Case Study: Wheat Calculator

1 What is the Wheat Calculator?

1.1 The Wheat Calculator is a management decision support tool built from a wheat crop simulation model that evolved from publicly funded basic crop physiology science.

1.2 Science undertaken by Crop & Food Research (CFR) sought to define the climatic adaptation and development responses of arable and horticultural crops and to develop strategies to add value to crop products on-farm by minimising variability and increasing productivity and yield.

1.3 The information was used to develop the Sirius wheat simulation model which simulates wheat crop growth under different conditions. This model consists of all the code that describes the responses of the crop to its environment and simulates soil processes. It also includes the file and data structure that supply the model with information (soil and crop definitions, weather data etc), the inputs and outputs from the models and the management schedules (the information generated for farmers about when to irrigate and fertilise the crop).

1.4 The model and associated research produced many publications and presentations over about twenty years and there has been substantial additional research involving the model concurrent with the development of the Wheat Calculator.

1.5 The Wheat Calculator is an extension and interface to the model, and comprises;

- a scheduler to apply decision rules about the amounts and timing of water and nitrogen fertiliser to produce a management schedule;
- a system that allows prediction of crop responses to different scenarios

1.6 The calculator is used over the season to predict the rate of crop development related to weather, and give recommendations on when and how much fertiliser/irrigation is needed to give the best yield and quality. By inputting the decision on fertiliser or irrigation the farmer can predict yield, profit and how nitrogen leaching will be affected.

1.7 The Wheat Calculator has been provided to 60% of wheat growers, and many have changed their nitrogen management as a result of the project. Growers identify their improved understanding of crop physiology and nitrogen use as the greatest benefit arising from the Calculator. Although many of the growers are no longer using the Calculator, they are still applying the learning from it. The Wheat Calculator is estimated to have resulted in increased revenue to growers of approximately $6m p.a., and alongside information and guidelines from FAR, has assisted growers to reduce nitrogen leaching.

2 What were the Issues?

2.1 The Wheat Calculator case study illustrates a number of the access issues;

- it was funded by parties other than FRST to make the base information more useful
- co-funding and IP issues affected the access and usability (in this case its updating)

- there was a substantial investment over and above the FRST research funding to make the information more usable

2.2 This case study also highlighted a number of wider issues that affect accessibility of databases and tools derived from them;

- How should the basic science and modelling continue to be funded to enable the model and thus the calculator to remain current and therefore accessible and useful?
- What means can be used by CRIs to manage the IP and its sale from products such as the Wheat Calculator?

See below for discussion of the issues.

3 History and development of the Wheat Calculator

3.1 The origins of the Wheat Calculator were in the Foundation funded programmes of crop physiology science, and model development. The model had potential to be used for predicting efficient inputs for maximising returns from wheat production.

3.2 FRST funding for the crop physiology science ceased in 2000, and funding for model development stopped in 2002. The model was the end point of nearly 20 years of basic research. CFR understood the potential value of the model they had developed from the FRST funded research, but to be accessible to users, it needed to be converted to a calculator tool by adding a front end for use in decision-making on the farm.

3.3 To achieve this, CFR had to work with farmers to get them to see the value of using the science outputs (the science knowledge and the model) to make on-farm management decisions. However, this could only be done with further funding, as the FRST programme was not set up to fund the transfer phase of the research and it stopped in 2002.

3.4 The grower organisation, the Foundation for Arable Research (FAR) with CFR co-funded a pilot study for the initial testing of a prototype calculator and improvements to the interface between the model and the calculator from 2001-2002.

3.5 The Sustainable Farming Fund (SFF), administered by the Ministry of Agriculture and Forestry (MAF) supported the testing, adapting and disseminating of the calculator among growers over 2002-2005.

4 How was it funded?

4.1 The underlying science and model was funded through several Crop & Food Research contracts with the Foundation viz; CO2621 Characterisation and Genetic Control of Vernalisation 1996-1999, CO2614 Environmental Physiology of Arable Crops 1996-2000 and CO2X0022 Knowledge Management Systems 2000-2002.

4.2 The understanding of wheat physiology and its response under a variety of climatic, soil situations and fertiliser inputs and the model development, was funded through the above three programmes for four years-$.5m (CO2621) and $3.033m (CO2614) over 1996-2000 and part of $1.8m (CO2X0022) for the modelling programme over 2000-2002. It should be noted that the focus of all contracts was on

a number of arable crops and not just on wheat. It included barley, oats and peas as well, so not all the funding can be attributed to the wheat model.

4.3 FAR provided co-funding in 2001-2002 ($20,000), for the initial testing of the prototype calculator and for calculator interface improvements.

4.4 MAF through the SFF, the industry through the FAR levies, and the fertiliser company, Ballance Agri-Nutrients, funded a programme to test, adapt and disseminate a farmer-friendly wheat calculator among growers over the three years commencing July 2002. The funding levels were the MAF SFF $283,875, FAR ($ 67,500) and Ballance Agri-Nutrients ($67,500) over three years, a total funding input of $418,875 over three years. A further $62,000 of wheat growers' in-kind time was donated to the project.

5 How was it managed?

5.1 The FRST funded research was managed as part of the normal contract requirements of the Foundation with a research leader and Objective leaders. The initial prototype calculator development was a relationship development phase between the scientists and the growers. At this stage no formal agreements were discussed on IP ownership.

5.2 The testing and dissemination of the Wheat Calculator was initially discussed between CFR and FAR and managed through the SFF requirements, comprising a Project Manager from FAR, a grower, and the science team leader from CFR. CFR was contracted to deliver the calculator and IP was to be shared. The project started in July 2002 and was substantially completed in 2005.

5.3 Key to the development of the calculator was the testing and reviewing by the growers who provided feedback on its usability.

5.4 Public release of the calculator coincided with new FAR recommendations, based on local and overseas research, on the timing and rate of N fertiliser application. These new recommendations were incorporated into the scheduling part of the Wheat Calculator, assisting its success.

6 Accessibility Issues

The research institution context

6.1 At the end of 2003 funding for the basic science and modelling that underpins the Wheat Calculator stopped. Funding was shifted to a new more applied programme –Land Use Change and Intensification (LUCI).

6.2 This created a problem for CFR and for the industry. The ability to underpin the tool with a science programme (both crop physiology and modelling) was gone. This means that there is a lack of funding for the science that would update the calculator, make it simpler to use, and maintain its usefulness in the face of changing environmental conditions. This is likely to reduce the user uptake of the calculator over time.

6.3 In addition, crop physiology capability has left or is being deployed elsewhere in CFR, leaving a gap in the provision of core crop physiology science.

6.4 These wider issues affected the interactions between CFR and FAR by creating pressure on the scientists to update and improve the science and modelling, to make the calculator more useful, when they are not funded to do so. FAR regards the crop physiology and modelling science as public good research that they would be unwilling to fund, although they do consider that the costs of ongoing maintenance of the Calculator (e.g. adding new cultivars to it) could be met by the industry

User drivers

7.1 FAR supported the testing of the prototype calculator and it took three years of testing to give FAR and the growers enough confidence to trust that the Calculator could be used to improve nitrogen management without imposing costs on growers. The value of the tool as a defence around environmental performance in the regulatory environment was an additional driver for uptake of the tool: the regional council was considering regulation of nitrogen application as a way of reducing leaching.

7.2 The positive role of a link person at CFR, working between the scientists and farmers, helped facilitate the communications between two very different groups and ultimately facilitated the success of the project.

IP and co-funding issues

7.3 To some degree there was an artificial cut off point between the development of the model and the development of the calculator. However the two can be distinguished by virtue of the model being an output from the FRST funded research programme that can stand alone and be used in a number of applications, while the calculator can only be used with the model embedded in it. .

7.4 The FRST funding of the core science and model development clearly leaves the IP for those components with CFR. However, some blurring of ownership emerged when FAR provided some funding to improve the prototype calculator and to conduct initial trials prior to the co-funded SFF project, which tested the calculator more widely with farmers. The inputs from the model to the prototype calculator, were modified as a result of FAR advice, and FAR therefore perceives its initial funding as contributing to the model improvements, not just the calculator development.

7.5 This, along with the fact that IP ownership was not specified early in the project, created some differences between FAR and CFR with respect to who owns which IP, and thus whether revenue can be gained from sale of licences for the model. The SFF project set up a shared IP arrangement:

- CFR owns the response simulation code, the file and data structure that feeds information into the model, the inputs to and outputs from the model, and the management schedule.
- The funding group (comprising FAR and Ballance Agri-Nutrients) owns the scheduler and the system to predict crop responses using built-in future scenarios

7.6 Three factors give rise to IP issues:

- The calculator testing, adaptation and dissemination (funded by a group of users) relies on an embedded model owned by CFR, while the model can be used independently of the calculator
- FAR contributed funding for the calculator prototype testing and calculator interface improvements and thus sees itself as having a stake in the model

- CFR has a proposal for annual licensing of the executable wheat calculator software overseas i.e. the IP owned by CFR. FAR believes it is owned by the group and would like any revenue to go back into the calculator. Discussions are underway to develop a MOU to address the IP issues so the licensing and sale overseas can proceed

7.7 These ownership issues are seen by FAR and growers as affecting the accessibility of the calculator for the growers in New Zealand. The calculator is seen by FAR as primarily something that New Zealand growers can use, while CFR sees an opportunity to use the IP to generate revenue that can be used to update the calculator in a sustainable way, given that the market is now limited in New Zealand. This situation has developed in part because of a gap in funding for the underpinning crop physiology and modelling science.

8 Accessibility success factors

8.1 The critical success factors that enabled the public good science results to be accessible through the development of the wheat calculator include;

- The development of a model with potential for application through a delivery mechanism. It was not known when the FRST funding of the basic science on arable crops began, that a model would emerge
- The scientists' ability to get the industry group interested in funding a calculator and success in raising the credibility of science with growers by doing something useful for them
- Funding from FAR (growers' levy funds), Ballance Agri-Nutrients and the government through MAF's Sustainable Farming Fund for the testing, adapting and disseminating the calculator
- The role played by the CFR facilitator between the scientists and the growers during the pilot study and the SFF project. The facilitator, Tabitha Armour, sat with the farmers as they used the calculator to get direct feedback on its user-friendliness. Having seen what created difficulties for farmers she was able to work with the modeller and other scientists to suggest improvements to the calculator. This role proved critical to bridge gaps in understanding between the different groups and to ensure that the feedback from the growers could be used to adjust the model and calculator

9 Accessibility barriers

9.1 There were a number of barriers to accessibility of the findings of the FRST research that feed into the calculator.

- When a science programme ends and is not replaced by equivalent basic science and related modelling, any tool developed based on that science has a limited shelf life because it can no longer be updated with new knowledge. This has some significant implications for the economy. For example, NZ arable agriculture is influenced by changing climate, water availability, and release of new cultivars. So unless the physiological response of crops to these changing factors is researched, the utility of the tool will diminish over time, reduce the ability of growers to manage water and nutrients, exacerbating environmental stressors and diminishing growers' ability to be productive
- The view by CFR that they are not extension deliverers, created a cultural barrier that gave the impression that the researchers were focussed on the science and their timeframes, while the growers were focussed on a

three year SFF project with project milestones to meet. These perspectives created a barrier to the integration of feedback from growers

- Computer literacy amongst growers was an issue, so the tool needed to be very user-friendly. Further work on the calculator is necessary to make it easier to use at the farm level, but all the improvements have not been incorporated. This provides an additional barrier to the ongoing utility of the tool.
- Availability of the most up to date weather information for specific wheat growing areas was critical for simulations of potential yield. Information at the required scale has not always been readily available, because of the lack of weather stations that record the necessary weather variables
- Pressure on the scientists to obtain revenue to enable the calculator science to be updated was a barrier raised by both CFR and FAR. This created the drive to sell the product and/or its software and gave rise to issues around who owned the IP-CFR or FAR

10 The Foundation draft access principles

10.1 The Foundation's draft access principles are:

1. ***Public good primary results and codified information should be made available to the maximum extent possible at the cost of dissemination, so long as that access maximises the national benefit.***
2. ***Where possible, research organisations would identify in advance the public good outputs that should be publicly accessible.***
3. ***Disclosure by research contractors to the Foundation when release of public good outputs or primary results is denied and reasons for the denial.***
4. ***Provide for a dispute resolution and escalation process where there is a difference of views between the Foundation and research contractors over access to public good outputs***

There are several conditions where withholding or deferral of access could align with the national benefit. These are:

a. ***Where release may result in loss of, or significant reduction in commercialisation opportunities and returns to New Zealand, including damaging commercial partnerships between research contractors and firms or industry groups;***
b. ***Where the release may have significant adverse effects on the environment, existing New Zealand industry, or the cultural values of groups of people***

Comment on the above principles concentrated on Principle 1 and 2.

10.1 Principle 1 was supported by both the scientists and the industry group. It was suggested that if the line between science and extension was clearer, issues about ownership when co-funding exists, would diminish. There was a view that co-funding with public good researchers creates a complication around IP ownership where revenue is sought and thus creates a barrier to accessibility. Comment was made that this creates the need for protocols over access (and hence increased administration) and/or sale of research results, which is not in the public good.

10.2 Principle 2 created a problem for the scientists since it is not always known when the research project starts what the outputs will be that can be made

accessible. As above, close association with private sector interests can also generate access difficulties when the nature of outputs are unknown at the start of a programme. When the first science programme started the development of a model was not known. The modelling programme did however envisage a model as the output.

10.3 The application of these principles to the wheat calculator development would have made little difference to how the information was made accessible. The information was made freely available to the growers through a tool. To maximise the accessibility did however require a funding source which was found successfully through the SFF and industry.

10.4 The sale of the Wheat Calculator software overseas is not affected by the Principles since the information for New Zealand growers has essentially been transferred and thus could be viewed as in the national interest, especially if the revenue is used to maintain the product in New Zealand.

10.5 It would not have been possible for CFR at the start of the FRST funding of the crop physiology programme to predict that a model would be developed, nor that a calculator would be needed to make the model useful for growers.