Plants, soils and environment

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An outstanding feature of biological systems is the significance of context for their functioning. Reductionism is a paradigm of the physical sciences where significant progress has been made with systems that can be 'decomposed' into a number of simpler subsystems. These can be regarded as essentially isolated and the whole system can be understood as a simple superposition of the behaviour of the parts. By contrast, biological systems may not be similarly decomposed because such weakly interacting subsystems cannot usually be defined. Their functioning is a consequence of the significance of couplings within and between different levels of organisation, and with the system's environment. Most importantly, these interactions are generally not linear in nature and many of the conceptual devices developed in the physical sciences such as reductionism, linear superposition and determinism are not universally appropriate. The work under the Plants, Soils and Environment theme is strongly integrative in character, and addresses these issues in the context of several related topics.

The soil-plant-microbe complex is the epitome of a natural system strongly influenced by its environment, in this case the physico-chemical environment of the soil. Our research has explicitly demonstrated the two-way interaction between soil architecture and biological functioning. These interactions provide the capacity for self-organisation in the system, and explicitly demonstrate emergent behaviour arising at the system scale as a consequence of fine-scale interactions.

Plants interact with each other locally *via* competition for heterogeneously distributed resources, and both locally and distally through geneflow. The balance between coexisting individuals within a community depends on the distribution of phenotypic traits among individuals, as well as the fate of novel genes or individuals that enter the population. Thus, the dynamics of populations are driven by the properties of individuals and by couplings which operate across a broad range in spatial and temporal scales. This complexity presents significant challenges to experimental and theoretical insight, especially where the environment impacts significantly on the dynamics, since the conceptual tools for defining and understanding the equilibria and stability of such systems are lacking.

Our research focuses on determining the nature of the couplings between individuals and on the significance of individualistic behaviour for community-scale dynamics. Experimental approaches are being developed in tandem with novel theory to provide the necessary synthesis to tackle the underlying complexity. The fundamental component of the research programme of this theme underpins SCRI's strategic research on major environmental issues carried out in partnership with policy makers and industry. Targets include the fate of organic compounds in soil, solute transport in river catchments, reduced-input control of plant-pathogenic nematodes, geneflow in spatially fragmented populations including mahogany and Scots pine, dynamics of *E.coli* O157, and the environmental impact of genetically modified organisms.