

GRG396T: Species Distribution Modeling (Spring 2014)

Tuesday 5:00-8:00

CLA 4.106

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OFFICE HOURS: Tu, Th 3:30- 4:30 or by appt.

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 inductive modeling applications, we will focus on species distribution models (SDM) as the application area. There is no formal lab component although students are expected to be sufficiently familiar 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 weekly discussion will focus on 2-4 required articles per week that pertain to a specific technical or conceptual aspect of SDM, as well as 1-2 related articles presented by a student. All of the readings (listed in references below) are available on-line. Students should use the list of recommended references associated with each week's theme 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.

RECOMMENDED BOOK: Franklin, J. (2009) [Mapping Species Distributions: Spatial Inference and Prediction](#). It's not required, but this book is a great introduction to and extensive overview of SDM and would be a really useful complement to the topics we'll discuss.

ASSESSMENT: Your grade will be determined based on an article report, group SDM exercise, final project (paper & presentation), and contribution to class discussion.

- ❖ *Discussion leader & article summary (20%):* Students will be responsible for leading discussions 1-2 times per semester. The discussion will be based primarily on an article selected from the list of [recommended references](#) and the article should be discussed in the context of that day's topic. The discussion leader should also submit at the beginning of class a summary of the article and 'bullet points' (interesting things, issues) they plan to discuss (can be 1-2 pages typed).
- ❖ *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.
- ❖ *Weekly summary (15%):* At the beginning of (almost) each class, students will submit a 1 page 'mini review' of the week's topic based on the articles read. 'WS' in the deliverable section below indicates the days these are submitted. On the days that you are discussion leader, you must submit both the weekly summary pertaining to all articles as well as the summary pertaining to the recommended article you are discussing.
- ❖ *Final project (40%):* The final 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) and will be due by 5 pm on May 2. A rubric will be available on Blackboard.
- ❖ *Participation (5%):* 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 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	Deliverable/(student discussant)
Jan. 14	Introduction/course overview		
Jan. 21	Introduction to species distribution models (SDM)	Guisan & Zimmermann (2000) Elith & Leathwick (2009)	
Jan. 28	SDM: concepts & theory	Araújo & Peterson (2012) Guisan et al. (2013) Jiménez-Valverde et al. (2008) Soberón J and Nakamura M (2009)	WS
Feb. 4	SDM components: response data	Vaughan & Ormerod (2003) Lobo et al. (2010) TBA	WS Student
Feb. 11	Scale SDM components: predictor data Prospectus due	Goodchild (2011) Parra et al. (2004) Pradervand et al. (2013) TBA	WS Student
Feb. 18	SDM components: statistical methods	Elith et al. (2006) Elith & Graham (2009) TBA	WS Student
Feb. 25	SDM components: assessing outcomes (accuracy & transferability)	Randin et al. (2006) Liu et al. (2011) TBA	WS Student
Mar. 4	SDM issues: uncertainty (& climate change applications)	Anderson RP (2013) Araújo & New (2007) Beale & Lennon (2012) TBA	WS Student
Mar. 11	Spring Break		
Mar. 18	SDM issues: spatial autocorrelation	Bahn & McGill (2007) Dormann (2007) Kühn (2007) TBA	WS Student
Mar. 25	SDM applications: simulated data	Elith & Graham (2009) Miller (2014, in press) Zurell et al. (2010) TBA	WS Student

Date	Topic(s)	Required readings	Deliverable/(student discussant)
Apr. 1	SDM issues: spatial nonstationarity	Foody (2004) Jetz et al. (2005) Eiserhardt et al. (2011) Fotheringham (2009) TBA	WS Student
Apr. 8	No Class		
Apr. 15	SDM applications: movement	Fortin et al. (2005) Franklin (2010) Engler R and Guisan A (2009) TBA	WS Student SDM exercise results due Apr. 14 by 5 pm
Apr. 22	Wrap-up	TBA	
Apr. 29	Student paper presentations		
	Final paper due by 5 pm, Friday May 2		

MISCELLANEOUS DETAILS AND INFORMATION FOR GRG396T:

PROSPECTUS: A 1-2 page prospectus that outlines your plan for the final project will be due at the beginning of class on Feb. 11. The prospectus should consist of your research question, data description, and the methods you intend to use, as well as what your intended outcome. 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 product, a species distribution map, on April 14 by 5 pm. Each group will submit a report outlining the steps they took, subjective decisions made, and each individual's contribution.

REQUIRED REFERENCES:

- Anderson RP (2013) A framework for using niche models to estimate impacts of climate change on species distributions. *Annals of the New York Academy of Sciences*, 1297(1), 8–28.
- Araújo, M.B. & New, M., 2007. Ensemble forecasting of species distributions. *Trends in Ecology & Evolution*, 22(1), pp.42-47.
- Araújo, Miguel B., and A. Townsend Peterson. 2012. Uses and misuses of bioclimatic envelope modeling. *Ecology* 93:1527–1539. <http://dx.doi.org.ezproxy.lib.utexas.edu/10.1890/11-1930.1>
- 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.
- Dormann C (2007) Effects of incorporating spatial autocorrelation into the analysis of species distribution data. *Global Ecology and Biogeography*, 16, 129–138.

- 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, Anderson R, et al. (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography*, 29(2), 129–151.
- 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.
- Engler R and Guisan A (2009) MigClim: Predicting plant distribution and dispersal in a changing climate. *Diversity and Distributions*, 15(4), 590–601.
- Fortin, D., Beyer, H.L., Boyce, M.S., Smith, D.W., Duchesné, T. & Mao, J.S. (2005). Wolves influence elk movements: behavior shapes a trophic cascade in Yellowstone National Park. *Ecology*, 86, 1320–1331.
- Fotheringham, A.S., 2009. “The problem of spatial autocorrelation” and local spatial statistics. *Geographical Analysis*, 41(4), pp.398–403.
- Franklin, J. 2010. Moving beyond static species distribution models in support of conservation biogeography. *Diversity and Distributions* 16(3), pp. 321-330.
- Goodchild, M.F., 2011. Scale in GIS: An overview. *Geomorphology*, 130(1-2), pp.5-9.
- Guisan A, Tingley R, Baumgartner JB, et al. (2013) Predicting species distributions for conservation decisions. *Ecology Letters*, 16(12), 1424–1435.
- Guisan, A. & Zimmermann, N., 2000. Predictive habitat distribution models in ecology. *Ecological Modelling*, 135, pp.147-186.
- 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.
- Kühn, I., 2007. Incorporating spatial autocorrelation may invert observed patterns. *Diversity and Distributions*, 13(1), pp.66-69.
- 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.
- 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.
- Miller, J. (2014, in press). Virtual species distribution models: using simulated data to evaluate aspects of model performance. *Progress in Physical Geography*.
- 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.
- Pradervand J-N, Dubuis A, Pellissier L, et al. (2013) Very high resolution environmental predictors in species distribution models: Moving beyond topography? *Progress in Physical Geography*, 0309133313512667.
- Randin, C.F. et al., 2006. Are niche-based species distribution models transferable in space? *Journal of Biogeography*, 33(10), pp.1689-1703.
- Soberón J and Nakamura M (2009) Niches and Distributional Areas: Concepts, Methods, and Assumptions. *Proceedings of the National Academy of Sciences of the United States of America*, 106, 19644–19650.
- 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.

- 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:

- Barbet-Massin, M., Jiguet, F., Albert, C. H. and Thuiller, W. (2012), Selecting pseudo-absences for species distribution models: how, where and how many? *Methods in Ecology and Evolution*, 3: 327–338. doi: 10.1111/j.2041-210X.2011.00172.x
- Feeley, K. J. and Silman, M. R. (2011), Keep collecting: accurate species distribution modelling requires more collections than previously thought. *Diversity and Distributions*, 17: 1132–1140. doi: 10.1111/j.1472-4642.2011.00813.x
- Li, W., Guo, Q. & Elkan, C. (2011) Can we model the probability of presence of species without absence data? *Ecography*, 34, 1096–1105.
- 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:

- Franklin, J., Davis, F. W., Ikegami, M., Syphard, A. D., Flint, L. E., Flint, A. L. and Hannah, L. (2013), Modeling plant species distributions under future climates: how fine scale do climate projections need to be? *Global Change Biology*, 19: 473–483. doi: 10.1111/gcb.12051
- 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 [Accessed January 15, 2012].
- Cord AF, Klein D, Mora F, et al. (2014) Comparing the suitability of classified land cover data and remote sensing variables for modeling distribution patterns of plants. *Ecological Modelling*, 272, 129–140.

Statistical methods:

- Elith J, Kearney M and Phillips S (2010) The art of modelling range-shifting species. *Methods in Ecology and Evolution*, 1(4), 330–342.
- Lawler JJ, White D, Neilson RP, et al. (2006) Predicting climate-induced range shifts: model differences and model reliability. *Global Change Biology*, 12(8), 1568–1584.
- Pearson RG, Thuiller W, Araújo MB, et al. (2006) Model-based uncertainty in species range prediction. *Journal of Biogeography*, 33(10), 1704–1711.
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Assessing outcomes:

- Bahn, V. and McGill, B (2012/in press). Testing the predictive performance of distribution models. *Oikos*. DOI: 10.1111/j.1600-0706.2012.00299.x

- 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. and Luoto, M. (2012), Does the interpolation accuracy of species distribution models come at the expense of transferability?. *Ecography*, 35: 276–288. doi: 10.1111/j.1600-0587.2011.06999.x
- 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.
- Roberts, D.R. & Hamann, A. (2012) Method selection for species distribution modelling: are temporally or spatially independent evaluations necessary? *Ecography*. DOI 10.1111/j.1600-0587.2011.07147.x.
- Smulders M, Nelson TA, Jelinski DE, et al. (2010) A spatially explicit method for evaluating accuracy of species distribution models. *Diversity and Distributions*, 16(6), 996–1008.
- 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.
- Lawler JJ, White D, Neilson RP, et al. (2006) Predicting climate-induced range shifts: model differences and model reliability. *Global Change Biology*, 12(8), 1568–1584.
- Pearson RG, Thuiller W, Araújo MB, et al. (2006) Model-based uncertainty in species range prediction. *Journal of Biogeography*, 33(10), 1704–1711.

Spatial autocorrelation:

- 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.
- Crase B, Liedloff AC and Wintle BA (2012) A new method for dealing with residual spatial autocorrelation in species distribution models. *Ecography*, 35(10),): 879–888.
- 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.

Simulated Data:

- Barbet-Massin M, Jiguet F, Albert CH, et al. (2012) Selecting pseudo-absences for species distribution models: how, where and how many? *Methods in Ecology and Evolution*, 3(2):, 327–338.
- Meynard, C. N., Kaplan, D. M. (2013), Using virtual species to study species distributions and model performance. *Journal of Biogeography*, 40: 1–8. doi: 10.1111/jbi.12006
- Santika, T. (2011) Assessing the effect of prevalence on the predictive performance of species distribution models using simulated data. *Global Ecology and Biogeography*, 20, 181–192.
- Saupe EE, Barve V, Myers CE, et al. (2012) Variation in niche and distribution model performance: The need for a priori assessment of key causal factors. *Ecological Modelling*, 237–238, 11–22.

Movement:

- Barve N, Barve V, Jiménez-Valverde A, et al. (2011) The crucial role of the accessible area in ecological niche modeling and species distribution modeling. *Ecological Modelling*, 222(11), 1810–1819.
- Elith J, Kearney M and Phillips S (2010) The art of modelling range-shifting species. *Methods in Ecology and Evolution*, 1(4), 330–342.
- Schloss CA, Nuñez TA and Lawler JJ (2012) Dispersal will limit ability of mammals to track climate change in the Western Hemisphere. *Proceedings of the National Academy of Sciences*, 109(22), 8606–8611.
- Travis MJ, Mustin K, Bartoń KA, et al. (2012) Modelling dispersal: an eco-evolutionary framework incorporating emigration, movement, settlement behaviour and the multiple costs involved. *Methods in Ecology and Evolution*, 3(4), 628–641.