Plants and Animals: Analyzing Abundance and Limiting Factors (Newsletter)*

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Sage-grouse, salmon, desert tortoise, and many other animals are listed under the Endangered Species Act (ESA) or are being considered for listing. Much data have been collected on population abundance, distribution, and habitat quantity and quality. Unfortunately, most biotic data are incorrectly analyzed because count data differ from continuous data and require different statistical models. Because ineffective policy decisions result from inappropriate models correct analytical results are critical for regulated industries, regulators, and other stakeholders.

Physical and chemical environmental data are continuous and rarely normally distributed because most cannot have values below zero; e.g., chemical concentrations and dissolved oxygen. Appropriate and correct non-parametric statistical models exist for these data.

Biotic data are counts, not continuous. Count data can be abundance (sometimes transformed to proportions or percentages) or presence-absence. Each type requires a different statistical regression model for technically sound and legally defensible results. Compositional data analysis (CoDA) provides descriptive summaries and general linear models (GLM) measure cause-and-effect relationships between the response variable (the plant or animal) and one or more explanatory variables (habitat quantity and quality). These models also allow forecasts for informing operational and regulatory decisions.

For reclamation bond release at mine sites, plant cover of desired species is a criterion. Since plant cover is reported as a percentage (0 to 100) or proportion by species (0.0 to 1.0) the range of values is bounded. Traditional statistical methods, such as least-squares regression, mixed-effects models, and nonparametric methods such as the Wilcoxon test may yield incorrect results when applied to data bound within a defined range. Logistic quantile regression is an appropriate method for analyzing these data. Logistic regression is applied to count or proportional data. Quantile regression expresses the relationship between equal size portions of the response variable across the range of the explanatory variable; linear regression expresses the relationship between the mean value of the response variable across the range of the explanatory variable.

Animal abundance can be recorded two ways: abundance or presence-absence; the latter is preferred for small samples. Presence-absence data are analyzed using Poisson, geometric, or negative binomial regression models.

Biotic data have two other complicating factors.

It is common to not observe animals of interest during data collection events. The absence might be because the animal does not inhabit that area, or it does but was not observed at that time. This is particularly the case when the animals of interest at that site are seen sometimes but not always. Many zeros in the data, called 'zero-inflated' in statistics, requires analytic models correctly accounting for this condition.

The Poisson distribution (for count data) has variance equal to the mean. When variability is greater than expected the data exhibit overdispersion, very common in environmental, economic, and societal data. There also is the less frequent case of underdispersion. Standard Poisson regression models cannot produce correct results in these cases. There are specific modifications for over- or underdispersion correction in GLM regression models.

These considerations in biological data analyses are important to natural resource industries and environmental regulators because animals such as sage-grouse, Lahontan cutthroat trout, sockeye salmon, and desert tortoises are either ESA-listed or under consideration for listing. Listing/de-listing decisions, and how industry can operate, should be based on robust and correct statistical analyses of populations, their habitats, and limiting factors. The appropriate statistical models exist and should be used with all biotic data.

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