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

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Habitat use is one of the first factors considered when determining limitations on species abundance and distribution. For species being considered for some level of protection there are existing data describing habitats in which they have been found as well as abundance estimates.

When projects are proposed in areas with potential habitats for the species it is common to survey these habitats for the species' presence. The survey methods seek data to answer this question: What is the probability of the species occupying a site if it is not observed during a visit?

This question cannot be answered using frequentist (null hypothesis significance testing) statistical models because these measure frequencies of long-term averages rather than predicting the probability of a single observation.

Because data exist for the presence of the species in the habitat type even when they are not observed, these data are used to calculate the probability of the species being present but not observed. This prior information is applied using Bayes' Rule of conditional probability: the probability of the species being present but unobserved given that it has been seen in these habitats in other locations. The proportion of prior observations of the species in this habitat is the prior probability of its presence in the one being surveyed..

The prior probability is combined with the probabilities of obtaining the observed data of the visited habitat under all hypotheses (species present or species absent). The probability that a hypothesis is true increases if the data support it more than they support competing hypotheses.

For example, the probability of the species being observed in other surveys of this habitat is 80% when it is known to be present there, with a 20% probability that it was present but not observed. If the probability of the species being present or absent in any visit are equal (each = 0.5), and the species was not observed, then the likelihood of it being present is 0.2 x 0.5 = 0.1 and the likelihood of it being absent is 1.0 x 0.5 = 0.5. The posterior probabilities must sum to 1.0, so the proportional values 0.5 and 0.1 are converted to probabilities by dividing each by their sum (0.6). Under the above conditions the probability of the species being present but unobserved is 0.1/0.6 = 0.17 (17%) and the probability of it being absent is 0.5/0.6 = 0.83 (83%).

This analytical approach can accommodate additional prior information. Consider that other surveys in the region have found predators of the species killing young or adults. In this case, the analyst might determine that the likelihood of the species being present is 0.15 and of it being absent is 0.85. Now the likelihood of the species being present is 0.2 x 0.15 = 0.03 and the likelihood of it being absent is 1.0 x 0.85 = 0.85. When converted the posterior probabilities of the species being present but unobserved is 0.04 (4%) and of being absent is 0.96 (96%).

The null hypothesis significance testing paradigm has only two hypotheses: the null and the alternative, and only the null is tested for truth. The Bayesian paradigm accommodates as many hypotheses for which there are data or other reasons to set prior probabilities. And all hypothesis are tested for truth in explaining the observed data.

Incorporating prior information about the species' abundances and other factors affecting its population size at a particular location makes this approach to analyzing complex natural ecosystems better able to inform choices by operators as well as those who make environmental policy and regulation. When decisions on species abundance in habitats of interest are based on a Bayesian statistical model they are more technically sound and legally defensible.

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