Modelling an Intensive Deer Farming System - InverDeer

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Keywords: *Deer; InverDeer; System research model.*

EXTENDED ABSTRACT

New Zealand’s deer industry is relatively small compared to New Zealand’s other livestock industries, but it is large in deer farming terms, and strong growth is projected for the next decade. Market positioning in the low priced commodity sector for core products must be avoided, requiring growth in niche markets and the support of new production systems.

A research model of an intensive deer system, InverDeer, is in development to capture knowledge generated from two decades of dedicated deer research through AgResearch’s Invermay deer research unit, in New Zealand’s South Island. InverDeer’s purpose is to help farm systems researchers design new deer systems, based on new technologies or approaches. It will provide deer researchers with an aid to assist in the development of the New Zealand deer industry by allowing investigation of challenging new scenarios (e.g. advancing calving date and targeted management of nutrition and growth during lactation and autumn seasonal growth periods), and by allowing the performance of a variety of deer farming systems to be compared. During the InverDeer development process, deer researchers have already identified knowledge gaps, and this has been helpful in making decisions about future research.

The design requirements of InverDeer represented an interesting challenge for a model of a managed agroecosystem, i.e. intensively farmed deer. Features of interest included modelling individual animals to allow investigation of cross-breeding using different genetics, the special physiological characteristics of deer (as opposed to sheep and cattle), such as the mating rut by stags, and aspects of herd management specific to deer.

InverDeer was developed using Microsoft Excel™ for the user interface and Visual Basic for Applications™ for coding model details. The current implementation of InverDeer (Figure 1) reflects its evolution to the point where model outputs are stored in a relational database management system. The decision to move to a specialist database program to manage model outputs was a significant point in the development stage.

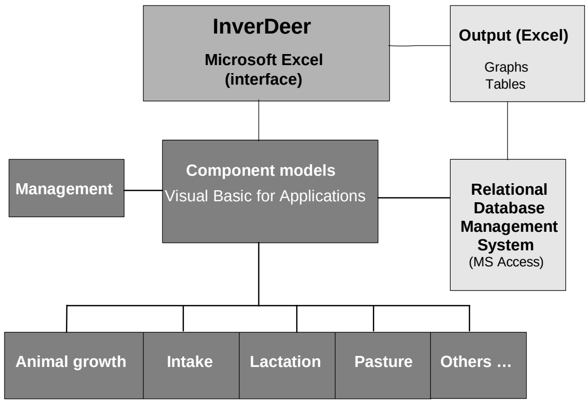

Figure 1. Implementation of InverDeer

The development process itself has recently been helped by use of the communication software Microsoft NetMeeting™.

We describe the evolution of InverDeer to date, as a combination of several sub-models, and reflect on the processes of model conception, construction and refinement.

1. INTRODUCTION

Deer farming in New Zealand began with a law change in 1969 that allowed the issuing of the first deer farming license in 1971, and the start of an industry with an animal previously classed as a feral pest. Within 15 years the farmed deer population had grown to approximately 300,000 (Moore *et al* 1985), managed by 2500 farmers. The main species that is farmed is the European red deer (*Cervus elaphus scoticus, hippelaphus*) with strains from North America (*Cervus elaphus nelsoni, roosevelti, manitobensis*) represented and interbred. By 2005 the farmed deer population was approximately 1.7 million, with nearly 4300 active farmers in the industry (Deer Industry New Zealand). Export receipts have recently ranged between NZ$250 and $350 million with volumes of approximately 500t of velvet antler and 25,000t of venison sold to mainly traditional markets in Asia and Europe respectively.

During that time there has also been a significant research programme in New Zealand aimed at developing farming systems to accommodate the unique behaviour, needs and productive traits of red deer. This programme prompted the first international Biology of Deer Production conference (Fennessy & Drew 1985) to be held in New Zealand. Significant research developments that have been incorporated into deer farming systems have been in the areas of physiology, lactation, reproduction, nutrition, genetics, and animal behaviour.

New demands from farm systems researchers assessing possible alternative production systems motivated the development of a computer simulation model. The resultant model, InverDeer, comprises several component sub-models that capture the existing understanding of deer scientists. This paper looks at how InverDeer has evolved, its structure and implementation, and reflects on some of the key issues to date in its development.

2. REQUIREMENTS

The development of a systems model to assist deer researchers followed meetings examining how modelling could help researchers meet, and lead, production and market signals coming from the New Zealand deer industry.

A tool that incorporated existing research could help with developing and evaluating new management technologies (e.g. interstrain crossbreeding and a terminal sire system to produce carcasses of a given specification faster (Archer and Stevens 2005)), and guide future research.

Model development requirements centred on two key issues: actual development and implementation of a computer model, and using the development process and model to help guide future research.

The latter requirement distinguishes InverDeer from most agricultural decision support software (DSS) models, which are not expected to directly identify research needs. Most DSSs are designed to help decision makers (e.g. farmers) over short timeframes (days to months), and are mostly narrowly focused around a specific issue.

Meetings between the deer systems researchers and modellers established and documented initial model requirements and outcomes. These formed the basis for the specification and design of the deer systems model InverDeer, and evolved as the model was implemented.

3. MODEL SPECIFICATION, DESIGN AND IMPLEMENTATION

3.1. Farming Systems

Farming can be viewed as an integration of many components interacting as a system. Specialist knowledge about its components therefore had to be combined to represent an intensively farmed deer system. In New Zealand most farming is pastorally (grass)-based, and it was therefore possible to make use of existing knowledge of pastures and their interaction with grazed farm animals. While extensive knowledge exists for cattle and sheep, similar knowledge about deer is still being developed from intensive research (e.g. Asher 2003, Asher and Mulley 2003, Asher and Pollard 2003, Mulley 2003, Nicol and Barry 2003, Nicol et al. 2003, Rhodes et al. 2003, Stevens et al. 2003, Stevens et al. 2005, Wells and Berg 2003).

As InverDeer was intended to present results at a system level, these results were expected to raise questions not addressed by typical component research, and to expose gaps in knowledge at the component level. New understanding of larger system level problems was expected to emerge from the development process itself, and the interactions between the specialists involved (deer and other scientists, and modellers).

3.2. Specifications

InverDeer was required to simulate individual animals, grouped into herds, through time. Animals were represented as individuals, though hinds included the conceptus and suckling calf until weaning. This allowed us to look at variation within the herd, which was expected to be important in these systems. Each herd was assigned to a block of land, consisting of individual paddocks, with changes in feed availability and quality through time simulated for each paddock. The ability to feed out, and to track stocks of supplementary feeds, was required. Farm management decisions (Figure 2) were simulated, and form part of the simulation output. Changes were modelled using continuous (biological) and discrete (management) methods.

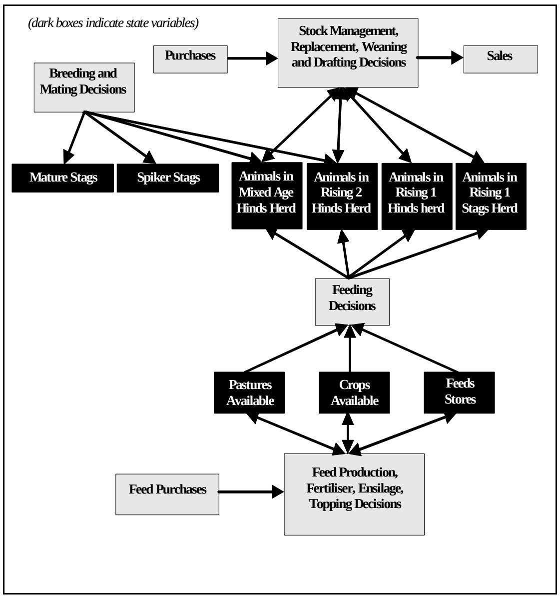

Figure 2. InverDeer management interactions

3.3. Design and Implementation

A prototype was implemented using a Microsoft Excel™ spreadsheet interface. The main details of model structure and calculations were coded in Visual Basic for Applications™ (VBA), motivated largely by expediency, with the necessary skills being available. However, Excel™ also provided a familiar interface for the target user group of deer scientists, and they were known to have good computer skills. InverDeer was not intended to be a farmer decision support tool.

Management decisions were implemented using rules corresponding to those used to farm deer. They were specified in an intuitive way in VBA (due to Woodward), with great care taken to make them accessible to the deer scientist users. This allowed non-programming scientists to change the rules in the source code, and gave them great flexibility, without the investment of developing a special interface and the checks required to ensure valid rule sets.

```
If Herd(R2Hinds).CurrentPaddock.Green < 1000 Then
Call Herd(R2Hinds).MoveToBestPasture
```

Figure 3. Grazing management rule in VBA

Figure 3 shows an example of a grazing management rule for InverDeer specified in VBA. It checks the amount of green material in the current paddock grazed by rising 2 year old (R2) hinds. If the green mass is less than 1000kg DM/ha, the herd is moved to the paddock with the "best" pasture available for that herd. Readability is enhanced by using the (limited) object oriented facilities available in VBA.

The Microsoft Access™ database (Figure 1) was added later to deal conveniently with the large quantity of outputs generated by running InverDeer, and the relatively slow execution times in the Excel™/VBA environment. Storing all outputs during each simulation speeded up the subsequent analysis by allowing any output to be examined at leisure once a scenario had been setup and run, rather than having to re-run a scenario to generate some output that had not been reported during the earlier run. Design of a suitable database to store and retrieve outputs was straightforward (e.g. Roman 2002).

The InverDeer model has not yet been finalised. One final requirement is the parameterisation of the model against known data. The sub-models of individual animal responses have been parameterised (Vetharaniam *et al.* unpublished) but there are currently no full systems data to use to parameterise the model. The deer scientists, who collaborated in the model development, currently have a system experiment underway that will be used for this purpose when it is completed.

4. DISCUSSION

4.1. Model Use and Judgment

All of the component models (Figure 4) forming InverDeer are expected to be updated using research results. The pregnancy and lactation aspects of the animal model (Vetharaniam *et al.* 2001) have been updated (Vetharaniam 2004), with results of adapting the animal model to deer to be published (Vetharaniam *et al.* unpublished).

Development of InverDeer as a research tool did not preclude the possibility of farmer decision support tools being spun-off from the development process surrounding the model. Q-Graze (for deer) is one such example. Stevens *et al.* (2005) reported using this learning package successfully to help New Zealand deer farmers learn about pasture quality. It was adapted from the successful programme with pastoral sheep and beef farmers reported by Woodward and Lambert (2001). Knowledge about deer feed intake and its effect on pasture quality, gained from the work on QGraze (for deer) was later incorporated into InverDeer, thereby partially achieving one of the aims of the project, incorporating new knowledge into the model.

In contrast to other DS software, InverDeer was designed to be part of a complex linking between research results (historical and current), industry drivers and funding capability, sciences drive for understanding, and the added complexities resulting from system level interactions (Figure 4). The experienced judgment of the researchers' use of InverDeer is an essential part of its successful contribution to their research.

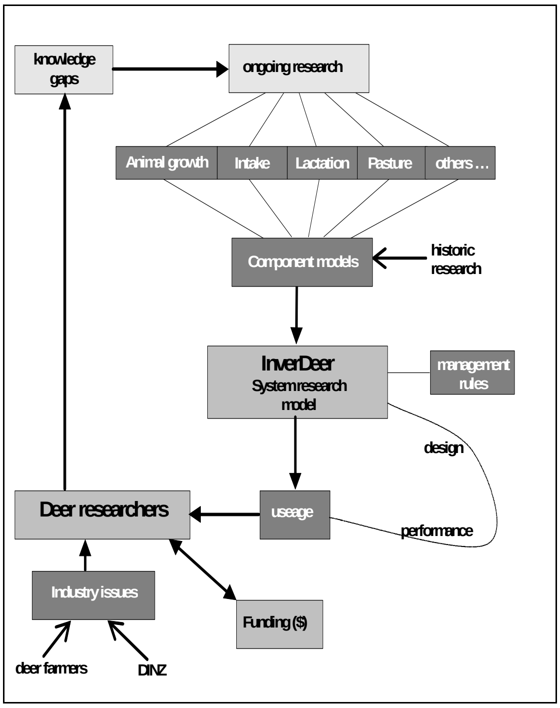

Figure 4. InverDeer's research and industry linkages

This contrasts with the usual role of most DS software, which often excludes judgment as an element of use of the model. For example, Hayman (2004) made the following observation on the apparent lack of success of DSS,

> "On the contrary, one of the likely reasons for the low adoption of DSS is that the partial analysis offered is inferior to experienced human judgment".

Earlier, economist Samuelson (2000) also commented on the importance of judgment,

> "There is a tempting and fatal fascination in mathematics. Albert Einstein warned against it. He said elegance is for tailors, don't believe in something because it's a beautiful formula. There will always be room for judgment."

4.2. Refactoring

Algebra makes good use of factorisation where possible, with the dual aim of simplification and clarification. This makes some otherwise complex equations easier to understand and discuss with other people.

The design of a simulation model, and certainly its implementation in computer code, can result in code that is complex and difficult to understand. This is particularly important when communicating the model and its code to others. With aims similar to those of algebraic factorisation, simplifying and clarifying computer code, refactoring, has recently been given the same attention (Fowler 2000). It is important to note that the external results of running the refactored code will remain unchanged, as with a factorised algebraic expression. The key outcome is code that is clearer, easier to understand and communicate, and produces the same results.

The refactoring approach relies on the cumulative effect of a large number of small changes. Giving a name to a process which may have been carried out on an ad hoc basis previously, has helped give the process credibility. There is a list of standard refactorings with the potential to improve any code (Fowler 2000). The process can also be applied to the design of a model, as distinct from its implementation in computer code, allowing iterative improvement of the model's design.

InverDeer was subjected to a considered refactoring that achieved these aims: external results remained unchanged, and complex code became easier to understand, communicate, and change. The authors' experience with refactoring InverDeer was very satisfactory and they would recommend this approach to any model developer.

4.3. Working Together

Robinson and Freebairn (2001) addressed the issue of people in modelling, specifically model use by decision makers. The development of a systems research model such as InverDeer was a complex undertaking in its own right, and issues of people working together to achieve this were made more challenging by geographic separation. Majchrzak *et al.* (2004) provided useful suggestions on how teams can work together virtually.

Hargreaves *et al.* (2001) reported using Microsoft NetMeeting™ (www.microsoft.com/netmeeting) to bring geographically dispersed farmers together with experts (advisors and scientists) using the Internet. The benefits of having experts on-hand, albeit virtually, quickly overcame the loss of face-to-face contact. The 'application sharing' feature of this collaboration and conferencing client software was used effectively in the later stages of InverDeer development, enabling modellers and deer scientists to "share the same screen", in spite of being at different locations. InverDeer could be controlled by either user. NetMeeting™ was always used in conjunction with a telephone call. A critical aspect of success in developing a model like InverDeer was for biologists and modellers to work closely together and NetMeeting™ certainly helped achieve this, supplementing the necessary meetings and user workshops.

5. CONCLUSIONS

InverDeer was conceived as a research model, its users being farm systems researchers who needed help designing deer systems. The expectation that its use would provide feedback into the model via research over a longer time frame differentiated it from most decision support software tools. The target users were intimately involved in its development, and this avoided some (but not all) of the common issues facing uptake of DSS tools.

The use of a database to store model outputs transformed usability, and would be recommended in most development environments for models of InverDeer's complexity. Extending this approach to model parameters and inputs, would be another improvement. With hindsight, a different development environment may have been preferable (e.g. Java and XML), but the ease with which VBA allowed non-programmers to adjust code and see the results was an unexpected benefit of using Excel™/VBA for development.

The practice of refactoring is recommended to model developers. Applying refactoring to InverDeer paid big dividends both in helping incorporate inevitable changes, and in communicating the model and its code to others.

Working closely with the users on the development of InverDeer was essential to the project's success. As the project progressed, the authors made use of technology that helped them work better, even though they were geographically separated. Face-to-face meetings and workshops still remained important.

Further development of the software is needed to improve usability, though the model may never be finalised. The organisation and presentation of results is being reworked to further improve InverDeer's utility. The rules-based application of management decisions will be examined further. The development processes of conceptualising the models and re-examining data to provide parameters for those models have already given significant insights into research requirements.

6. ACKNOWLEDGMENTS

Thanks to Simon Lovatt for several stimulating discussions regarding aspects of modelling. The InverDeer project is part of work funded by the New Zealand Foundation for Science, Research and Technology under contract C10X0202.

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