10 simple rules for designing and analyzing field experiments in ecology

A set of 10 fundamental rules to successfully design, execute, and analyze biological field experiments. This list tackles the main components of an experiment beginning with the hypothesis and predictions, to the design and execution, as well as statistical analysis and interpretation of data in order for researchers to create the best experimental design for their project. Although this paper is aimed at field experiments in ecology, many of the rules are applicable to other streams of biology.

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There are several fundamental rules to successfully design, execute, and analyze field experiments such as those in ecology. The main components of an experiment are the hypothesis, experimental design and execution, statistical analysis, and interpretation (Hurlbert, 1984).

Rule 1: Choose a specific topic or area of research that interests you.

As Ioannidis (2005) points out, popular fields of research with many teams of investigators decreases the probability that a research finding is true.

Rule 2: Develop questions, predictions, and a testable hypothesis.

The prediction is a testable outcome that should support or reject the null hypothesis. The best hypotheses include hints of the mechanism; describing *why* we see an effect.

Rule 3: Decide on the type of experiment that will be used to test the hypothesis.

As Hurlbert (1984) mentioned, mensurative experiments involve making measurements at one or more points in space or time whereas manipulative experiments involve assigning treatments to experimental units.

Rule 4: If you decide to do a manipulative experiment, define your control(s).

Use a control to compare the results against the other treatment(s) (Hurlbert, 1984).

Rule 5: Determine the experimental units and avoid pseudoreplication.

Hurlbert (1984) mentions that pseudoreplication arises from a failure to define what the experimental unit is. Do not confuse experimental units with samples.

Rule 6: Ensure to replicate your experiment in order to reduce the effects of noise thus increasing the precision of statistical estimate.

Ioannidis (2005) and Hurlbert (1984) point out that non-replication results in false positive findings. Determine how many experimental units will be in each treatment.

Rule 7: Randomize your experiment in order to eliminate experimental bias.

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Randomization controls for experimental bias when assigning experimental units (Hurlbert, 1984).

Rule 8: When analyzing the results, determine which statistical technique is appropriate (ex. ANOVA, regression).

Cottingham and colleagues (2005) demonstrate which approach is more appropriate when testing different ecological research scenarios.

Rule 9: When analyzing the results, do not misinterpret the P value.

The P value provides a value reporting the likelihood of failure rather than the efficacy of a treatment (Ioannidis, 2005; Sterne and Smith, 2001).

Rule 10: Avoid biases when analyzing and reporting your results and findings.

In addition to randomizing experiments to eliminate bias, manipulation of the analysis and selective reporting can introduce bias (Hurlbert, 1984; Ioannidis, 2005).

References

Cottingham KL, Lennon JT, Brown BL. 2005. Knowing when to draw the line: Designing more informative ecological experiments. Front Ecol Environ. 3(3): 145-152.

Hurlbert SH. 1984. Pseudoreplication and the design of ecological field experiments. Ecol Monogr. 54(2): 187-211.

Ioannidis JPA. 2005. Why most published research findings are false. PLoS Med. 2(8): 696-701.

Sterne JAC, Smith GD. 2001. Sifting the evidence—what's wrong with significance tests? BMJ. 322(7280): 226-231.

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