Farm agro-ecosystems: an application for modelling

Pastoral farms are complex agricultural ecosystems made up of many components such as weather, soils, plants, animals, people, capital and economics. Soil, plants and animals involve key biological processes, such as nutrient cycling and growth processes, which control how they function and interact with other components. Managers use economics to aid decision making, and labour and machinery to implement management decisions.

While it is comparatively easy to study each of these components, it is much more difficult, and expensive, to study all the components and the interactions in real-life field experiments.

Modelling pastoral farm systems

An alternative or complimentary way of studying these systems is to describe the relationships between the components using mathematical models and simulating a range of likely scenarios.

Pastoral farm eco-system models provide a means to test a number of different strategies before farmlet studies commence, providing insight into the design of studied strategies, and also reducing costs.

Through examining the key features of a range of models and how they have been applied, their suitability can be assessed and options for future model development can be considered.

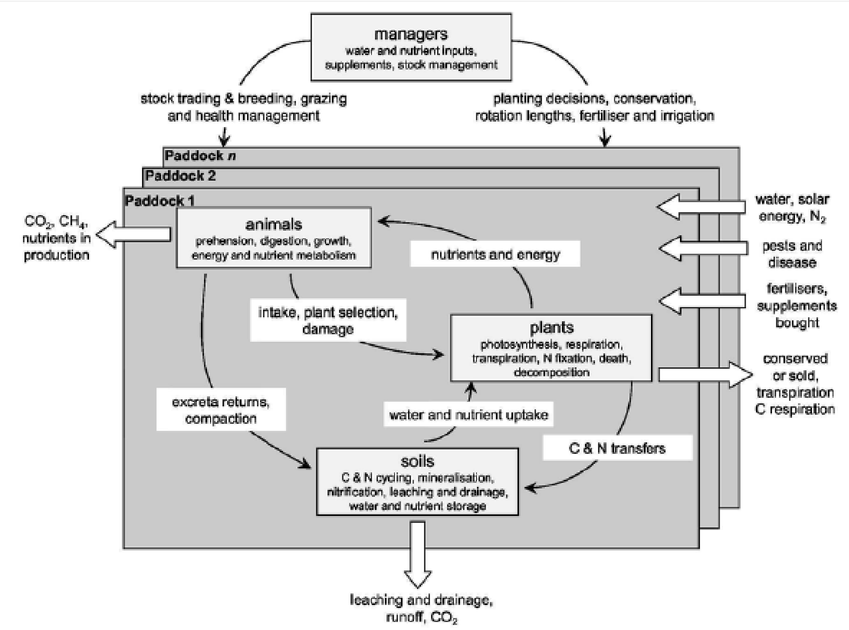

Figure 1. Schematic representation of a pastoral farm agro-ecosystem.

Modelling scenarios can help land managers and scientists visualise future management options and farming outcomes.

Some models, such as Farmax, are developed to assist farmers make management decisions to optimise specific desired business outcomes. However, the models described in this review have been built for research purposes in order to better understand the interactions of the components in the system.

The minimum features that need to be incorporated within a model are considered to be:

- Management decisions around activities and their timing
- Weather experienced in a location, as it affects the growth of plants and the bio-physical environment
- Multiple animal species, performance, feed preferences and susceptibility to disease.
- Composition of the species in the pasture, the feed quality, susceptibility to pests and disease.
- Soil characteristics that affect plant growth, pest and disease levels, nutrient profiles and other environmental services.
- Variability in soil properties and grazing animal excreta across the landscape of the farm
- Ability to explore the impact of genetic variability on the system performance
- Ability to apply paddock-level variation within the context of the whole farm system.

The models that were evaluated

From world-wide screening of literature for published accounts of models used for research, nine were selected for evaluation. The main selection criterion was the extent to which the model had been used, and referred to, in published research studies involving grazing animals.

The features of each of the models were reviewed, and are detailed in the full report.

Simplistically, the dominant features of the models reviewed in this study were:

- The Farm Assessment Tool (FASSET) model is well equipped to assess the financial and environmental consequences such as N cycling and greenhouse gas emission of different farming scenarios in Denmark.
- The strength of the EcoMod suite of models is its ability to explore soil and plant processes spatially across multiple paddocks.
- The Agricultural Production Systems Simulator (APSIM) model is used by both farmers and researchers and has been integrated with EcoMod to strength the flexibility of the management description in EcoMod.

- The model Great Plains Framework for Agricultural Resource Management (GPFARM) can be used to predict forage production of different plant functional groups at the paddock scale and predict stock live weights.
- The GrassGro part of the GRAZPLAN suite model is able to predict pasture production, sheep and beef live weight gain, milk yields and stock feed requirements as well as explore whole-farm economics and risk.
- The Hurley Pasture Model is able to explore nutrient cycling in the presence of climate change.
- The Integrated Farm System Model (IFSM) is able to explore the economic consequences of alternative farming and cropping systems, and predict plant and soil nutrient cycling.
- The Lincoln University Farm Model (LINCFARM) includes genetic variation in protein deposition, the interplay between live weight change, reproductive performance and specific management events.
- The Dexcel Whole Farm Model (WFM) allows for predictions of dairy cow intake and milk yield and the exploration of farm management scenarios and economic measures.

Areas for improvement in the models

Farm management – The farmers decision-making behaviours are crudely represented and the models typically assume the farmers main goals are to maximise production. The commonly accepted farm management decision rules need to be quantified and integrated into the simulation models.

Spatial Variations – The models need to account more accurately for the patchiness of soil chemical and physical properties, especially as these relate to the spatial variation of farm animal urine and faeces deposits.

Pests and diseases – Since pests and diseases can impact greatly on the economic viability of farm systems, models that are able to incorporate the intensity or the spatial distribution of the impacts will be useful.

Animal performance – Detailed understanding of animal feeding preferences and the effects of the rumen functionality is need as these factors impact on the end products of fermentation such as excreted nutrients and greenhouse gas emissions.

Genetic representation – Most animal and plant traits of agricultural importance are under the control of interacting networks of genes and environmental factors. Only APSIM included the capability to model the effects of genes on an agro-ecosystem performance.

Insights

Whole-farm agro-ecosystem simulation models need to demonstrate realism, relevance, and significance to farming practice. Relevance and significance to farming practice may be best achieved by building scientifically sound and detailed sub-models to integrate into larger frameworks such as APSIM.

Modular development of the models has several advantages. The creators of the modules can retain ownership of their work. The modules can be '*plugged in'* when and if they are relevant to specific agro-ecosystem scenarios depending of the required level of complexity of a simulation exercise. The modules can be 'debugged' and validated independently of the whole system. Different teams of people can collaborate on separate modules and they do not need to use the same programming languages.

In reviewing commonly available and widely published pastoral farm agro-ecosystem models that have been used with grazing animals, the conclusions were:

- WFM had the strongest representation of the animal interactions.
- GRAZPLAN, WFM and LINCFARM gave the most detailed attention to farm management.
- APSIM, FASSET, EcoMod and the Hurley models were strongest for their soil nutrient dynamics, crop or pasture production and spatial variation in soil properties.
- IFSM had a comprehensive representation of machinery and costs of intensive farm systems.
- The modular framework of APSIM and GRAZPLAN provide the opportunity to develop a powerful and flexible pastoral agro-ecosystem model.

Further information

The full paper that this summary is based on is *Modelling pastoral farm agro-ecosystems: A review*. J. R. Bryant & V. O. Snow (2008), New Zealand Journal of Agricultural Research. Vol **51(3), 349-363.** www.climatecloud.co.nz/CloudLibrary/Modelling%20pastoral%20farm%20agro.pdf

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