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Entropy, non-linearity and hierarchy in ecosystems

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Soil-plant systems are open systems thermodynamically because they exchange both energy and matter with their surroundings. Thus they are properly described by the second and third of the three stages of thermodynamics defined by Prigogine and Stengers (1984). The second stage describes a system in which the flow is linearly related to the force. Such a system tends towards a steady state in which entropy production is minimized, but it depends on the capacity of the system for self-organization. In a third stage system, flow is non-linearly related to force, and the system can move far from equilibrium. This system maximizes entropy production but in so doing facilitates self-organization. The second stage system was suggested earlier to provide a useful analogue of the behaviour of natural and agricultural ecosystems subjected to perturbations, but it needs the capacity for self-organization. Considering an ecosystem as a hierarchy suggests this capacity is provided by the soil population, which releases from dead plant matter nutrients such as nitrate, phosphate and captions needed for growth of new plants and the renewal of the whole ecosystem. This release of small molecules from macromolecules increases entropy, and the soil population maximizes entropy production by releasing nutrients and carbon dioxide as vigorously as conditions allow. In so doing it behaves as a third stage thermodynamic system.

Other authors (Schneider and Kay, 1994, 1995) consider that it is in the plants in an ecosystem that maximize entropy, mainly through transpiration, but studies on transpiration efficiency suggest that this is questionable.

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