# Bringing Environmental Policy and Regulation into the 21st Century, Part 1 (Newsletter)*

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After 50 years it is time to bring environmental policy and regulatory decision making into the 21st century by applying statistical paradigms that produce technically sound and legally defensible results from environmental data.

When the Clean Water Act, Endangered Species Act, and National Environmental Policy Act were created, and federal agencies directed to develop regulations to ensure compliance with them, biologists and ecologists knew less about environmental systems and data analyses than we do today. The federal scientists had insufficient data for the wide variety of ecosystems covered by these statutes, and the only statistical paradigm they knew was the null hypothesis/significance testing (NHST) approach that is still the only one taught in basic statistics courses. Unfortunately, this frequentist paradigm is rarely appropriate for environmental data. The mathematical, logical, and philosophical problems with the frequentist paradigm have been argued by statisticians for about 80 years. Regulators, regulated companies, and the consultants and attorneys who assist them have better paradigms available for analyzing environmental data.

Understanding why the frequentist paradigm fails environmental data is necessary to recognize the benefits to you by applying alternative approaches to your data.

The frequentist defines a null hypothesis (Ho) and an alternative hypothesis (Ha). Almost always, Ho is written as "there is no difference" between two samples (i.e., they are from the same population); Ha states that there are differences between the two data sets. There are two hypotheses, and neither can be proven, only rejected. The null hypothesis is tested by the statistical model and is accepted or rejected by the probability (the P-value) that the observed data fit the null hypothesis. If the P-value is less than the arbitrary value of 0.05 the null hypothesis is rejected and the alternative is accepted without explicit testing.

The problems with the frequentist paradigm are many; a few are summarized here. Details will be provided in a forthcoming white paper.

1. The statistical test is how well the observed/measured data fit the null hypothesis, not how well the null hypothesis explains the data. A serious problem.

2. Only two hypotheses are open for examination. Almost always there are multiple possible explanations for the observed data including weather, season, altitude, antecedent precipitation; it might not be the regulated operation.

3. Almost always, the null hypothesis of no difference is known to be false a priori, even before data are collected. Therefore, rejecting it as an explanation of the data's fit to the hypothesis is a tautology. These are called silly nulls. In very rare cases the analyst creates a meaningful null hypothesis, but the single (non-specific) alternative is still not tested, just accepted.

4. The significance level of 95% (that the null hypothesis is true based on the data) is totally arbitrary. There is no mathematical, logical, biological/ecological, or philosophical basis for this value. It's been accepted as "true" only because of repetition and being taught in every basic statistics course.

The two alternative paradigms, likelihood and Bayesian, correct these problems.

Environmental issues are prominent in society and politics: climate change, drought, fossil fuels and renewable energy sources, mining, livestock grazing, sage grouse, anadromous salmon, and other wildlife. Regulated companies, their regulators, consultants, and attorneys will appreciate the value they gain after changing their approach to environmental data analysis.

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