Species Populations, Their Habitats, and Opportunity Costs (Newsletter)*

January 8, 2018

Natural resource operators are directly affected by habitat preservation requirements for species listed under the ESA and state equivalents. One possible explanation is that environmental decision-makers do not have sufficient information, ecological training, or appropriate analytical tools so they fall back on the precautionary principle (hope for the best, prepare for the worst) and declare that all actual and potential habitat for the species be left untouched for population sustainability. This is both unnecessary and wasteful as there are robust statistical and spatio-temporal models that can inform technically sound and legally defensible decisions, even with limited data.

Species sustainability decisions require knowledge of population abundance, distribution, and habitat use. This knowledge often comes from the likelihood of the species being present but not observed in a habitat. The typical methods for getting useful knowledge do not provide answers.

For many species presence or absence in a habitat plays a major role in determining whether an operation is approved. Species presence/absence and counts estimate population abundance and distribution and whether a specific habitat must be preserved.

As an example: the Oregon spotted frog. It inhabits marshes with extensive shallow water, abundant emergent or floating vegetation, and available food resources. Marsh size 4 hectares (9 acres) or larger support sustainable populations. The problem is detecting the frog during a visit to a marsh possibly inhabited by the species.

Previous surveys for spotted frogs observed them only 80% of the time when they are actually present. At this marsh, no spotted frogs were observed during a 2-hour visit. How does this information determine presence/absence and, by extrapolation, the frog's overall abundance and distribution?

The usual approach is null hypothesis significance testing (NHST). The null hypothesis is that the frog is absent; we want to determine the probability of not observing the frog if the null hypothesis is true. The probability (p) threshold is 0.05. If $p < 0.05$ the null hypothesis is rejected and the alternate hypothesis (the frog is present) is accepted. This alternate hypothesis is not tested or confirmed, only assumed to be true.

In this example, the *p*-value is 1.0; the probability no frog was observed if it was absent. With such a high *p*-value rejecting the null hypothesis that the frog was absent fails and the frog is assumed to have been present but not observed.

The alternative null hypothesis is that the frog was present. In this case, the probability is 0.2 that it was not observed while actually present. The NHST *p*-value of 0.02 means null hypothesis is rejected and the frog recorded as being absent when it possibly was actually present.

The NHST approach can record the frog as present or absent depending on which null hypothesis is used. This is because it asks, "What are the probabilities of observing the data given that the various hypothesis are true?" No wonder there is hesitation in making decisions.

The better approach asks, "What are the probabilities of the hypotheses being true given the observed data?" This approach is based on prior likelihood (existing knowledge) as explained by Thomas Bayes, an eighteenth-century English minister. This is the likelihood of an event given another event. The approach, Bayesian methods, has four parts: prior likelihoods (what we know), data (what we observe), a model combining prior likelihoods and data, and posterior likelihoods used to adjust the initial likelihoods of each alternative.

For example, the forecast for rain is 30% (the prior probability). We go out the door and check the sky and see it's cloudy (the data). We decide (the model) to update the probability of rain and take an umbrella.

For the spotted frog example, the likelihood that the frog was present but not seen (0.2) and the likelihood the frog was absent (1.0) are weighted by their respective prior probabilities.

Both conditions might be equally likely (0.5) if earlier surveys found frogs in 50% of all surveyed marshes. Therefore, the prior probability of the frog being absent is 0.5 x 1.0 or 0.5, and the prior probability of it being present is 0.5 x 0.2 or 0.1.

The posterior likelihoods must sum to 1.0, so the prior likelihoods (0.5 and 0.1) are converted to posterior probabilities by dividing by their sum (0.6). The probability of the frog being absent is 0.5 / 0.6 or $p = 0.83$; the probability of it being present is 0.1 / 0.6 or $p = 0.17$. Of course, different prior probabilities produce different posterior probabilities.

Comparing the two probabilities of the frog's presence with the NHST conflicting results strongly suggests the Bayesian approach better supports operational, policy, and regulatory decisions. In this case, with only a 17% likelihood of frogs using this marsh it might not be considered critical habitat for spotted frog population sustainability.

The opportunity costs for decision-makers (operational, policy, and regulatory) can be reduced by applying Bayesian methods to calculate species population abundances, distributions, and habitats used because the decisions are based on technically sound and legally defensible analytical methods

. —

All newsletters, white papers, and other technical resources can be freely downloaded from `http://www.appl-ecosys.com/publications/`.