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TRACKING TRENDS & PERFORMANCE IN BASIC RESEARCH

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Special Topics : Climate Change : Steven Phillips, Rob Anderson, & Rob Schapire Interview - Special Topic of Climate Change

AUTHOR COMMENTARIES - From Special Topics

Climate Change - November 2009
Interview Date: November 2009

PDF

Steven Phillips, Rob Anderson, & Rob Schapire

From the Special Topic of Climate Change

In the Research Front Map "Climate Change and Species Distributions," which is part of our Special Topics analysis of Climate Change research over the past decade, the paper "Maximum entropy modeling of species geographic distributions," (Phillips SJ, Anderson RP, Schapire RE, Ecol. Model. *190[3-4]: 231-59, 25 January 2006) has 192 cites. This paper is also a Highly Cited Paper in the field of Environment & Ecology in* Essential Science IndicatorsSM from Thomson Reuters.

Authors Dr. Steven Phillips, Dr. Robert P. Anderson, and Dr. Robert Schapire are also in the top 1% among scientists in this field in the database. Dr. Phillips is a Lead Member of Technical Staff, Research, at AT&T Labs in Florham Park, NJ; Dr. Anderson is an Associate Professor in the Department of Biology at the City College of the City University of New York in New York City; and Dr. Schapire is Professor of Computer Science at Princeton University in Princeton, NJ.

Below, they talk with* ScienceWatch.com *about their paper, its impact on conservation research, and the future of ecological modeling.

SW: Would you please describe the significance of your paper and why it is highly cited?

Our paper introduced a mathematically rigorous method (Maxent) for modeling species geographic distributions, based on known occurrences and environmental (especially climatic) predictor variables. Applying such models to predicted future climatic conditions enables prediction of climate-change impact on individual species, so ecologists can better understand the likely scope of climate change as a threat to biodiversity. Maxent relies on data for species presences (such as from natural history museums and herbaria) rather than presence/absence surveys, which allows for modeling of many more species. Although other techniques are available for this, ours has a clear mathematical formulation with explicit assumptions and links to ecological theory, and is available in user-friendly, free software.

SW: How did you become involved in this research, and were there any particular successes or obstacles that stand out?

Steven Phillips was seeking ways for a computer scientist to contribute to conservation. He learned of the uses of species distribution models while volunteering at the Center for Biodiversity and Conservation at the American Museum of Natural History, where Rob Anderson was modeling mammal distributions. Rob Schapire, a colleague of Steven's at AT&T Research at the time, is a machine-learning specialist. Together, we decided to see how machine learning could help to model species distributions.

Two major successes:

1. Early on, our research team was joined by Miroslav Dudík, a Ph.D. student working with Rob Schapire. Miro made major contributions to the theory and implementation of Maxent that followed the publication of this first paper.

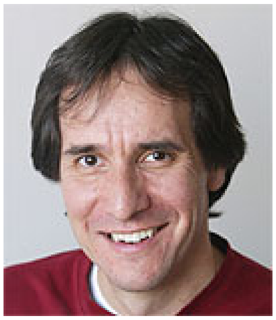
2. Our Maxent software participated in a species-distribution modeling "bakeoff"—a comparison of the performance of a wide variety of modeling methods (Elith J, *et al., Ecography*, 2006). Maxent and boosted regression trees emerged as the two highly performing methods in that study.

Two obstacles:

1. Machine learning and ecology use different and specialized vocabulary, so the collaboration required each of us to learn a new language, in some cases even new meanings for the same word from our original discipline.

2. Biological data are particularly challenging: by machine-learning standards, the amount of occurrence data available for modeling many species is miniscule, especially for rare species which are of special concern. In addition, there are multiple biases in the data, and absence data are missing for most species, making both modeling and model evaluation difficult. These challenges have all yielded fruitful topics for new research in machine learning.

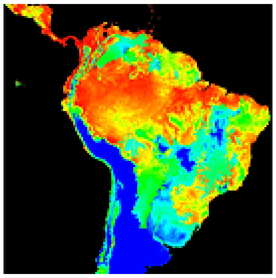
Rob Anderson



Rob Schapire

Steven Phillips in a baobab in Madagascar...

[+] details



A Maxent model of the distribution of Bradypus variegatus...

[+] details

SW: Where do you see your research and the broader field leading in the future?

Recent publications have shown that predictions from different species-distribution models can vary widely, especially when predicting species distributions under climate change. Such variations are driven by climate-model uncertainty; by data issues such as bias, small sample sizes and missing predictors; by mathematical differences among modeling methods; and by the fact that models consider only a portion of the inherent complexity of ecological systems.

In addition to better addressing each of these sources of error, we need better ways to evaluate predictions of future distributions, and ways to estimate and communicate the degree of confidence in predictions. Finally, since many important applications (including climate change and invasive species) require models of species distributions that are transferable across space and/or time, additional tests of model performance in this arena (rather than of species' current distributions) are necessary.

Both for ourselves and our respective fields, we look forward to further fruitful collaborations and applications of machine learning, computer science, and statistics to problems in ecology.

SW: What are the implications of your work for this field?

The technique has and will continue to be used for myriad applications related to climate change and species distributions. Examples include the study of niche evolution and speciation, discovery of new populations of rare species, large-scale conservation planning and site prioritization, prediction of the spread of invasive species, and anticipation of outbreaks of zoonotic and other kinds of diseases.

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Steven Phillips, Rob Anderson, & Rob Schapire's current most-cited paper in *Essential Science Indicators*, with 340 cites:

Elith J, *et al*., "Novel methods improve prediction of species' distributions from occurrence data," *Ecography* 29(2): 129-151, April 2006. Source: *Essential Science Indicators* from Thomson Reuters.

Rob Schapire is featured in ISIHighlyCited.com.

KEYWORDS: MAXENT, MODEL, SPECIES GEOGRAPHIC DISTRIBUTIONS, KNOWN OCCURENCES, ENVIRONMENTAL PREDICTOR VARIABLES, CLIMACTIC CONDITIONS, CLIMATE-CHANGE IMPACT, BIODIVERSITY, MACHINE LEARNING, BIOLOGICAL DATA.

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