ABSTRACTS OF COMMUNICATIONS

Operational Research, Agriculture and the Environment

The Agricultural and Related Industries Study Group of the Operational Research Society held a one-day meeting on 'Operational Research, Agriculture and the Environment' on 27 November 1998 at Silsoe Research Institute, Bedfordshire, UK. The group promotes the use of the scientific method in solving management problems. The aim of this meeting was to look at models concerned with the effects of management of the environment in agriculture. Two looked at decision support systems – one for land use balancing different interests and one from the point of view of biodiversity. Andrew Moxey however highlighted the difficulties of interdisciplinary projects and the risk of the 'illusion of technique' in decision support systems. Three other papers were more specific – concerned with livestock and climate change, nitrogen fertilizer rates and slurry application.

Model based decision support to minimize environmental pollution from slurry spreading. M. B. MᶜGECHAN. *Scottish Agricultural College*, *West Mains Road*, *Edinburgh*, *EH9 3JG*, *UK*

Land spread animal slurry (liquid manure) from housed livestock is both a potential environmental pollutant and a valuable source of plant nutrients to replace chemical fertilizer, but typical farming practice neither minimizes pollution nor maximises fertilizer value of slurry. With a view to providing decision support, a modelling approach has been adopted to study the effects of slurry management options on two forms of pollution, that transported by surface runoff (overland flow), and nitrate leaching to field drains or deep groundwater. The Swedish weather-driven simulation models SOIL (soil water) and SOILN (soil nitrogen dynamics) have been adapted for this purpose, including implementation of drainage theory, and calibration/validation for site-specific soils and cropping in Scotland and Ireland (Lewis & McGechan 1999).

Ten year simulations were carried out with a range of management options in different climatic regions. Results show that surface runoff is minimized by confining spreading slurry in winter to fields with low runoff susceptibility because of a high profile conductivity, so it is important to identify such fields. There is limited scope for reducing runoff pollution by selecting days with suitable soil and weather conditions, and this is applicable only to fields with a narrow (intermediate) range of profile conductivities (McGechan & Lewis 1998). Nitrate leaching (as well as N losses by volatilization and denitrification) increases non-linearly with N application and varies with application date (Lewis & McGechan 1998).

Results have been incorporated into decision support software for managing slurry in terms of selection of fields for spreading, the quantity and timing of field applications, and also applications of complementary mineral fertilizer. Fields are classified in terms of their susceptibility to surface runoff, with a defined spreading window (the summer months) for fields with high susceptibility, daily decisions about conditions being suitable for spreading for fields with intermediate susceptibility, and almost no restriction on fields with low susceptibility. Nitrate leaching is minimized by making decisions about the quantity of slurry applied to match nutrients in the slurry to the requirements of the crop, taking account of details of the application method. An accurate knowledge of the nutrient composition of slurry is required for this, with the computer system communicating with a modified slurry tanker equipped to carry out on-line sensing of nutrients and to give an even spread at a specified application rate (Lenehan *et al*. 1998).

LENEHAN, J. J., CUMBY, T., HUIJSMANS, J., LORENZ, F., PROVOLO, G., PERROS, J. & MᶜGECHAN, M. B. (1998). SWAMP – Optimising the use of slurry. In *RAMIRAN 98, 8th International Conference on Management Strategies for Organic Wastes in Agriculture*, Rennes, France, 26–29 May 1998.

Lewis, D. R. & McGechan, M. B. (1998). Simulating field-scale nitrogen management scenarios involving fertiliser and slurry applications. Paper 98-E-057 (poster), International Conference AgEng98, Oslo, 24–27 August.

Lewis, D. R. & McGechan, M. B. (1999). Watercourse pollution due to surface runoff following slurry spreading. Part 1. Calibration of the soil water simulation model SOIL for fields prone to surface runoff. *Journal of Agricultural Engineering Research* **72**, 275–290.

McGechan, M. B. & Lewis, D. R. (1998). Modelling in support of decisions about field spreading of animal slurry to avoid surface runoff pollution. Paper 98-E-016, International Conference AgEng98, Oslo, 24–27 August.

Implementation of a Land Allocation Decision Support System (LADSS), for farm-scale strategic land use planning.

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This paper presented the insights gained during the process of implementing a spatial decision support system for farm-scale strategic land use planning. The paper also highlighted both the opportunities presented by continuing information technology developments and the scientific and organizational challenges of deploying operational systems.

The Land Allocation Decision Support System (LADSS) is being developed in response to the increasing complexity of land use decisions facing land managers (Matthews *et al.*, in press). Sources of this complexity include novel land uses and land use systems, a changing policy context and an increasing public interest in the balance of economic, social and environmental benefits derived from land use systems. To support these complex decisions an information technology based framework has been created (based on geographic information system and model development environment technologies), within which the options and impacts of alternative land use scenarios may be explored. This framework provides a focus for the integration of models derived from field systems research, biophysical land evaluation methodologies, socio-economic and landscape ecological analyses. The paper presents the implementation of the framework, based on a systems integration approach and indicates future developments based on OpenGIS and CORBA. Also examined are the implications for acquiring spatial data for an operational deployment of LADSS; a strategy using meta-data based reasoning is proposed. Within the LADSS framework, a series of land use planning tools have been developed based on the evolutionary computational paradigm. These flexible search and optimization tools present significant opportunities for tackling complex land use planning problems especially in determining the structure of trade-off between multiple objectives.

Matthews, K. B., Sibbald, A. R. & Craw, S. (in press).

Implementation of a spatial decision support system for rural land use planning: integrating geographic information system and environmental models with search and optimization algorithms. *Computers and Electronics in Agriculture.*

Global Warming? OR saves the day // An OCR approach to the effects of climate changes on livestock systems.

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This project used a series of mathematical models to assess how climate change could affect grassland-livestock and intensive-livestock systems (Armstrong *et al.*, submitted). A livestock feeding model was integrated with a livestock thermal energy balance model, with its building model (where appropriate) (Cooper *et al.*, 1998) and with a grass production model (where appropriate). The component models interact with one another, for example an increase in temperature in the building (from that model) may produce increased stress (from the livestock thermal balance model) which in turn reduces the appetite and hence growth rate of the animal (from the livestock feeding model). The systems studied were: beef calf, dairy cow, lamb, pig and broiler. The system models predict the grass production and consumption (where relevant), the growth rate of animals raised for meat, the milk yield of cows, the frequency of heat stress experienced by the animals (housing and grazed) and the energy inputs required for ventilation of the intensive livestock. Different climate change scenarios were used to generate a set of weather data for the year 2050 for three representative regions of the UK which are then used with the integrated model.

The results showed that grassland livestock enterprises are well capable of adapting to climate change. Heat stress will be an increased risk for intensive livestock, especially broilers, unless there is investment in improved ventilation and cooling systems. Climate change will result in a modest increase in grass production and thus grass-based enterprises are likely to have a small increase in profits. Overall, there is no evidence of change in the relative suitability of the areas considered for the major types of livestock enterprises.

Climatic change modelling is very complex. Attempting to integrate the models highlighted several inconsistencies between the models which had been constructed by other people for different purposes and problems with the data, particularly when combining the feeding and thermal balance models. Many of the data used in the development and validation are over 30 years old, and do not reflect the performance of modern genotypes. Furthermore, there were no experiments in which good quality nutritional and calorimetry data were collected simultaneously. These problems were usually overcome by adjusting the models using partial data sets,
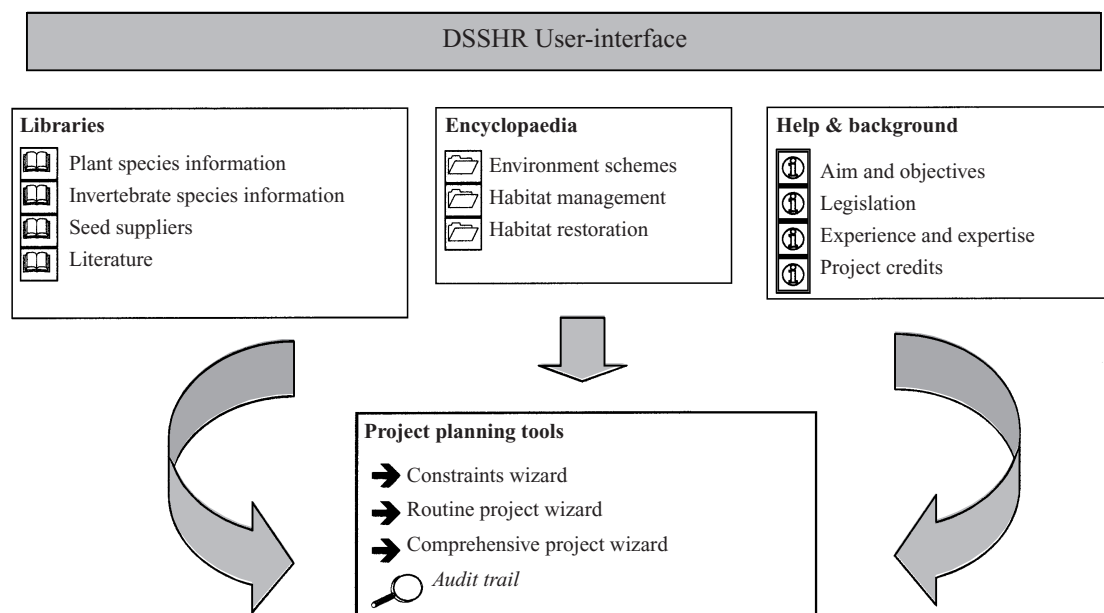
Fig. 1. The structure of the Decision Support System for Habitat Restoration (DSSHR).

but could not all be fully resolved with the available data. There is a need for some of the experimental work to be updated.

ARMSTRONG, A. C., PARSONS, D. J., TURNPENNY, J. R., MATTHEWS, A. M., COOPER, K. & CLARK, J. A. (submitted). Integrated models of livestock systems for climate change studies. 1. Grazing systems. *Global Change Biology*.

COOPER, K., PARSONS, D. J. & DEMMERS, T. (1998). A thermal balance model for livestock buildings for use in climate change studies. *Journal of Agricultural Engineering Research* **69**, 43–54.

The use of large scale interdisciplinary models. A. MOXEY. *University of Newcastle upon Tyne*

Documented output from the successful 1990–1995 NERC/ESRC Lane Use Programme (NELUP) conducted at Newcastle highlights the importance of spatial connectivity in agri-environmental systems and the need to account explicitly for interactions between economics, ecology and hydrology. Both the research councils and the research team deserve credit for delivering such an overtly interdisciplinary and well reported suite of models and Decision Support System (DSS).

However, discussions with academic modellers elsewhere in Europe and North America reveal that some issues encountered during the research process are common to many interdisciplinary projects, yet are seldom reported. In particular: (*a*) in an era of Research Assessment Exercises, peer pressure reinforces a tendency for insular academic territories to persist in the face of theoretical and empirical disciplinary differences; (*b*) data and modelling uncertainties, especially in terms of spatial and temporal resolutions, can risk an 'illusion of technique' if DSS outputs are not accompanied by meta-data and caveats; (*c*) potential DSS users are discouraged by a lack of empirical focus and a perceived move towards automated decision making.

Acknowledgement of these issues may enhance further the success of future interdisciplinary modelling projects.

A decision support system for habitat restoration and management. R. PYWELL. *NERC Institute of Terrestrial Ecology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE17 2LS, UK*

The Institute of Terrestrial Ecology have developed user-friendly computer software which provides advice on the maintenance and enhancement of biodiversity in the British countryside. The system dynamically links best practice habitat restoration and management prescriptions with extensive data sources for plant species and their associated invertebrates (Fig. 1). Scoring and ranking of site-specific details is used to define ecologically appropriate targets for management and restoration, as well as identifying potential constraints on their achievement. The use of this software at the project planning stage should make habitat restoration more reliable and cost-effective. The software development was jointly funded by the Natural Environment Research Council and the Ministry of Agriculture, Fisheries and Food.

A nitrogen cycle model for optimizing fertilizer application to grassland. I. BROWN. *Institute of Grassland and Environmental Research, North Wyke, Okehampton, Devon, UK*

The increased use of N fertilizer in UK grassland during the past 35 years has enabled farmers to exploit the potential responses in plant yield and to increase production. High N use in intensive grassland production systems is, however, often associated with high levels of nitrate leaching and loss of gaseous N. A fertilizer recommendation system that enables losses to be quantified and controlled is essential for sustainable grassland farming.

The NCYCLE model, which is an empirical annual mass-balance simulation of N transfers and losses in UK grassland systems (Scholefield *et al*. 1991), has been modified to obtain a shorter time step version (NFERT) for optimization of N fertilizer use towards specific yield and N loss targets. The optimization procedure within NFERT involves distributing inorganic N across a series of equations that describe, for each month, the efficiency of the plant in recovering the available inorganic N. NFERT has been tested with data from a multi-site cutting experiment at three sites over 2 years. The model predicted herbage dry matter, N yield and nitrate leaching reasonably well, but overestimated denitrification and underestimated net N mineralisation.

NFERT is the core of a decision support system (DSS) being developed for use in N fertilizer management in grassland. The DSS will provide the farmer with a clear account of N efficiency and N budgets of the farm and will enable improved efficiency of N use to be achieved, thereby reducing losses.

SCHOLEFIELD, D., LOCKYER, D. R., WHITEHEAD, D. C. & TYSON, K. C. (1991). A model to predict transformation and losses of nitrogen in UK pastures grazed by beef cattle. *Plant and Soil* **132**, 165–177.