

Process Ecology: Another Perspective on Causality in Nature

Robert E. Ulanowicz

University of Maryland Center for Environmental Science

In the normal scheme of science, all causes are assumed to be efficient (mechanical) and to propagate from smaller-scale phenomena to larger. Ecosystems science does not readily conform to such a scenario: It is primarily relational in nature, and much emphasis is given to the role of context in ordering affairs. It can be argued that agencies other than those mechanical are operative in ecosystems. Specifically, configurations of processes are often more enduring than their constituent populations and mechanisms. They are non-mechanical insofar as they impart a direction for the selection of constituents (downward causality), and they serve to define the system as an independent entity by generating their own focus of centripetal activity.

Quantifying the agency of coupled processes is initiated by identifying individual processes, estimating their magnitudes, and signifying how they are linked together in nature. In the ecological theatre, this usually consists of estimating and analyzing networks of trophic interactions. The agency of (autocatalytic) configurations of processes is usually manifested in the form of progressive (sometimes hidden) constraints that channel flows along those pathways that (cyclically) augment their own action. The overall magnitude of constraints in ecosystem networks can be quantified using information theory. The magnitude of the constraints, when scaled by the magnitude of the total action channeled by the constraints is called the system ascendancy. The complement of the ascendancy, the degrees of freedom or adaptability, can be assessed using the same calculus and is called the system overhead. Finally, the sensitivities of the ascendancy with respect to the trophic processes can be used to pinpoint the controlling processes and elements in the ecosystem.