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Resolving the complexity of ecological networks

Ecosystems are often modelled as directed graphs, representing flows of conserved quantities (e.g. biomass, energy, C, N) among a set of compartments (e.g. species, detritus). Ecological networks can be fairly large and complex. Decomposing an ecosystem model into smaller sub networks for easier analysis is often tempting. However, essential ecosystem behaviour may be lost by breaking connections, excluding compartments, or clustering. Neither flows, nor compartments can function in isolation.

Motivated by flux based analysis and metabolic control analysis, we propose an alternative building block for ecological networks, called fluxes. A flux is a smaller subnetwork defined according to specific mathematical rules. In ecological terms, a flux represents the smallest process within the ecosystem that can theoretically sustain itself. This can be a material cycle within the ecosystem, or a simple foodchain in a complex foodweb. Fluxes have interesting mathematical properties that render them extremely useful for ecological representation and studies. For example, any ecological network has a unique set of fluxes, and any ecosystem model can be expressed as a linear combination of its fluxes.

Fluxes provide a unique opportunity to study complex and large ecosystems. Since no connections are lost during this mapping, system-wide properties of the full ecosystem can be studied using individual fluxes. For example, the amount of material cycling that occurs within the entire ecosystem equals the sum of material cycling that occurs within each of its fluxes. This result holds regardless of model size or complexity.

Intertidal oyster reef ecosystem model will be used to demonstrate flux decomposition via EcoNet (http://eco.engr.uga.edu), a free online software we have developed.

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