Regulatory Science: Factors Limiting Species Populations, Part I (Newsletter)*

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There are many plant and animal species considered to be threatened, endangered, or of special concern to regulators and the public. Correctly estimating population sizes, relationship to habitats, and potential effects of anthropomorphic activities is crucial to making informed policy and regulatory decisions.

Environmental conditions affecting species populations are the limiting factors. Quantifying limiting factors is fundamental to developing policies and practices that are most likely to create the desired future conditions for the species and its habitats. When limiting factor analyses are incomplete or otherwise flawed policies and regulations are ineffective and result in environmental and economic harm. One reason for ineffective limiting factors analysis is treating biological data the same as more familiar types of continuous data.

The differences between biological data and business, financial, or economic data are important. Biological data require different statistical models and paradigms than those taught in introductory statistics courses.

Biological data are either counts or presence/absence of individuals; integers rather than a continuum of values such as temperature or chemical concentration. Counts and presence/absence (binomial data) cannot be fit to the familiar normal ("bell-shape") distribution. Count data fit a Poisson distribution (predicting the probability of a given number of counts) while presence/absence data fit a logistic distribution (similar to the normal distribution but with a heavier right-side tail.) Descriptive and summary statistics must use the proper parametric distribution or non-parametric approaches such as those based on Bayes' theory.

When we want to identify limiting factors for a species (e.g., greater sage-grouse, bull trout, spotted frogs) we use the count or presence/absence data as the response variable with potential explanatory variables using an appropriate regression model (Poisson, logistic, Bayesian) to quantify cause and effect.

Most readers are familiar with regression plots (the response variable on the Y-axis and the explanatory variable on the X-axis) and the regression model summary statistic of R-squared which represents the proportion of the response variable explained by the regression line on the plot. While this frequentist paradigm can provide useful insights that inform policy and regulatory decisions, there is increasing unease among ecologists and environmental scientist with this approach. The response is a growing acceptance of Bayesian methods that incorporate existing knowledge and prior experience in predicting future conditions. While the mathematical basis for statistical models is unfamiliar, everyone qualitatively applies prior knowledge to making daily decisions.

Commuters try to select a starting time and route based on past experiences of getting from home to work, and back again. Fishers and hunters return to locations that have been productive in the past. Corporate executives and lawyers select strategies and plans based on what worked well for them before. Bayesian statistical models quantify these decisions using a robust mathematical base.

Thomas Bayes was an 18th Century statistician, philosopher, and minister who developed a mathematical basis for calculating the probability of a specific outcome based on knowledge of prior conditions. His method was slow to be adopted, a situation that still exists. The value for policy and regulatory decision makers of applying Bayesian models to identify and quantify limiting factors of species populations will be explained in this series of newsletters.

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