Rural communities

In many countries worldwide, small family farms struggle to compete with larger, corporate enterprises, which benefit from economies of scale and a greater potential to negotiate with major suppliers and consumers (e.g. [3]). Bringing the consumer base that is available to any one farm from international and national to regional and local levels might promote the competitiveness of smaller enterprises, reduce the loss of small farms, and help both to conserve rural communities and bolster rural economies [5].

Pollution and infrastructure

A more local food economy would reduce the freight transport of agri-food produce on the roads. In the UK, for example, agri-food transport currently accounts for 27% of all tonne-kms traveled and tonnes of goods lifted [6], and goods carried on the roads (billion tonne-kms) have risen by 65% since 1980. These changes are matched in other industrialized countries. A shift towards the consumption of more local goods would have significant benefits for the maintenance of the physical infrastructure of a country, its public health, and its prospects for reducing emissions of greenhouse gases.

Livestock disease

Long-distance transport and nonlocalized centers for the processing of livestock (as opposed to local or even regional abattoirs, for example) have been implicated in the spread of several agricultural diseases through Europe, including foot and mouth disease, classical swine fever and BSE [7–10]. A shorter, more locally centered food supply chain might be expected to inhibit the rapid spread of such diseases.

The question of how to promote a move towards increasing consumption of local produce is complex. A recent review of agricultural policy [3] noted that local food is already becoming established in mainstream markets and suggested many local funding and advisory mechanisms for facilitating that process. Such mechanisms will be equally workable elsewhere in Europe and North America. However, for most consumers, discriminating between products on the basis of provenance rather than price remains a luxury that they cannot afford.

One obvious mechanism for promoting the competitiveness of local produce is to tax long-distance transport of goods in a realistic way, taking into account the damage caused to the environment, the economy, human health and national infrastructure. Congestion charging is now accepted in several countries in northern Europe and the Far East, suggesting that the public might be prepared to accept realistic charging of transport for the environmental costs that it incurs. In the UK, this is currently part of the Government's plans for the real pricing of road transport. However, throughout the industrialized world, such changes must be supplemented by changes in consumer behaviour and farm practice if there are to be substantial increases in local heterogeneity [1] and the production of other public benefits from the countryside.

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Book Reviews

Chaos in a bottle

Chaos in Ecology: Experimental Non Linear Dynamics by J.M. Cushing *et al.* Academic Press, 2003. £45.00, hbk (597 pages)
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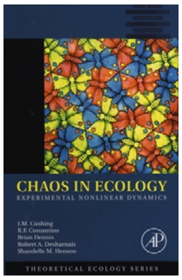

Why are oscillations of population densities often so wild and complex? The idea that simple rules might underlie complex dynamics in nature is far from trivial. Indeed, it certainly came as a surprise to most ecologists in the mid-1970s that chaos theory could be used as a powerful theoretical framework. Evidence had been accumulating from time series that epidemics were not random: looking at their internal structure revealed much more order than was expected. Against any previous intuition, ecological complexity could be explained by a few nonlinear equations [1,2]. But, in tandem with the hopes raised by nonlinear science, doubts also emerged about their relevance or even their evolutionary significance: chaos often implies that populations are close to extinction and, thus, that they should be maladaptive [3].

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Theoretical speculation always needs to be grounded by empirical testing. Nature is so complex that it seems to evade the normal rules of a simple universe proposed by low-dimensional chaos and, consequently, evidence often has to be obtained from indirect methods [4]. As in physics, a system sometimes needs to be properly isolated, characterized and measured to identify the origins of its intrinsic behavior. This is the aim of *Chaos in Ecology*. Using *Tribolium* as a model laboratory organism, the authors give a concise summary of an ambitious research project. They provide the best example, to our knowledge, of a controlled ecosystem in which complex dynamics (including chaos) can be measured accurately. After reading this book, even the most skeptical minds will not be able to say that chaotic dynamics has no relevance in ecology.

Cushing *et al.* first provide a clear introduction to the main topics of nonlinear dynamics and chaos that, although well written, is sometimes too brief. This is disappointing because the book could have been a self-contained introduction to experimental chaos. For example, the authors should have clarified the simple idea underlying the linear stability analysis of fixed points, where very small perturbations tend to die out. What they call the 'linearized equation' is the general equation for very small perturbations from the stable state.

The following chapter is central and describes the process of model election, parameter estimation and model validation. With great mastery, the authors outline the main features of *Tribolium* biology to build their famous LPA (larval, pupal and adult) discrete time deterministic model [5]. Given that *Tribolium* generations overlap, it would also have been interesting to know what would happen were a continuous time description used. Such descriptions enable demographic stochasticity to be included by using stochastic equations. Although the authors do explain how to deal with stochasticity, they assume that the noise structure of data is due just to environmental stochasticity alone. However, they do show, importantly, the relevance of unstable equilibria of the deterministic equations whenever stochasticity is considered. Their *Tribolium* system is a good example of the interplay between deterministic and stochastic forces.

Bifurcations and chaos are explored in detail and the power of the experimental setup becomes clear. The LPA model is fully validated and highlighted, particularly by the observation of bifurcations from equilibria to cycles, quasiperiodicity and chaos. The authors also explore the possibility of manipulating chaotic orbits by introducing small perturbations. Specifically, the experiments show that adding a fixed, small amount of adult *Tribolium* to the experimental setup strongly reduces demographic stochasticity, as predicted by individual-based models [6]. Unfortunately, the book does not provide a single reference to the well developed field of chaos control (which includes some standard ecological models [7]) and thus readers might conclude that the authors invented the concept themselves.

Critics might argue that this is a rather specific system (in which cannibalistic interactions are the dominant mechanism driving the dynamics) and that many other factors would be revealed if field populations were analyzed. However, energy extraction by cannibals from their victims (neglected in the LPD model) can significantly affect the behavior of trophic cascades in some ecosystems [8]. In spite of this criticism, Cushing's *et al.* contributions to microcosm experiments are very important to our understanding of the basic mechanisms operating in ecological interactions. *Chaos in Ecology* ought to be read by both field and theoretical ecologists.

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