O.15 - Modelling management, yield, diversity and abundance in agricultural ecosystems

Caron-Lormier, G., Bohan, D. A., Humphry, R. W., Hawes, C., Haughton A. J., Raybould, A.

Ecosystem Dynamics and Biodiversity Group, Department of Plant and Invertebrate Ecology, Rothamsted Research, West Common, Harpenden, Hertfordshire, AL5 2JQ, UK

Contact: David.Bohan@bbsrc.ac.uk

Abstract

Using an individual based model we examine the abundance and variability between arable crop, weed and invertebrate groups trophically linked. Individual organisms within the model have mass and we evaluate how changes in abundance and biomass at one level ramify to different trophic levels. We also introduce stochastic inputs to the crop and weeds to investigate the effects of perturbation on the ecosystem. The dynamics of this ecosystem emerge from the local interactions between individuals of the different trophic-functional groups. In this talk we will present the results of this modelling exercise. We will discuss the conditions for extinction, regulation and co-existence between groups. Furthermore, we will highlight the consequences of stochasticity on crop yield, ecosystem abundance, biomass and diversity. This model can be useful for a better understanding of the complex dynamics of (within-field) arable agricultural ecosystems.

The drive to maximise arable yield through management, particularly over the last 50 years, has been implicated in the decline in arable biodiversity, and a potential loss of function and ecosystem services. Recent changes in governmental policy indicate that both function and diversity are now to be preserved. There is, therefore, a need to predict the impact of management on arable yield, diversity and abundance.

There are a number of exciting ecological 'hurdles' to clear if we are to achieve this need. Currently, two areas of ecology are used to describe the interactions of individuals; food webs and population dynamics. Food webs describe the interactions between many groupings of individuals but are typically static snapshots of the interactions at any one time and place. Population dynamics can be used to play out the interaction of individuals over time, but these approaches are typically limited to a few interacting groups. We will have to merge these two distinct areas of ecology if we are to model, over time, an ecosystem that contains many interacting groups.

Conceptually, one of the most pressing problems is to simplify the ecosystem to those components that are critical. Based on the Farm Scale Evaluations, we believe that the biodiversity of an ecosystem would be best modelled as functional groups rather than taxonomic species. In this formulation, species sharing the same trophic-functional traits are grouped together. Examples of functional traits might include various aspects of 'resource capture', such as form or habit in the plants and trophic behaviour (herbivore, predator, etc.) in the invertebrates. Potentially, this simplifies the ecosystem to its most important aspect: its function. Furthermore, we propose to model management by directly linking management effects to each trophic-functional trait.

Our modelling approach uses individual based models that account for the variability at the individual level and local interactions between individuals that drives ecosystem dynamics. At the moment there are three trophic levels: a plant level made up of a crop functional group and a series of functional groups describing the weeds in arable fields; a herbivore layer of different herbivorous-insect functional groups; and a predator level of different predator functional groups.

Here we examine the abundance and variability between groups linked trophically and between herbivore groups that share a common predator or predator groups that share a common herbivore prey group, and are therefore in apparent competition. Individual organisms within the model have mass and we evaluate how changes in abundance and biomass at one level ramifies to different trophic levels. We also introduce stochastic inputs to the crop and weeds to investigate the effects of perturbation on the ecosystem.

The dynamics of this ecosystem emerge from the local interactions between individuals of the different functional groups; we therefore analyse both individual variability within each functional group and also standard prey-predator system dynamics.

In this talk we will present the results of this modelling exercise. We will discuss the conditions for extinction, regulation and co-existence between groups. Furthermore, we will highlight the consequences of stochasticity on crop yield, ecosystem abundance, biomass and diversity. This model can be useful for better understanding the complex dynamics of (within-field) arable agricultural ecosystems.

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