

# ECOL 8910 - PERSPECTIVES IN COMPUTATIONAL ECOLOGY

John M. Drake

## Course Information

**Class time:** MWF 9:00-9:55am

**Location:** Ecology 117

**Instructor:** Dr. John Drake (Office: 133 Ecology, email: [jdrake@uga.edu](mailto:jdrake@uga.edu))

**Course description.** Discussion-based course focusing on computational concepts and methods in ecology. Emphasizes practical techniques relevant to research. The Spring 2016 section concerns ecological niche theory and species distribution modeling.

**Course objectives.** The student will be introduced to a range of techniques and scientific computing paradigms using the R statistical computing environment. The primary goal of this course is to develop new data analysis skills.

**Assignments and grading policy.** This course is graded on the S/U system. To receive a score of S you must perform satisfactorily on all assignments. Primary class activities include lectures (Mondays), discussion of contemporary literature (Wednesdays), and a class project (Fridays). Each student is expected to lead at least one discussion. Additionally, students are required each week to read one topical paper of their choosing, write a short summary, and post to the class website.

**Class project.** Class projects may be developed individually or in teams. A written proposal (including names of all team members) is due by January 29. A first draft is due March 25. The final paper is due on Reading Day (May 3) and must be written as a reproducible workflow using R Markdown.

**Late assignment policy.** Paper summaries are due on Wednesdays. Class projects are due by reading day. Late assignments will not be accepted.

**Missed class policy.** Unless permission is obtained in advance or appropriate documentation is received (e.g., doctor's note), the instructor reserves the right to assign a grade of U if more than three classes are missed.

**Office hours & contact policy.** Office hours are by appointment; the primary means for out-of-class contact should be e-mail ([jdrake@uga.edu](mailto:jdrake@uga.edu)).

**Reading assignments.** Students are assumed to have a basic understanding of R, equivalent to that in Crawley (2007) or Venables and Ripley (2002). Occasional readings will be assigned as background for lectures. Required and optional readings are listed in the schedule of topics below. Recommended supplemental texts include Franklin (2009), Peterson et al. (2011), and Hijmans et al. (2013).

**Official University Policy.** The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary. All academic work must meet the standards contained in *A Culture of Honesty*. Students are responsible for informing themselves about those standards before performing any academic work.

## Schedule of topics

Week	R packages	Topic	Readings
Jan 11	<code>dismo</code>	Overview, reproducible research	Elith and Leathwick (2009) <sup>R</sup>
Jan 18	<code>raster</code>	Data	Hijmans et al. (2005) <sup>R</sup>
Jan 25		Niche and fitness	Kearney et al. (2010) <sup>R</sup> Hutchinson (1957) <sup>R</sup> Leibold (1995) <sup>O</sup>
Feb 1		Niche and distribution	Pulliam (2000) <sup>R</sup>
Feb 8		Machine learning	Breiman (2001) <sup>R</sup> Domingos (2016) <sup>O</sup>
Feb 15	<code>ROCR</code>	Evaluation	Fawcett (2006) <sup>R</sup>
Feb 22	<code>e1071</code>	Presence-only: SVMs	Drake, Randin, and Guisan (2006) <sup>R</sup> Drake (2014) <sup>R</sup>
Feb 29	<code>geometry</code>	Presence-only: Range bagging	Drake (2015) <sup>R</sup>
Mar 14	<code>dismo</code>	Presence-background: MaxEnt	S. J. Phillips, Dudik, and Shapire (2004) <sup>R</sup> Elith et al. (2010) <sup>R</sup>
Mar 21	<code>ppmlasso</code>	Presence-background: Point processes	Renner and Warton (2013) <sup>R</sup> Ward et al. (2008) <sup>O</sup>
Mar 28	<code>maxlike</code>	Presence-background: Probabilistic models	Royle et al. (2012) <sup>R</sup>
Apr 4	<code>inla</code>	Conditional autoregressive models	Beale et al. (2010) <sup>R</sup> Beguín et al. (2012) <sup>O</sup>
Apr 11	<code>gbm</code>	Classification: Boosted regression trees	J. Elith, Leathwick, and Hastie (2008) <sup>R</sup>
Apr 18		Special topics	Velásquez-Tibatá, Graham, and Munch (2015) <sup>C</sup> S. J. Phillips et al. (2009) <sup>C</sup> N. Barve et al. (2011) <sup>C</sup>
Apr 25		Big data	

R: Required reading; O: Optional reading; C: Choose one paper

## Bibliography

Barve, Narayani, Vijay Barve, Alberto Jiménez-Valverde, Andrés Lira-Noriega, Sean P. Maher, A. Townsend Peterson, Jorge Soberón, and Fabricio Villalobos. 2011. “The Crucial Role of the Accessible Area in Ecological Niche Modeling and Species Distribution Modeling.” *Ecological Modelling* 222 (11). Elsevier BV: 1810–19. doi:[10.1016/j.ecolmodel.2011.02.011](https://doi.org/10.1016/j.ecolmodel.2011.02.011).

Beale, Colin M., Jack J. Lennon, Jon M. Yearsley, Mark J. Brewer, and David A. Elston. 2010. “Regression Analysis of Spatial Data.” *Ecology Letters* 13 (2). Wiley-Blackwell: 246–64. doi:[10.1111/j.1461-0248.2009.01422.x](https://doi.org/10.1111/j.1461-0248.2009.01422.x).

Beguín, Julien, Sara Martino, Havard Rue, and Steven G. Cumming. 2012. “Hierarchical Analysis of Spatially Autocorrelated Ecological Data Using Integrated Nested Laplace Approximation.” *Methods in Ecology & Evolution* 3 (5): 921–29. doi:[10.1111/j.2041-210X.2012.00211.x](https://doi.org/10.1111/j.2041-210X.2012.00211.x).

Breiman, Leo. 2001. “Statistical Modeling: The Two Cultures (with Comments and a Rejoinder by the Author).” *Statistical Science* 16 (3). Institute of Mathematical Statistics: 199–231. doi:[10.1214/ss/1009213726](https://doi.org/10.1214/ss/1009213726).

Crawley, Michael J. 2007. *The R Book*. Wiley-Blackwell. doi:[10.1002/9780470515075](https://doi.org/10.1002/9780470515075).

Domingos, Pedro. 2016. “A Few Useful Things to Know About Machine Learning.” <https://homes.cs.washington.edu/~pedrod/papers/cacm12.pdf>.

Drake, John M. 2014. “Ensemble Algorithms for Ecological Niche Modeling from Presence-Background and Presence-Only Data.” *Ecosphere* 5 (6). Ecological Society of America: art76. doi:[10.1890/es13-00202.1](https://doi.org/10.1890/es13-00202.1).

———. 2015. “Range Bagging: A New Method for Ecological Niche Modelling from Presence-Only Data.” *J. R. Soc. Interface* 12 (107). The Royal Society: 20150086. doi:[10.1098/rsif.2015.0086](https://doi.org/10.1098/rsif.2015.0086).

- Drake, John M., Christophe Randin, and Antoine Guisan. 2006. "Modelling Ecological Niches with Support Vector Machines." *Journal of Applied Ecology* 43 (3): 424–32. doi:[10.1111/j.1472-4642.2010.00725.x](https://doi.org/10.1111/j.1472-4642.2010.00725.x).
- Elith, J., J. R. Leathwick, and T. Hastie. 2008. "A Working Guide to Boosted Regression Trees." *Journal of Animal Ecology* 77 (4). Wiley-Blackwell: 802–13. doi:[10.1111/j.1365-2656.2008.01390.x](https://doi.org/10.1111/j.1365-2656.2008.01390.x).
- Elith, Jane, and John R. Leathwick. 2009. "Species Distribution Models: Ecological Explanation and Prediction Across Space and Time." *Annu. Rev. Ecol. Evol. Syst.* 40 (1). Annual Reviews: 677–97. doi:[10.1146/annurev.ecolsys.110308.120159](https://doi.org/10.1146/annurev.ecolsys.110308.120159).
- Elith, Jane, Steven J. Phillips, Trevor Hastie, Miroslav Dudik, Yung En Chee, and Colin J. Yates. 2010. "A Statistical Explanation of MaxEnt for Ecologists." *Diversity and Distributions* 17 (1): 43–57. doi:[10.1111/j.1472-4642.2010.00725.x](https://doi.org/10.1111/j.1472-4642.2010.00725.x).
- Fawcett, Tom. 2006. "An Introduction to ROC Analysis." *Pattern Recognition Letters* 27 (8). Elsevier BV: 861–74. doi:[10.1016/j.patrec.2005.10.010](https://doi.org/10.1016/j.patrec.2005.10.010).
- Franklin, Janet. 2009. *Mapping Species Distributions*. Cambridge University Press (CUP). doi:[10.1017/cbo9780511810602](https://doi.org/10.1017/cbo9780511810602).
- Hijmans, Robert J., Susan E. Cameron, Juan L. Parra, Peter G. Jones, and Andy Jarvis. 2005. "Very High Resolution Interpolated Climate Surfaces for Global Land Areas." *International Journal of Climatology* 25 (15). Wiley-Blackwell: 1965–78. doi:[10.1002/joc.1276](https://doi.org/10.1002/joc.1276).
- Hijmans, Robert J., Steven Phillips, John Leathwick, and Jane Elith. 2013. *Dismo: Species Distribution Modeling*. <https://CRAN.R-project.org/package=dismo>.
- Hutchinson, G. Evelyn. 1957. "Concluding Remarks." *Cold Spring Harbor Symposium on Quantitative Biology* 22: 415–27. <http://symposium.cshlp.org/content/22/415>.
- Kearney, M., S. J. Simpson, D. Raubenheimer, and B. Helmuth. 2010. "Modelling the Ecological Niche from Functional Traits." *Philosophical Transactions of the Royal Society B: Biological Sciences* 365 (1557). The Royal Society: 3469–83. doi:[10.1098/rstb.2010.0034](https://doi.org/10.1098/rstb.2010.0034).
- Leibold, Matthew A. 1995. "The Niche Concept Revisited: Mechanistic Models and Community Context." *Ecology* 76 (5). JSTOR: 1371. doi:[10.2307/1938141](https://doi.org/10.2307/1938141).
- Peterson, A. Townsend, Jorge Soberon, Richard G. Pearson, Robert P. Anderson, Enrique Martinez-Meyer, Miguel Nakamura, and Miguel B. Araujo. 2011. *Ecological Niches and Geographic Distributions*. Princeton, NJ: Princeton University Press. <http://press.princeton.edu/titles/9641.html>.
- Phillips, Steven J., Miroslav Dudik, and Robert E. Shapire. 2004. "A Maximum Entropy Approach to Species Distribution Modeling." In *Proceedings of the Twenty-First International Conference on Machine Learning*, edited by Carla Brodley, 665–62. [https://www.cs.princeton.edu/~schapire/papers/maxent\\_icml.pdf](https://www.cs.princeton.edu/~schapire/papers/maxent_icml.pdf).
- Phillips, Steven J., Miroslav Dudik, Jane Elith, Catherine H. Graham, Anthony Lehman, John Leathwick, and Simon Ferrier. 2009. "Sample Selection Bias and Presence-Only Distribution Models: Implications for Background and Pseudo-Absence Data." *Ecological Applications* 19: 181–97. doi:[10.1890/07-2153.1](https://doi.org/10.1890/07-2153.1).
- Pulliam, H.R. 2000. "On the Relationship Between Niche and Distribution." *Ecology Letters* 3 (4). Wiley-Blackwell: 349–61. doi:[10.1046/j.1461-0248.2000.00143.x](https://doi.org/10.1046/j.1461-0248.2000.00143.x).
- Renner, Ian W., and David I. Warton. 2013. "Equivalence of MAXENT and Poisson Point Process Models for Species Distribution Modeling in Ecology." *Biometrics* 69 (1). Wiley-Blackwell: 274–81. doi:[10.1111/j.1541-0420.2012.01824.x](https://doi.org/10.1111/j.1541-0420.2012.01824.x).
- Royle, J. Andrew, Richard B. Chandler, Charles Yackulic, and James D. Nichols. 2012. "Likelihood Analysis of Species Occurrence Probability from Presence-Only Data for Modelling Species Distributions." *Methods in Ecology and Evolution* 3 (3). Wiley-Blackwell: 545–54. doi:[10.1111/j.2041-210x.2011.00182.x](https://doi.org/10.1111/j.2041-210x.2011.00182.x).
- Velásquez-Tibatá, Jorge, Catherine H. Graham, and Stephan B. Munch. 2015. "Using Measurement Error Models to Account for Georeferencing Error in Species Distribution Models." *Ecography*, May. Wiley-Blackwell, n/a–/a. doi:[10.1111/ecog.01205](https://doi.org/10.1111/ecog.01205).
- Venables, W. N., and B. D. Ripley. 2002. *Modern Applied Statistics with S*. Springer New York. doi:[10.1007/978-0-387-21706-2](https://doi.org/10.1007/978-0-387-21706-2).

Ward, Gill, Trevor Hastie, Simon Barry, Jane Elith, and John R. Leathwick. 2008. "Presence-Only Data and the EM Algorithm." *Biometrics* 65 (2). Wiley-Blackwell: 554–63. doi:[10.1111/j.1541-0420.2008.01116.x](https://doi.org/10.1111/j.1541-0420.2008.01116.x).