

IN SCIENCE, ALL MODELS ARE WRONG BUT SOME MODELS ARE USEFUL

The word “model” means many different things in our modern society. We speak of a new model of car, model the latest clothing or fashions, and build model railroads or rockets in our basements and backyards. Many of us are also familiar with the North American Model of Wildlife Conservation—a set of foundational principles that describes the highly successful form of wildlife management originally developed by conservation pioneers affiliated with the Boone and Crockett Club, which has been now successfully implemented in the United States and Canada for nearly a century. One of the foundational principles of the North American Model, as articulated in a 2012 review published by The Wildlife Society, is that “science is the proper tool for discharge of public policy.” According to this model, then, understanding science and the information that science can provide is a critically important step toward the development of sound wildlife management and policy.

In science, we find that the word “model” has a fairly specific meaning. It refers to a physical, mathematical, or conceptual representation of a system, often using diagrams or mathematical formulas, which attempts to represent some aspect of the world and provide insights into the workings of certain processes. A scientific model may be as simple as a flowchart or diagram on a piece of paper, or it may be so mathematically complex as to require the vast computational powers of a supercomputer to provide meaningful

insights into the workings of the modeled system.

WILDLIFE MODELS

Wildlife scientists often use models to study various aspects of animal species and their biology, and to predict how species and habitats might respond to changing conditions over time. In this regard, scientists are no different than those of us in our society who use scientific or science-based models, whether those models help to inform daily weather forecasts, give insights into the performance of the financial markets, or provide investors with information on the best place to open a new business location.

In the field of wildlife management, models are widely used to help managers understand what is happening with wildlife populations and to examine how various management interventions might affect a species or its habitats. One of the most famous wildlife models is the coupled predator-prey model, which is taught to students in introductory biology classes and advanced mathematics classes in colleges and universities around the world. In this quantitative model, fluctuations in one species (the prey) trigger fluctuations in the other species (the predator) resulting in a series of repetitive cyclings, which closely resemble the boom-bust population dynamics that can be observed in many real-world predator-prey interactions. Take, for instance, Canada lynx and snowshoe hare.

Wildlife managers also use models to understand the demographics and population trends of harvested species. Species-habitat models give managers a set of tools to

estimate the population capacity of an area and to examine how habitat improvements might increase populations of desired species. Demographic models provide managers with an understanding of population age structure and sex ratios, enabling the development of detailed harvest and management recommendations for particular populations. Climatological models help managers understand how fluctuations in weather and climate can affect populations of a particular species. And models of population structure and gene flow, derived from newly available genetic and genomic data, can help inform refinements to the conservation and management prescriptions for a species.

I recently had the pleasure and privilege of speaking with Dr. Thomas Edwards, one of the nation’s leading ecological modelers, who recently retired from my program, the USGS Cooperative Fish and Wildlife Research Unit Program. Dr. Edwards has spent many decades refining the practice of ecological modeling and has trained literally hundreds of students and wildlife professionals in the methods used by wildlife scientists to model natural systems. His specialty is species distribution modeling, a scientific discipline that uses information about the places we find species—the habitat features, vegetation, underlying geology, soils, elevation, slope, aspect, and so forth—to help predict where else the species might occur on the landscape. The models produced by Dr. Edwards are geospatially explicit, meaning that a key output is a geographic map with areas of suitability for a species



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indicated by markers or by some sort of shading, which indicates greater or lesser habitat suitability for the species in question. Dr. Edwards’ models are often used by conservation agencies to help identify occurrences of rare species on larger landscapes, so that mitigation and conservation measures can be directed more effectively towards these species. But the same approaches can also be used by wildlife managers when planning species translocation or habitat restoration efforts. If we can identify the key habitat features and environmental factors that support a species in one place, then it stands to reason that the species *may* thrive at a different locality, which also has those same habitat features and environmental factors.

I emphasize the word “may” in the previous paragraph for good reason. One of Dr. Edwards’ favorite sayings is that “all models are wrong, but some models are useful.” Just because a model makes a prediction or suggests that a species may occur at a particular point on the landscape, does not necessarily make it so! In the effort to simplify complex relationships among biotic and abiotic factors, models inevitably leave out some factor or another, which inevitably makes the model’s output less than precise. We see this easily with weather forecasts,

where short-term predictions (on the order of hours to days) are usually reasonably accurate, but the accuracy of predictions declines the further out you go into the future. Wildlife population dynamics and species-habitat relations are likewise highly complex, and thus our abilities to accurately predict population behavior or changes over time are also going to be limited.

But this does not mean that the entire modeling enterprise is a waste of time! In the case of Dr. Edwards' species distribution models, the models are genuinely useful in that they suggest areas where researchers can search and potentially find rare species or where species translocation efforts could potentially be successful. Narrowing down the field of possible study sites is undoubtedly an important first step. But this is only a first step. What is needed is to couple the modeling effort with good old-fashioned boots-on-the-ground fieldwork where wildlife biologists actually get outdoors and look for the rare species, or conduct a habitat assessment for translocation at the sites recommended by the model. The maps provided by the species distribution models are a good place to start, but at the end of the day there is really no substitute for biologists getting into the field and seeing the locations for themselves. This process, called "ground truthing," is a critical step in validating the output of scientific models and ensuring that scarce conservation resources are in fact being directed toward the best available sites on the ground. It is also expensive to send biologists into the field, which is why we often see modeling efforts being published or reported with little or no ground truthing.

With all this in mind, it is absolutely appropriate for wildlife managers, conservation

leaders, and members of the general public to ask some questions of the scientists who are developing models. Some of the more relevant questions include: What data sources are you using, and how do you know that you are using the most relevant and complete data sets available? Which agency/ies provided data for your effort and which did not? Are your modeling methods open, replicable, and transparent to outside scientists and the interested public? Have your models and modeling outputs been peer-reviewed by knowledgeable experts on the species or ecosystems you are modeling? Have your modeling studies been published in a reputable peer-reviewed scientific journal? What ground truthing efforts or other validation studies have been conducted to date, and what did those efforts find?

Models can be useful tools for wildlife management, but as we have seen here, there are important caveats and considerations accompanying their use. Programs such as the one that I administer, the USGS Cooperative Fish and Wildlife Research Unit Program, have a long history of bringing scientists together with wildlife managers at state and federal agencies to develop models that will actually be useful in real-world management of species and their habitats. Working together, scientists and managers can help ensure that these complex and easily misunderstood tools will help to provide us with the information that will be necessary to continue the long and highly successful tradition of wildlife conservation and management in North America. ■



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An example of "ground truthing"—Dan Morina, a University of Montana B&C fellow conducting fieldwork on the Theodore Roosevelt Memorial Ranch.

