

# The nature and prevalence of collective behaviour in ecological communities

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How collectively integrated are real ecological communities? Is the fate of a species determined only by its direct interactions - the species it eats, pollinates, or competes with? Or must we consider indirect feedbacks rippling across the whole community? These questions touch on the fundamental and unresolved issue of the dynamical nature of ecological systems. Here we propose a measure of collective integration that quantifies the behaviour of indirect effects between species following an abiotic change. At low values of collective integration, indirect effects via long interaction pathways are dampened, and do not contribute to the reorganisation of the community following the abiotic change. For large values of collective integration, these long pathways can, on the contrary, grow in strength and thus have arbitrarily large contributions. Importantly, this does not imply dynamical instability. We demonstrate observable consequences of collective integration, such as perturbation depth: the typical distance travelled in the network by a species-specific perturbation (e.g. removal); the temporal consistency between short and long term responses to abiotic changes; and the respective parts of the abiotic and biotic environment as a predictor of species abundance. The more collectively integrated the community, the larger the perturbation depth; the weaker the consistency between short and long term responses; and finally, the weaker the relationship between a species abundance and its abiotic environment.