophic structure of fish communities on Pacific coral reefs. *Global Change Biology* 24: e67-e76.
- Sillero N, Barbosa AM. 2021. Common mistakes in *ecological niche models*. *International Journal of Geographical Information Science* 35:213-226.
- Zurell et al 2020. A standard protocol for reporting species distribution models. *Ecography* 43:1261-1277.