Multi-Functional Uses for Pastures

Andrew Rook[1], Tom Misselbrook[2] & David Scholefield[3]

[1] Behavioural and Community Ecology
[2] Manures and Farm Resources
[3] Nutrient Flows and System Modelling

Minimising pollution 44

Impacts of manures on biodiversity 45

Systems models 46

MULTI-FUNCTIONAL USES FOR PASTURES

Andrew Rook, Tom Misselbrook & David Scholefield

Changes in agricultural policy have led to great emphasis being placed on the need for agricultural land to fulfil not only its traditional function of food production but also to contribute other 'ecosystem services' such as reduction of pollution and enhancement of biodiversity and landscape value. Work at North Wyke is increasingly moving toward integrated approaches to delivery of these diverse functions with the aim of delivering 'win, win, win' outcomes. In this article we describe some of the key projects in this area.

Minimising pollution

Urine and faecal deposits by grazing animals are potential hotspots of pollution to both air and water. Although potentially valuable as sources of plant nutrients, the uneven nature of urine and faecal distribution results in poor efficiency of use of these nutrients by the sward. The nitrogen (N) content of urine, in particular, is very labile and may readily be lost to the atmosphere through ammonia volatilisation and (following nitrification and denitrification in the soil) as nitrous oxide and nitrogen gas. The high concentration of nitrogen in urine patches can also result in significant amounts leaching as nitrate to the ground water. It is important to be able to quantify these emissions (Figure 7.1), to understand the processes leading to them and to seek management practices which can mitigate them.

Figure 7.1 Measuring ammonia volatilisation from grazing livestock

This research is underpinned by studies of animal behaviour which show when and where animals deposit dung and urine

Figure 7.2 Behavioural studies on patterns of excretion

(Figure 7.2). This is important because the impact of the excreta and the time course of its breakdown will depend on the substrate on which it lands, the atmospheric conditions and the overall nutrient load within a given area. Multiple urine deposits to a small area will exacerbate the polluting potential in comparison with a more uniform distribution of urine over a larger area. Preliminary results suggest that, the pattern of excretion differs markedly when different stocking rates are used.

Nitrogen concentration in dung and urine will be directly influenced by the composition of the herbage being eaten and may also vary throughout the day, as determined by animal physiology. Management of sward composition, such as the inclusion of plants containing condensed tannins or polyphenols, offers a potential mitigation strategy. When eaten and digested by the animal, plants containing these compounds have been shown to reduce labile N excretion. However, grazing behaviour research is required to ensure optimal intake of such plant species within mixed swards. Improving our knowledge of the spatial and temporal distribution of urine and faecal deposits and how this relates to the sward composition, grazing management and animal behaviour, is important for our overall understanding and ability to manage the pollution risk from grazing livestock.

Impacts of manures on biodiversity

In multi-functional systems, we must consider not only the effects of manure usage on pollution but also its effect on the biodiversity and productivity of the swards. An ongoing long-term study is examining the effects of farmyard manure applications to hay meadows. Results from the first 5-year phase of this project suggest that the impact of organic as opposed to inorganic manures on diversity is complex and equivocal and thus a further

3- to 5-year experimental period has commenced in order to allow effects to develop more clearly over a longer timescale.

Systems models

The studies described above focus on key components of multifunctional pasture systems. However, if we are to understand fully the impacts of management practices we need to look at the system holistically. To do this in real systems is very expensive and therefore much of our work utilises mathematical modelling to explore various scenarios.

The basis for our current systems modelling was founded in the early years of IGER North Wyke with the development of NCYCLE – a simulation of the nitrogen flows within and from a beef grazing system under UK conditions. This simple mass-balance model was one of the first that enabled the consideration of both production and N losses from the system, according to the level of inputs from fertilisers, excretal returns and site conditions. It therefore provided a preliminary tool with which to investigate and specify the sustainability of livestock systems in terms of animal liveweight produced, on the one hand, and levels of environmental pollution from emissions of N compounds to air and drainage water, on the other. This model has been developed over the last 20 years through several iterations to improve its applicability to real livestock systems. This resulted in the creation of a new model, NGAUGE, which is not only capable of simulating N flows in different livestock systems over the whole course of the year, taking account of particular site conditions and previous history of management, but also of seeking an N fertiliser regime optimised for specified economic and/or environmental goals. This model is being used both for aiding policy formulation and implementation in relation to the

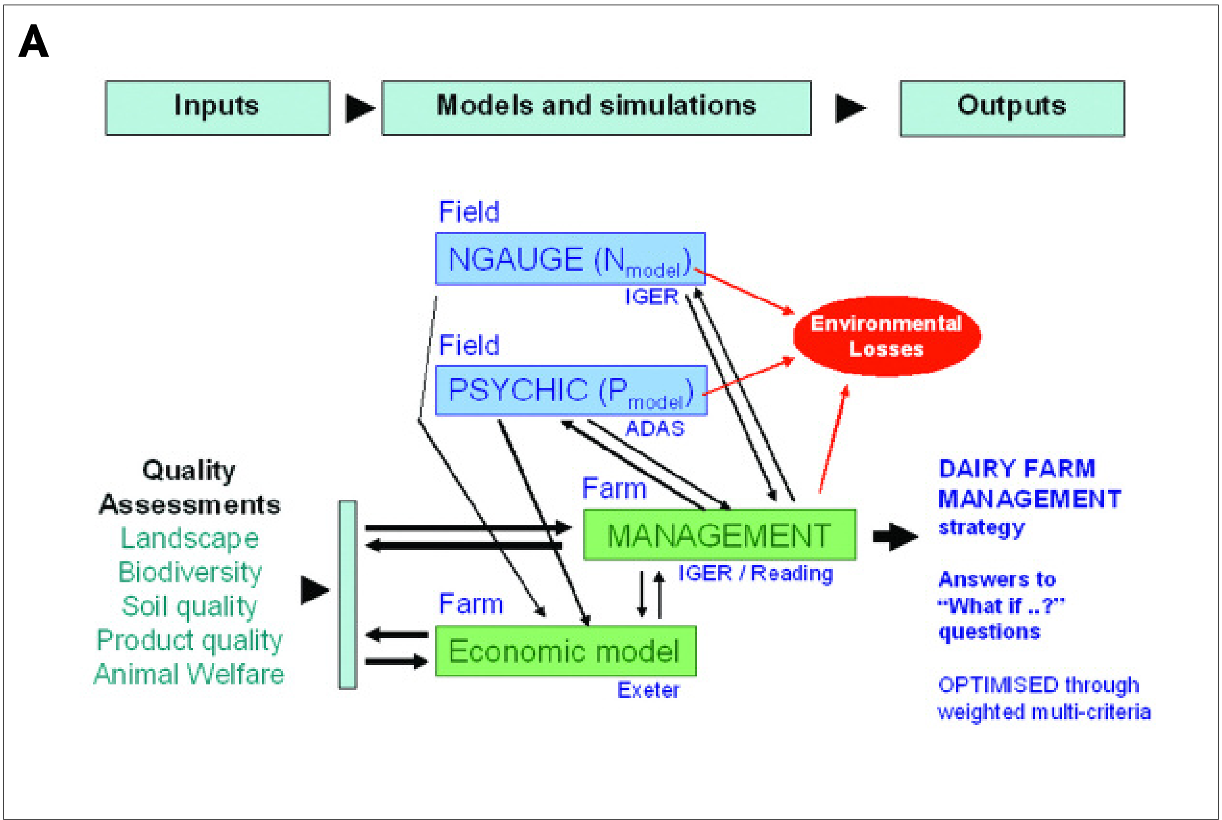

Figure 7.3 A. Diagram of the inputs, outputs and interactions between the 4 models comprising the SIMSDAIRY modelling framework.

B

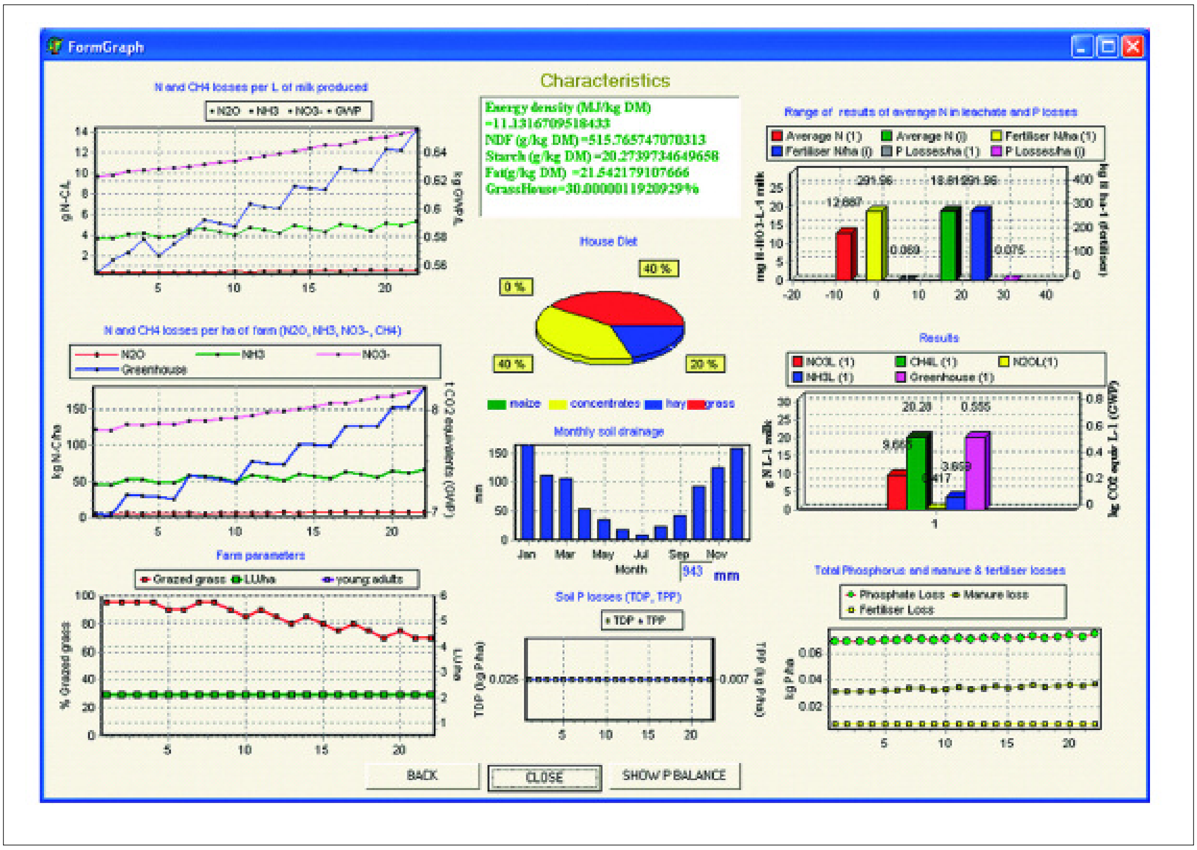

Figure 7.3 B. An example of a computer screen print of the model data

Nitrate Directive and for the basis of cost-benefit analyses of nitrate mitigation. Most recently, however, this modelling base has been further upgraded in capability and level of sophistication in the development of the SIMSDAIRY modelling framework (Figure 7.3 A & B). This framework comprises four simulation models: NGAUGE (IGER), PSYCHIC (ADAS), one on animal feeding (IGER-University of Reading) and one on farm economics (University of Exeter) linked together and interconnected with some sustainability 'matrices'. The modelling framework can thus consider N and phosphorus flows, farm profit (economic viability) and environmental sustainability from several standpoints:- air and water quality from the baseline models and through inclusion of the novel matrices, biodiversity and landscape indices, animal health and welfare, product quality and soil quality. It is being used in two modes: (i) to specify new integrated sustainable dairy systems for the UK and ways of implementing them starting from current system typologies; and (ii) to ask 'What if' questions about the potential benefits of making improvements to each of the systems components. The latter would include evaluating the potential of plant and animal breeding and of closer linkage of system typologies with particular soil and climatic conditions for optimising all-round sustainability.

Contact: david.scholefield@bbsrc.ac.uk
aj.rook@bbsrc.ac.uk
tom.misselbrook@bbsrc.ac.uk