

## GRG396T: GIS and Ecological Modeling (Sp12)

Th 3:30-6:30

GRG 408

**PROFESSOR:** Jennifer A. Miller

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**OFFICE HOURS:** Tu, Th 12:30- 1:30 or by appt.

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**COURSE OBJECTIVES:** While this seminar will cover some technical aspects, the main focus is to increase a student's understanding of the steps involved in conceptualizing inferential models in a GIS environment. Although many of the concepts of model-building and integrating spatial analysis and GIS discussed here are general enough to be appropriate for other types of applications, examples will focus on ecological models in general, and species distribution models (SDM) in particular. There is no formal lab component although students are expected to be familiar enough with a GIS software package (ESRI ArcGIS is recommended) in order to perform analysis for their final project as well as for a group modeling exercise. Additional experience with spatial statistics or other statistical analysis is highly recommended. An introductory GIS course is the only prerequisite, although students are expected to be very computer proficient in general.

**READINGS:** The main discussion will focus around 2-5 required articles per week that pertain to a specific technical or conceptual aspect of ecological modeling, as well as an article presented by a student. All of the readings (listed in references below) are available on-line. Students should use the list of recommended references to select a paper to present and discuss. Please let me know if you have any trouble getting an electronic version of any of the papers on the required or recommended list.

**ASSESSMENT:** Your grade will be determined based on an article report, SDM exercise, final paper/project, and contribution to class discussion.

- ❖ *Article report (20%):* Each student will select one article from the list of recommended references to read, review, and report to the class.
- ❖ *SDM exercise (20%):* Students will work in groups implementing all steps of developing a species distribution model using the same dataset; results are due April 5.
- ❖ *Final paper/project (50%):* The final paper/project will allow each student to implement a modeling project using real data within a GIS. The final paper should be written in manuscript format (~20 pages double-spaced; follow *Ecological Modelling* guidelines here: [http://www.elsevier.com/wps/find/journaldescription.cws\\_home/503306/authorinstructions](http://www.elsevier.com/wps/find/journaldescription.cws_home/503306/authorinstructions)) and will be due by 5 pm on May 11. A rubric will be available on Blackboard.
- ❖ *Participation (10%):* Seminars depend on class discussion--be prepared to read and talk a lot!

**CLASS STRUCTURE:** In order to facilitate the discussion-oriented seminar format, all required readings must be read by the assigned date. Obviously in a class that meets only once a week, attendance is very important. Please see me ahead of time if you must miss a class.

### TENTATIVE CLASS SCHEDULE:

Date	Topic(s)	Required readings	Student discussant(s)
Jan. 19	Introduction/course overview		
Jan. 26	Introduction to species distribution models (SDM)	Guisan & Zimmermann (2000) Elith & Leathwick (2009)	

Date	Topic(s)	Required readings	Student discussant(s)
Feb. 2	SDM: concepts & theory	Araújo & Guisan (2006) Austin (2007) Jiménez-Valverde et al. (2008)	
Feb. 9	SDM: response data	Vaughan & Ormerod (2003) DeVictor et al (2010) <i>TBA (x2)</i>	1. 2.
Feb. 16	Scale SDM: predictor data <b>Prospectus due</b>	Goodchild (2011) Parra et al., (2004) Austin & Van Niel (2011) <i>TBA</i>	3.
Feb. 23	<b>No class</b>		
Mar. 1	SDM: assessing outcomes (accuracy & transferability)	Randin et al. (2006) Liu et al. (2011) <i>TBA (x2)</i>	4. 5.
Mar. 8	SDM issues: uncertainty	Araújo & New (2007) Wiens et al. (2009) Beale & Lennon (2012) <i>TBA (x2)</i>	6. 7.
Mar. 15	<b>Spring Break</b>		
Mar. 22	SDM issues: simulated data	Austin et al. (2006) Elith & Graham (2009) Zurell et al. (2010) <i>TBA</i>	8.
Mar. 29	SDM issues: spatial autocorrelation	Bahn & McGill (2007) Bini et al. (2009) <i>TBA (x2)</i>	9. 10.
Apr. 5	SDM issues: spatial nonstationarity <b>SDM exercise results due</b>	Foody (2004) Jetz et al., (2005) Fotheringham (2009) Eiserhardt et al. (2011) <i>TBA</i>	11.
Apr. 12	SDM application: projecting effects of climate change	Dormann (2007) <i>Wiens et al. (2009)</i> Iverson et al. (2011) <i>TBA (x2)</i>	12. 13.
Apr. 19	SDM issues: ?	<i>TBA (x4)</i>	14. 15.
Apr. 26	Student paper presentations I		
May 3	Student paper presentations II		

Date	Topic(s)	Required readings	Student discussant(s)
	<b>Final paper due by 5 pm, Friday May 11</b>		

#### MISCELLANEOUS DETAILS AND INFORMATION FOR GRG396T (SP2012):

**ARTICLE REPORT:** The report should take the form of a written (2-3 pages typed) and oral (10-15 minutes) summary and critique of the article. The summary should focus on the weekly topics we'll cover in class (research question – data – model(s) – results) and should aim to place the article in the context of what we discuss. The student will also be responsible for leading the discussion about his/her chosen article, but all students are required to read the articles presented by other students and be prepared to participate in class discussion about them.

**PROSPECTUS:** A 1-2 page prospectus that outlines your plan for the final project will be due at the beginning of class on Feb. 16. The prospectus should consist of your research question, data, and the methods you intend to use, as well as what your intended spatial information product (SIP). I'll provide additional resources for appropriate data if you don't have your own.

**MODEL SOFTWARE EXERCISE:** Students will 'compete' in groups using the same data and a SDM method. The groups will follow the modeling steps outlined in class (conceptualization, formulation, assessment) and provide me with a GIS map of their SIP, a species distribution map, on April 5. Each group will submit a report outlining the steps they took and each individual's contribution.

#### REQUIRED REFERENCES:

- Araújo, M.B. & Guisan, Antoine, 2006. Five (or so) challenges for species distribution modelling. *Journal of Biogeography*, 33(10), pp.1677-1688.
- Araújo, M.B. & New, M., 2007. Ensemble forecasting of species distributions. *Trends in Ecology & Evolution*, 22(1), pp.42-47.
- Austin, M.P., 2007. Species distribution models and ecological theory: A critical assessment and some possible new approaches. *Ecological Modelling*, 200(1–2), pp.1-19.
- Austin, M.P. et al., 2006. Evaluation of statistical models used for predicting plant species distributions: Role of artificial data and theory. *Ecological Modelling*, 199(2), pp.197-216.
- Austin, Mike P & Van Niel, K.P., 2011. Improving species distribution models for climate change studies: variable selection and scale. *Journal of Biogeography*, 38(1), pp.1-8.
- Bahn, V. & McGill, B.J., 2007. Can niche-based distribution models outperform spatial interpolation? *Global Ecology and Biogeography*, 16(6), pp.733-742.
- Beale, C.M. & Lennon, J.J., 2012. Incorporating uncertainty in predictive species distribution modelling. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1586), pp.247 -258.
- Bini, L.M. et al., 2009. Coefficient shifts in geographical ecology: an empirical evaluation of spatial and non-spatial regression. *Ecography*, 32(2), pp.193-204.
- De Victor, V., Whittaker, R.J. & Beltrame, C., 2010. Beyond scarcity: citizen science programmes as useful tools for conservation biogeography. *Diversity and Distributions*, 16(3), pp.354-362.
- Dormann, C., 2007. Promising the future? Global change projections of species distributions. *Basic and Applied Ecology*, 8(5), pp.387-397.
- Eiserhardt, W.L. et al., 2011. Testing the Water–Energy Theory on American Palms (Arecaceae) Using Geographically Weighted Regression. *PLoS ONE*, 6(11), p.e27027.

- Elith, J. & Graham, C.H., 2009. Do they? How do they? WHY do they differ? On finding reasons for differing performances of species distribution models. *Ecography*, 32(1), pp.66-77.
- Elith, J. & Leathwick, J.R., 2009. Species Distribution Models: Ecological Explanation and Prediction Across Space and Time. *Annual Review of Ecology, Evolution, and Systematics*, 40(1), pp.677-697.
- Fotheringham, A.S., 2009. "The problem of spatial autocorrelation" and local spatial statistics. *Geographical Analysis*, 41(4), pp.398-403.
- Goodchild, M.F., 2011. Scale in GIS: An overview. *Geomorphology*, 130(1-2), pp.5-9.
- Guisan, A. & Zimmermann, N., 2000. Predictive habitat distribution models in ecology. *Ecological Modelling*, 135, pp.147-186.
- Iverson, L.R. et al., 2011. Lessons Learned While Integrating Habitat, Dispersal, Disturbance, and Life-History Traits into Species Habitat Models Under Climate Change. *Ecosystems*, 14(6), pp.1005-1020.
- Jiménez-Valverde, A., Lobo, J.M. & Hortal, J., 2008. Not as good as they seem: the importance of concepts in species distribution modelling. *Diversity and Distributions*, 14(6), pp.885-890.
- Liu, C., White, M. & Newell, G., 2011. Measuring and comparing the accuracy of species distribution models with presence-absence data. *Ecography*, 34(2), pp.232-243.
- Parra, J.L., Graham, C.C. & Freile, J.F., 2004. Evaluating alternative data sets for ecological niche models of birds in the Andes. *Ecography*, 27(3), pp.350-360.
- Randin, C.F. et al., 2006. Are niche-based species distribution models transferable in space? *Journal of Biogeography*, 33(10), pp.1689-1703.
- Vaughan, I.P. & Ormerod, S.J., 2003. Improving the Quality of Distribution Models for Conservation by Addressing Shortcomings in the Field Collection of Training Data. *Conservation Biology*, 17(6), pp.1601-1611.
- Wiens, J.A. et al., 2009. Colloquium Papers: Niches, models, and climate change: Assessing the assumptions and uncertainties. *Proceedings of the National Academy of Sciences*, 106(Supplement\_2), pp.19729-19736.
- Zurell, D. et al., 2010. The virtual ecologist approach: simulating data and observers. *Oikos*, 119(4), pp.622-635.

#### RECOMMENDED REFERENCES FOR STUDENT PRESENTATIONS:

##### Response data:

- Anderson, R.P. & Raza, A., 2010. The effect of the extent of the study region on GIS models of species geographic distributions and estimates of niche evolution: preliminary tests with montane rodents (genus *Nephelomys*) in Venezuela. *Journal of Biogeography*, 37(7), pp.1378-1393.
- Chefaoui, R.M. & Lobo, J.M., 2008. Assessing the effects of pseudo-absences on predictive distribution model performance. *Ecological Modelling*, 210(4), pp.478-486.
- Lobo, J.M., Jiménez-Valverde, A. & Hortal, J., 2010. The uncertain nature of absences and their importance in species distribution modelling. *Ecography*, 33(1), pp.103-114.
- Rota, C.T. et al., 2011. Does accounting for imperfect detection improve species distribution models? *Ecography*, 34(4), pp.659-670.
- VanDerWal, J. et al., 2009. Selecting pseudo-absence data for presence-only distribution modeling: How far should you stray from what you know? *Ecological Modelling*, 220(4), pp.589-594.

##### Scale/Predictor variables:

- Ashcroft, M.B., French, K.O. & Chisholm, L.A., 2011. An evaluation of environmental factors affecting species distributions. *Ecological Modelling*, 222(3), pp.524-531.

- Guisan, A. et al., 2007. Sensitivity of predictive species distribution models to change in grain size. Available at: [http://eprints.jcu.edu.au/2333/1/17262\\_Guisan\\_et\\_al\\_2007.pdf](http://eprints.jcu.edu.au/2333/1/17262_Guisan_et_al_2007.pdf) [Accessed January 15, 2012].

#### Assessing outcomes:

- Fitzpatrick, M.C. et al., 2007. The biogeography of prediction error: why does the introduced range of the fire ant over-predict its native range? *Global Ecology and Biogeography*, 16(1), pp.24-33.
- Hanspach, J. et al., 2011. Geographical patterns in prediction errors of species distribution models. *Global Ecology and Biogeography*, 20(5), pp.779-788.
- Heikkinen, R.K., Marmion, M. & Luoto, M., Does the interpolation accuracy of species distribution models come at the expense of transferability? *Ecography*. Available at: <http://onlinelibrary.wiley.com.ezproxy.lib.utexas.edu/doi/10.1111/j.1600-0587.2011.06999.x/abstract>
- Mouton, A.M., De Baets, B. & Goethals, P.L.M., 2010. Ecological relevance of performance criteria for species distribution models. *Ecological Modelling*, 221(16), pp.1995-2002.
- Nenzén, H.K. & Araújo, M.B., 2011. Choice of threshold alters projections of species range shifts under climate change. *Ecological Modelling*, 222(18), pp.3346-3354.
- Peterson, A.T., Papeş, M. & Eaton, M., 2007. Transferability and model evaluation in ecological niche modeling: a comparison of GARP and Maxent. *Ecography*, 30(4), pp.550-560.
- Zanini, F., Pellet, J. & Schmidt, B.R., 2009. The transferability of distribution models across regions: an amphibian case study. *Diversity and Distributions*, 15(3), pp.469-480.

#### Uncertainty:

- Araújo, M. et al., 2005. Reducing uncertainty in projections of extinction risk from climate change. *Global Ecology & Biogeography*, 14(6), pp.529-538.
- Buisson, Laëtitia et al., 2010. Uncertainty in ensemble forecasting of species distribution. *Global Change Biology*, 16(4), pp.1145-1157.
- Diniz-Filho, J.A.F. et al., 2009. Partitioning and mapping uncertainties in ensembles of forecasts of species turnover under climate change. *Ecography*, 32(6), pp.897-906.
- Dormann, C.F. et al., 2008. Components of Uncertainty in Species Distribution Analysis: A Case Study of the Great Grey Shrike. *Ecology*, 89(12), pp.3371-3386.
- Grenouillet, Gael et al., 2011. Ensemble modelling of species distribution: the effects of geographical and environmental ranges. *Ecography*, 34(1), pp.9-17.

#### Simulated Data:

- Bahn, V., Krohn, W.B. & O'Connor, R.J., 2008. Dispersal leads to spatial autocorrelation in species distributions: A simulation model. *Ecological Modelling*, 213(3-4), pp.285-292.
- De Marco, P., Diniz-Filho, J.A.F. & Bini, L.M., 2008. Spatial analysis improves species distribution modelling during range expansion. *Biology Letters*, 4(5), pp.577-580.
- Meynard, C.N. & Quinn, J.F., 2007. Predicting species distributions: a critical comparison of the most common statistical models using artificial species. *Journal of Biogeography*, 34(8), pp.1455-1469.
- Pitt, J.P.W., Worner, S.P. & Suarez, A.V., 2009. Predicting Argentine ant spread over the heterogeneous landscape using a spatially explicit stochastic model. *Ecological Applications*, 19(5), pp.1176-1186.

#### Spatial autocorrelation:

- Bahn, V., Krohn, W.B. & O'Connor, R.J., 2008. Dispersal leads to spatial autocorrelation in species distributions: A simulation model. *Ecological Modelling*, 213(3–4), pp.285-292.
- Bahn, V., O'Connor, R. & Krohn, W., 2006. Importance of spatial autocorrelation in modeling bird distributions at a continental scale. *Ecography*, 29, pp.835-844.
- Kühn, I., 2007. Incorporating spatial autocorrelation may invert observed patterns. *Diversity and Distributions*, 13(1), pp.66-69.
- Segurado, P., Araújo, M. & Kunin, W., 2006. Consequences of spatial autocorrelation for niche-based models. *Journal of Applied Ecology*, 43, pp.433-444.
- Václavík, T., Kupfer, J.A. & Meentemeyer, R.K., 2012. Accounting for multi-scale spatial autocorrelation improves performance of invasive species distribution modelling (iSDM). *Journal of Biogeography*, 39(1), pp.42-55.

#### **Spatial nonstationarity:**

- Bickford, S. & Laffan, S., 2006. Multi-extent analysis of the relationship between pteridophyte species richness and climate. *Global Ecology & Biogeography*, 15, pp.588-601.
- Kupfer, J. & Farris, C., 2007. Incorporating spatial non-stationarity of regression coefficients into predictive vegetation models. *Landscape Ecology*, 22, pp.837-852.
- Martín-Queller, E., Gil-Tena, A. & Saura, S., 2011. Species richness of woody plants in the landscapes of Central Spain: the role of management disturbances, environment and non-stationarity. *Journal of Vegetation Science*, 22(2), pp.238-250.
- Osborne, P., Foody, G. & Suárez-Seoane, S., 2007. Non-stationarity and local approaches to modelling the distribution of wildlife. *Diversity and Distributions*, 13, pp.313-323.
- Powney, G.D. et al., 2010. Hot, dry and different: Australian lizard richness is unlike that of mammals, amphibians and birds. *Global Ecology and Biogeography*, 19(3), pp.386-396.

#### **Effects of climate change:**

- Araújo, M. et al., 2005. Reducing uncertainty in projections of extinction risk from climate change. *Global Ecology & Biogeography*, 14(6), pp.529-538.
- Beaumont, L.J., Hughes, L. & Pitman, A.J., 2008. Why is the choice of future climate scenarios for species distribution modelling important? *Ecology Letters*, 11(11), pp.1135-1146.
- Fitzpatrick, M.C. & Hargrove, W.W., 2009. The projection of species distribution models and the problem of non-analog climate. *Biodiversity and Conservation*, 18(8), pp.2255-2261.
- Nogués-Bravo, D., 2009. Predicting the past distribution of species climatic niches. *Global Ecology and Biogeography*, 18(5), pp.521-531.