Multiple Scale Ideal in Environmental Research and Publication

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Two methodologies for research on environmental systems appear to be in conflict in the 1990's. Both contribute to the advancement of science, are potentially complementary, and both are required to understand systems. Unfortunately, zealous teaching on one approach alone has made many scientists unaware of the need for both, sometimes producing narrow-minded intolerance. A consideration of scale helps explain why neither methodology alone is adequate science. A revision may be needed in graduate education and journal policies.

(1) Method one isolates parts of the environmental system for intensive study, experimental testing where possible, with hypotheses relating a few variables, and heavy use of tests of statistical significance. Many in current generations have been taught that this methodology of study of one relationship at a time is the only sound approach. Experiments are planned to eliminate all factors except the relationship and single hypothesis under study. Mathematical relationships (models) are used to give the observed relationship quantitative expression in a generalized form. The roots of this kind of investigation may be traceable to environmental physiology after the turn of the century when it was popular in experimental biology at Woods Hole to say: "one experiment one paper".

In many graduate departments, the doctoral dissertation has been changed from the earlier tradition of a unified consideration of a major question to a set of loosely combined separate papers, each easily publishable according to the ideal of the tests of a single relationship. Part of the motivation was to increase the number of published papers for graduates to cite in job hunting. Many graduates were not taught to synthesize. Several environmental journals have been reduced to papers of only the simple type by preponderance of referees that reject papers not in the simple mode of their ideal.

(2) Method two combines information about many parts and relationships in order to infer how the various parts work, how the many connections and relationships operate together, and how the system might be changed to solve problems that have been identified. Where experiments are done

the scale of recognized interest and methodology and doesn't seem to be a discrete unit like an organism.

Whatever, the scale and field of a scientific interest, it is embedded in a universal hierarchy of scales. There is always a smaller scale that has to be somewhat aggregated (i.e. organismal biologist aggregating some of the biochemistry). There is always a larger scale than the window of interest, which is interdependently controlled and impacted by large scale events affecting smaller scales.

The suggestion of this essay is that education in science and engineering is not adequate unless each graduate learns to consider the scale above and below his window of interest. This requires both the methodologies of one relationship and those of synthesis. Scientists should not be trained to focus on one scale only(e.g. organisms, populations, chemicals, etc). They should be able to show how what they study fits into and is affected by the systems of the next larger scale.

Perhaps also we need reevaluation of practices and policies of journals which seek understanding of environmental systems as to what papers are desirable. Referees dedicated to relationship methodology should not be asked to referee papers with systems synthesis.