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REPLICATION AND TREATMENT STRENGTH IN WHOLE-LAKE EXPERIMENTS[1]

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Abstract. Replication of large-scale experiments is desirable, but the numbers of replicates needed are not known. Costs and feasibility of ecosystem experiments depend critically on the numbers of replicates needed because of the high cost per replicate and the scarcity of experimental ecosystems. This paper examines the numbers of replicates and magnitudes of manipulation needed to detect changes in lake primary productivity resulting from piscivore manipulations. Substantial ($\approx 10\times$ changes in the independent variable, piscivore biomass) and sustained (at least 3–5 yr) manipulations using five reference and five experimental ecosystems produced significant t test results in >80% of simulated experiments. The need for substantial and sustained manipulations is consistent with published results of whole-lake experiments on nutrient inputs, chemical contaminants, and the biota.

In many cases, limited numbers of experimental systems or high costs will prevent adequate replication of ecosystem experiments. When large-scale experiments employ insufficient (e.g., 2 or 3) replicates and/or modest perturbations of the independent variate, there is great risk of erroneously accepting the hypothesis of no treatment effect. Therefore, unreplicated paired-system experiments (one reference and one experimental system) are often preferable even though classical statistics cannot be used to determine whether manipulation caused a change in the experimental system. A series of unreplicated paired-system experiments, staggered in time and performed in many locations, will provide more ecological insight than a replicated experiment in a single region. Few statistical methods pertain to large-scale ecological experiments; innovations could be very beneficial.

Key words: cascading trophic interactions; ecosystem experiment; experimental design; food web; lakes; press experiment; pulse experiment; replication.