Bringing Environmental Policy and Regulation into the 21st Century, Part 3 (Newsletter)*

December 11, 2015

The frequentist and likelihood frameworks for analyzing environmental data assume that there is a "true" state of the world represented by the values described by a single hypothesis and its probability distribution. The Bayesian framework assumes that observations are the "truth" while the hypotheses explaining the observations have probability distributions. The Bayesian approach solves many conceptual problems of applying the frequentist approach to environmental data because Bayesian results depend on observations (or measurements) rather than on a range of hypothetical outcomes. Also the Bayesian approach allows comparison of the probabilities of different hypotheses explaining the observations.

The major criticism of the Bayesian approach is that it requires specifying prior beliefs about the probability of different hypotheses explaining the observations, and these prior beliefs affect the results. This potential subjectivity is removed by using existing data or setting all potential hypotheses to the same probability. The advantages of the Bayesian approach include ease of interpretation, incorporation of existing data into the analytical results, accommodation of complex models with missing or irregular data and different patterns of variability, and the ability to include unlikely or catastrophic outcomes. All these situations are common in environmental data.

The Bayesian framework implements Bayes' theorem describing the probability of an event based on the probability of a related event. That is, determine the probability of observing event A given that event B is true. This is the situation with most animal population assessments such as those for the sage grouse, salmon and trout, bats, and other species of concern.

Animals are not always seen when a location is visited. The presence or absence of an species by direct observation or mark/recapture efforts requires incorporation of previous knowledge into the statistical analyses for valid results. These conditions occur when sites are revisited, when policy or regulatory decisions need to be made about potential habitats that have no prior

*Copyright ©2015 Applied Ecosystem Services, Inc.

data, and when assessing potential affects on a species' population or habitats by human activities.

Consider the wildlife biologist who surveys proposed mining or grazing areas for sage grouse. On a visit to a site he carefully looks for an hour, but sees no birds. However, he would not be particularly surprised that the species was not seen because experience of surveying similar habitats found that sage grouse are detected only 80% of the time when they are actually present. While this area has excellent sage grouse habitats, not seeing birds on a visit does not mean that they do not occupy it.

The frequentist approach would estimate the probability of not finding birds based on the defined hypothesis while the Bayesian approach estimates the probability of a hypothesis being true if no birds were observed. The former fits the data to a pre-determined model, the latter fits a model to the observed data.

Applying an appropriate Bayesian model to the sage grouse data finds that the probability of sage grouse being present but not seen at this site is approximately 0.375 and the probability of it being absent is approximately 0.625. If prior knowledge of sage grouse presence in this type of habitat was not incorporated into the statistical analysis the probability that sage grouse were present but not seen would be 0.167.

While the Bayesian framework for analyzing environmental data is not as familiar to regulators and policy makers as is the frequentist framework, it is more technically sound and legally defensible and should be used when making policy and regulatory decisions that have great importance to the public, the natural resource industries, and the species of concern.