Special Feature

Statistical Analysis of Ecological Response to Large-Scale Perturbations[1]

One of the critical challenges for ecological science in the next decade is the understanding and management of Earth's resources in the face of environmental change. Perturbations resulting from natural phenomena (e.g., El Niño–Southern Oscillation, insect outbreaks), inadvertent anthropogenic effects (e.g., greenhouse warming, acid deposition), management practices (e.g., forestry, fisheries), and planned experimental manipulations all may be considered large-scale perturbations and may result in ecological changes. Statistical analysis of ecological response to those changes is a necessary step in the development of both basic understanding and management plans, yet many of the statistical approaches familiar to ecologists today are not geared to the appropriate scales and dimensions. While most ecologists agree that adequately replicated, properly randomized experiments should be used whenever possible, there are situations for which statistical analysis can be informative even when treatments are not replicated. Most of the techniques that are promising for analysis of large-scale perturbations derive from areas of statistics unfamiliar to ecologists.

The goal of this Special Feature is to inform ecologists of a range of statistical approaches useful for interpreting ecological response to large-scale perturbations. In the first paper, Carpenter presents an overview of statistical approaches for large-scale planned and unplanned experiments. The second paper, by Jassby and Powell, focuses on trend detection and inference in time-series data. Reckhow, in the third paper, addresses opportunities in Bayesian statistics, and points out key differences between Bayesian statistics and the frequentist statistics in which most ecologists are trained. The final paper, by Walters and Holling, discusses statistical analysis and decision-making in the context of large-scale management.

The analyses and approaches discussed in these papers are appropriate for natural or inadvertent changes as well as for deliberate experimental manipulations. At certain scales of perturbation, global climate change, for example, the possibilities for replication are virtually nil and alternative statistical approaches such as those outlined here are necessary. In the case of deliberate experiments, even those occurring at large scales, the benefits and costs of replication and reference (or control) systems need to be carefully considered. This Special Feature is not intended to advocate unreplicated experiments; it is intended to inform ecologists of the prospects for statistical analysis in unreplicated situations.

Early in this century, advances in statistics such as analysis of variance revolutionized agronomic experimentation. Similar techniques have greatly enriched ecology when applied to plot, enclosure, mesocosm, and microcosm experiments. Large-scale experimentation in ecology could be greatly enhanced by infusion of analytic techniques appropriate to the scales of global change, landscape processes, and ecosystem perturbations. We hope that this Special Feature will prompt the innovative interactions among ecologists and statisticians needed to facilitate progress in studies of ecological response to perturbations occurring on ecosystem, regional, and global scales.

PAMELA A. MATSON—*Special Features Editor* STEPHEN R. CARPENTER—*Guest Editor*

Key words: Bayesian statistics; causal inference; change detection; disturbance; ecosystem experiments; global change; management; principal component; statistics; time series analysis; trend.

[1] Reprints of this 32-page Special Feature are available for $3.00 each. Order reprints from the Business Manager, Ecological Society of America, Arizona State University, Tempe, AZ 85287.