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LESSONS FROM A DECADE OF WHOLE-FARM MODELLING IN WESTERN AUSTRALIA

D.J. Pannell

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Nedlands, Western Australia 6009

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EXECUTIVE SUMMARY

This paper outlines important lessons and experiences in successful development and use of the MIDAS whole-farm models in Western Australia. The paper includes discussions of whole-farm planning and whole-farm modelling in general and various aspects of the MIDAS experience, including the model's history, strengths and weaknesses, uses, positive outcomes and negative aspects. It is argued that the factors contributing to success of MIDAS include the choice of level of detail (with an emphasis on representing biological detail as well as financial factors), the strategies of MIDAS use (involving a high degree of collaboration with scientists and emphasizing understanding rather than prediction or prescription), a supportive institutional environment and the optimization framework.

Many management decisions made by farmers depend on factors external to the particular crop or livestock enterprise directly affected. Issues which arise at the level of the whole-farm, such as the allocation of limited resources between alternative enterprises, can be especially difficult to analyze. Whole-farm models of various types provide a vehicle for better understanding these issues and decisions. In Western Australia a particular whole-farm model, MIDAS (Model of an Integrated Dryland Agricultural System), has been an influential tool for over a decade. My aim here is to outline some of our experiences in the development and use of MIDAS with a view to providing guidance to others commencing or contemplating development of similar models. I start with some points on whole-farm planning and whole-farm modelling in general and then consider a wide range of issues arising out of the several versions of the MIDAS model.

WHOLE-FARM PLANNING

Managing a farm can be blindingly complex. In deciding on the best mix of farm enterprises and management practices, the diversity and extent of relevant information is enormous. The choice of farm strategy may be influenced by the farmer's knowledge of: scientific issues (biological and/or physical), machinery, economic/commercial factors, political events, legal constraints, historical trends, climate/weather, environmental issues, personal circumstances and any number of practical considerations. Even if a farmer had a complete grasp of all relevant information, the problem of combining it and appropriately weighing it all up for decision making would be very substantial indeed. A thorough and detailed analysis would certainly be beyond the capability of any single human mind.

Despite the apparent difficulties, farmers in general seem to cope well with their planning and day-to-day management decisions. Many are enthusiastic

collectors of information and ideas. They do agonize over some decisions, but they are not defeated by the intractability of the problem. They appreciate that their decision making processes are not rigorous and formal, but they must be careful not to spend too much time on formal analyses because there are so many decisions to make for them and most of their time is required for the many physical tasks which are needed to run the farm. Very important decisions may have to be made (or at least finalized) during times when the time available for contemplation and analysis is at a minimum; i.e. during crop seeding. They get by using judgment, guesses, hunches, outside advice and some limited numerical analysis and they can do so because of their intimate knowledge of their farm.

In my judgment, farmers' decisions made in this ad hoc way are usually very good. They are not perfect (farmers are human!) but they are usually near enough to the theoretical ideal for their particular circumstances to obtain most of the potential benefits. They are helped in this by the forgiving nature of many agricultural decisions; often there is a range of strategies around the optimum which give near optimal levels of profits.

People who are not themselves farmers usually have at best a dim appreciation of the complexity and difficulty of decision making for farm management and just how much is at stake. If farmers are not doing something which an outsider (such as a scientist) thinks is obviously the right thing to do, it is probably for a very good reason which has not been recognized by the outsider. It may be a reason which is apparently remote from the issue at hand, such as the availability of labor or an issue in the farmer's private life. This observation about non-farmers applies even to many professionals serving agriculture. Scientists, even those with a close relationship with farmers, are protected from the messiness of farm decision making by their own specialization. Farmers specialize to some extent too, but they can only

afford to do so to a small degree. In general they have to be reasonably well on top of all aspects of their farm to stay in business.

WHOLE-FARM MODELLING

Although whole-farm decision making is very complex, it is very important for outsiders attempting to serve or influence farmers to have some way of analyzing and understanding whole-farm issues. Without this, any advice given may be incompatible with the local farming practices, or may lead to lower, rather than higher, economic returns to farmers. One way in which non-farmers can assess the whole-farm implications of any change to the farming system is by the use of whole-farm computer models. These fall into one of two broad categories: simulation and optimization.

Simulation approaches to whole-farm modelling range from very simple to pipe dreams of complexity. Simple simulation models are common and widely used. Most farm advisors and many farmers build simple whole-farm budgets, which are in essence simple simulation models, with almost all of the detail simplified away. They can be very valuable and revealing, especially in the hands of an experienced farmer or advisor. At the other end of the complexity spectrum, is an integrated system of bio-physical dynamic simulation models (one for each species of plant or animal on the farm), perhaps feeding directly into an economic model. These systems exist most commonly in the dreams and imaginations of simulation modellers, rather than in reality. In my view they are well-intentioned but misguided. If actually implemented they would involve a level of detail which is inappropriate for the messy job of whole-farm planning.

The second category of whole-farm models is optimization. These have a long but often disappointing history in the area of whole-farm planning.

Optimization modellers working in agriculture also seem to have had a pipe-dream - that of an automated system of whole-farm optimization models serving farmers in a region. Beginning in the 1960s, there have been a number of attempts to implement such systems. To my knowledge, all have failed the test of commercial viability. In my view there are several reasons for this:

- farmers already do well in their whole-farm planning (as discussed above);
- in order to provide advice which is better than the farmer's own judgment, a very large amount of farm-specific information needs to be collected; and
- the cost to farmers of providing the time to reveal this farm-specific information is large, whereas the potential gains are modest at best.

These problems would also dog any large integrated whole-farm system of simulation models, if such a system were ever to be offered as a service to farmers.

Nevertheless there is an audience for which such models are potentially of very great value: outsiders attempting to serve or influence farmers. In Western Australia we have had a notable degree of success in targeting a whole-farm optimization model to this audience. The MIDAS model was originally developed at the Western Australian Department of Agriculture (WADA) and has been used for a wide range of applications (e.g. Abadi Ghadim and Pannell, Bathgate et al., Ewing and Pannell, Ewing et al., Pannell 1987, Pannell and Falconer). It is now in use in several institutions in Western Australia and is the inspiration for model developments in several Australian states and in other countries (e.g. Nordblom et al.). An indication of the model's success within Western Australia is provided by the following quote, from a Western Australian scientist in a 1994 meeting.

"What has MIDAS ever really achieved apart from changing the thinking about whole-farm systems within the Department of Agriculture?"

Although intended as a criticism, I take this as praise of the highest order. I suggest that the fact that such an important achievement could be belittled in this way reflects the extent to which MIDAS and the understanding it generates have become so familiar that they are taken for granted.

The remainder of this paper focuses on the MIDAS models and their derivatives. After a brief history I will describe the various uses to which the models have been put, the mode in which we have attempted to use them, positive and negative aspects of our experiences with MIDAS and conclude with an outline of current and possible future developments. My aim is to highlight aspects of the MIDAS experience which may be of interest and of help to other modelling groups attempting to develop a whole-farm model of this type.

BRIEF HISTORY OF MIDAS

MIDAS is a whole-farm linear programming model with a joint emphasis on biology and economics. It has been described in detail elsewhere (e.g. Morrison et al., Kingwell and Pannell, Pannell and Bathgate). Here I will focus on its history. A brief overview of this history is given in Table 1.

(Table 1 near here)

The initiative for the model's initial development came from David Morrison (an economist in the head office of the Western Australian Department of Agriculture) and Mike Ewing (a pasture researcher in the Merredin regional office). Early model development was by Ross Kingwell, David Morrison and the author. Throughout its history, primary responsibility for development and management of the MIDAS models has rested with a group of agricultural

economists. At the time when MIDAS was established, economists had a very low profile within the Department of Agriculture, with active hostility from some quarters. This affected the MIDAS project in various ways. For example, the Department provided its own priority ratings of all applications for external research funds. The initial application for funding for MIDAS was given the lowest possible rating by the Department, but nevertheless received a high rating from the funding body, the Wheat Research Committee of Western Australia.

There has been a complete transformation in the attitude to economics and economists within most (but certainly not all) of the agricultural research and extension community in Western Australia. Economists are actively involved throughout the agricultural research and extension process to an extent which is remarkable and very rare internationally.

Regional versions

The first version of MIDAS was representative of the Merredin region in the eastern part of mixed crop-livestock producing region of Western Australia (the "wheatbelt"). Due to the regional specificity of model results a number of other versions have been developed. Currently six regional versions are actively maintained, covering most of the wheatbelt (Merredin, Morawa/Mullewa, Kojonup, Eradu, Esperance, Northam). Several other regional versions have been developed but not maintained. This reflects a high demand for model development, but a difficulty in procuring sufficient resources for the time-consuming task of model maintenance.

Risk and uncertainty

From its inception, the most prominent and persistent criticism of MIDAS was that it did not allow for risk. The standard versions are based on the

concept of an "expected season" (expected in the statistical sense). This eventually prompted us to develop MUDAS (Model of an Uncertain Dryland Agricultural System) (Kingwell et al., 1993; Kingwell, 1994) in the late 1980s.

As well as giving us a deeper insight into the farming system, MUDAS has allowed us to test the biases resulting from the simplifications inherent in MIDAS. As a result of this testing we now have more confidence using MIDAS for many analyses in which only a broad picture of the farming system is needed. We have found that the gross elements of the farming strategy (i.e. the types of rotations practiced, the levels of different enterprises) are reasonably consistent between MIDAS and MUDAS. Of course the MUDAS model specifies a different farming strategy for each year depending of climatic and economic conditions, but, for example, the expected value of optimal crop area selected by MUDAS is similar to the value selected by MIDAS. We have also found that our evaluations of particular farm management practices are rarely changed by using MUDAS rather than MIDAS (e.g. Kingwell and Schilizzi, 1994). This is important to us because of the greater difficulty of using MUDAS and the existence of only one regional version of MUDAS. There is an ongoing need for careful judgment about whether any given issue can be adequately analyzed using MIDAS or whether MUDAS is needed.

Software developments

Table 1 includes reference to three developments in the area of software. All three have increased the accessibility and usability of MIDAS. The first was the development of software capable of reliably solving large linear programming models on IBM compatible microcomputers. We use AESOP, a linear version of MINOS but there are now many packages available. The second was our development of MARG (Pannell, 1990), a menu driven system for generating

series of model solutions and summarizing results into tables. This has made the model much more accessible to non-specialist users and has allowed specialists to much more easily generate large series of runs, saving time and making practical much more detailed analyses of any given issue. The third development, MID (MIDAS Interactive Database), is a system for allowing users to interrogate a large database of MIDAS results addressing a particular issue. This allows very rapid response to "what-if" questions from users and has allowed MIDAS results to be easily accessed by users with very limited training and even limited computer skills.

STRENGTHS AND WEAKNESSES OF MIDAS

The major strengths of MIDAS are its joint emphasis on biology and economics and its ability to address a range of whole-farm issues in a profit-maximizing framework. The issues include:

- allocation of land to alternative enterprises;
- rotation selection;
- livestock flock/herd structure and stocking rate;
- strategies for grazing and supplementary feeding;
- machinery size and pattern of use; and
- impact of limited finance on the optimal farm strategy.

Additional strengths of MUDAS are:

- capacity to represent risk averse attitudes of farmers; and
- capacity to identify optimal tactical adjustments to the farm strategy in response to observed weather patterns.

On the other hand there are some clear weaknesses of MIDAS:

- The absence of risk aversion and tactical management adjustments in the identification of optimal strategies.
- The "equilibrium" approach to representing dynamics. Production figures in all the models are meant to represent sustainable medium- to long-term figures. MIDAS and MUDAS identify a target strategy but do not say how a farmer should move over time from their current farm plan to the new optimum. For some issues involving changes over several years (e.g. soil acidification, development of herbicide resistance) this is a significant limitation and MIDAS is not the best tool. Even for these problems, however, MIDAS can give some very valuable insights in the hands of a skillful analyst.
- The models are too big, detailed and cumbersome to be the best tool for use by farmers or even for direct one-to-one extension[1]. Simpler spreadsheet-based tools are much more appropriate for both these purposes. However MIDAS is very valuable for identifying the strategies which should be examined in the spreadsheet.

The major weakness of MUDAS is its limited geographic coverage. There is currently only one region with a MUDAS model.

USES OF MIDAS

Research priorities

The area in which MIDAS has had the biggest impact has been in influencing the research activities of the Western Australian Department of Agriculture. At one time in the mid 1980s, virtually every research project being conducted in the Merredin region was directly linked to the MIDAS model, either by filling

a data deficiency highlighted during model development or pursuing a direction of research identified by MIDAS as likely to be of benefit to farmers. MIDAS greatly facilitates the most difficult part of economic evaluations of research: the estimation of economic benefits from a given change in the farming system.

As well as influencing which research is conducted, MIDAS has had an impact on the details of how the research is conducted. I believe that scientists who have interacted closely with MIDAS have a better appreciation of the context and relevance of their work and are more likely to measure the variables which really matter for the farm-management problem they are addressing. In a sense the models act as a broker for the farming community, asking the scientist the questions which matter most to farmers and asking them in a way which focuses on the most important details for those questions. In my opinion, influencing the details of the research in this way is even more important than influencing which areas of research are pursued.

Extension

MIDAS has contributed directly to the Department's extension program through provision of quantitative information on profitability of alternative enterprises or management strategies. We have never offered a one-to-one service to farmers, but have instead focused on identifying robust messages which can be extended generally to groups of farmers or in the mass media. From time to time the models are adapted to represent individual farms, but this is more for the purposes of model testing than for extension.

The range of extension issues which have been analyzed using MIDAS is very large. It includes optimal crop-pasture rotations for particular soil types, profitability of new crop species (such as lupins, peas, chick peas, lentils) the optimal allocation of land between crops and pastures, and the economic

value of "farming to soil type"; that is, managing different parts of the farm differently to suit different soil characteristics.

As well as direct provision of information, MIDAS has also influenced extension indirectly, by improving the understanding of advisors about whole-farm management generally or about the whole-farm implications of a particular issue. Often its role has been in providing advisors with confidence that a particular strategy is or is not worth extending.

Policy

Policy measures with complex implications at the farm level have been investigated in order to support design or assessment of particular policies. For example payment of extra premiums for high-protein wheat, and provision of a guaranteed minimum price for wheat in Western Australia have been examined.

Education and Training

The models play a very valuable role in educating new extension staff on the nature of the farming system and how its components interact. Understanding which might otherwise take years to gain through accumulated experience can be achieved in weeks. MIDAS is also used at various tertiary education institutions, especially the University of Western Australia.

Database

Each model represents a very convenient summary of the key features of a farming system. Data from MIDAS are regularly used as indicative regional values in other economic analyses.

POSITIVE OUTCOMES OF MIDAS

Integrating effort

Especially during the model development phase, MIDAS has provided a focus for bringing together people who otherwise have little interaction. Researchers from different disciplines are brought together, and researchers are brought together with extension agents and farmers. Most people would agree that this sort of thing is good, but without the focus and structure of a modelling effort, it is difficult for meetings between such disparate groups to be productive.

Putting biological information in an economic context

Farmers are not only interested in profit, but if they are going to continue to be farmers, they must give it a high priority. The capacity to estimate the economic significance of any new piece of biological or technical information is clearly of great value to an organization attempting to benefit farmers. MIDAS and/or MUDAS provide this capacity for many types of information.

Affecting thinking

In my view, the biggest single benefit of MIDAS is the way it influences the thinking of researchers and extension agents about their role in influencing farm profit. Sometimes this is a painful process which challenges cherished beliefs and paradigms. Some scientists resist the process so strongly that they remain unconverted, but in most cases, the result of close interaction with MIDAS is positive.

I have already stated my view that the indirect benefits to farmers from this influence on scientists and advisers are likely to be greater than the direct

benefits which would arise if the resources involved were redirected towards direct extension of MIDAS results to farmers. This is because most farmers already have a good appreciation of whole-farm issues, whereas most scientists and many extension agents do not.

Highlighting data deficiencies

Especially during the model construction phase, many areas with little or no useful data are identified. While frustrating for the modellers, this does serve a very valuable role in directing the attention of researchers to these data gaps. Once a working model has been constructed, the relative importance of the various data gaps can be investigated to help further prioritize them and target attempts to fill the gaps.

NEGATIVE ASPECTS OF THE MIDAS EXPERIENCE

Maintenance

Maintenance and routine use of a MIDAS model is very resource hungry. To do the job properly I estimate that there is a need to dedicate half a person per model per year. This half a person is engaged in updating coefficients, debugging errors and problems as they arise, reviewing data, improving the model structure, and documenting the model.

Unfortunately we have found it much easier to attract resources for construction of new models than for maintenance of an existing model. As a consequence of this I believe that we have built too many versions of MIDAS for different regions. I would have preferred to do fewer things but to do them better.

Dependence on hierarchy

Success in a region is very dependent on support from the Officer in Charge. If scientists and advisors are not given a clear message that the model is an important activity for the office, it can be very difficult to involve them to the extent needed. There are too many day-to-day priorities to compete with. Unfortunately we have experienced indifference from leaders in a couple of regions. Of course this is better than outright antagonism, but it still means that the modelling effort falls well short of its potential.

Unconstructive criticism

Inevitably, some groups remain resistant to the charms of MIDAS. In Western Australia, some private agricultural consultants and some groups of scientists remain aloof. In some cases this can be seen to result from a MIDAS result which is unfavorable to their own interests, but in others, it is due to a more general attitude which is anti-economist, anti-modelling or, in the case of private consultants, anti-government.

A model like MIDAS, with its reliance on subjective data in a number of important areas, is rather susceptible to malicious criticisms. We have to give a high priority to maintaining good relations with our client groups. Often this means developing a very thick hide. In situations where one is receiving unfair criticism from someone with whom we would rather be on good terms, one is sometimes forced to swallow one's pride and concede issues which would not need to be conceded if they were to be settled on the merits of the arguments. Being of a temperament which can tolerate the psychological conflict which this entails is very valuable as a whole-farm modeler.

Availability of suitable modellers

MIDAS makes extreme demands on its developers. They must have sufficient

knowledge of biological and physical science to be able to win the confidence of relevant scientists. They obviously also need computer skills and knowledge of finance/economics and mathematical optimization. A feel for practical farming and farmers is very valuable, although this can be improved over time. Finally, interpersonal skills and communication (both verbal and written) are at least as important as any other skills. People with all of these attributes are very rare indeed. Our experience to date indicates that you do need top quality people for the model to succeed. Their limited availability is probably the factor which most constrains development of the models.

Misuse

Some outsiders to the MIDAS team are very concerned about the danger of MIDAS results being misused. Given the degree of uncertainty about MIDAS coefficients and the limited applicability of MIDAS to any specific farm, it certainly would be possible for a too literal interpretation and implementation of the model's results to make a farmer worse off rather than better off. Similarly there is a risk that research managers might use MIDAS results to make far-reaching changes to the priorities for research without an adequate appreciation of the limitations of the model and its data.

However for a number of reasons, I believe that the risk of either of these outcomes is very low indeed. Primarily, both farm managers and research managers are too sensible to uncritically apply MIDAS results in a prescriptive way. This is reinforced by the natural (and justified) general skepticism about the relevance and reliability of results from a computer model. Furthermore, we mitigate against the risk by the way we use MIDAS and communicate results. As emphasized below, our approach is not to focus on individual results but rather to provide understanding and to put issues in

perspective by examining a wide range of plausible scenarios. In this context I feel that the risk of misuse of MIDAS is very low. In 11 years I have only witnessed two cases of MIDAS results being badly misinterpreted. These were both by advisers, and I have no evidence to indicate that they had any negative consequences other than the knot in my stomach.

FACTORS CONTRIBUTING TO THE SUCCESS OF MIDAS

Strategies of MIDAS use

There are a number of distinguishing features of the way MIDAS has been used in Western Australia. Part of its impact is attributable to the way in which analyses have been conducted collaboratively, with interaction between different disciplines and between researchers and extension agents. For this reason, the MIDAS team relies just as much on communication and interpersonal skills as on computer skills. Maintaining the good-will and the communication channels is very time consuming, but essential. It is surprising to me how quickly a group's confidence in a particular MIDAS model can diminish if the level of contact is not high enough.

The model is primarily used to put issues in perspective, rather than to provide definitive or precise numerical results. Our philosophy is that our role is to provide inputs to the judgments of decision makers (whether they be farm managers or research managers) rather than to be prescriptive.

Consistent with this view, we place very little emphasis on detailed interpretation of any single model solution. Our approach is to conduct extensive sensitivity analyses to investigate how the optimal farm strategy and profitability varies in different plausible scenarios. This approach is partly necessitated by the uncertainty about our data and partly by our wish to improve understanding rather than provide a prescription. For any given

issue, the number of model solutions generated may be very large (up to 10,000). These can then be interpreted and summarized prior to dissemination or alternatively entered into a "MID" database to allow quick and easy interrogation of the model's behavior in particular scenarios.

Another similar approach is to conduct break-even analysis. For example, we might ask how high does the yield of a new crop species have to be before it would be as profitable as the best existing enterprise on a particular soil type in a given region? This provides scientists with a target and a perspective on the probability that the new species might ever be adopted.

Other elements of MIDAS strategy

Early in the life of MIDAS, a high emphasis was placed on regular production of up-to-date model documentation. Our approach is to make our assumptions as public and open to criticism as possible. This strategy creates the risk of providing ammunition for unconstructive criticism, but given the subjective nature of many of the assumptions in MIDAS, there is no sensible (or ethical) alternative to acknowledging the many weaknesses in data in a model of this scope. If somebody does not agree with one or more of our assumptions, we simply ask them for their preferred values and re-run the model with those values included.

The production of paper documentation has received less emphasis since the development of spreadsheet templates for displaying, storing and changing model assumptions. In my opinion, however, we still need paper documentation as well to better present an overview of the models assumptions and record background details about the reasons for assumptions. Some of our client group also prefer to work with paper than with a computer.

Our development of a reputation and profile has helped the MIDAS project in a

number of ways: attraction of funds, support from local scientists, attraction of international and interstate visitors, etc. A key element in developing this profile has been an emphasis on publications of all types. The aggregate number of publications of all types in now over 120.

Appropriate level of detail

MIDAS is unusual in its joint emphasis on economics and biology, and especially on the interactions between enterprises. The level of biological detail is low by the standards of biological models, but very high for an economic model. The choice of level of detail has been crucial to the success of MIDAS. There is enough detail to validly analyze a wide range of whole-farm issues, but not so much that we are overwhelmed by data collection and validation.

In part the degree of detail is dictated by the optimizing framework used. I consider this limitation on the level of detail which can practically be represented in an optimization model to be a great advantage. It provides a constraint and a discipline which ensures that the model does get finished and applied. It also forces us to identify the key parameters to which the farming system is most sensitive, rather than falling into the "black hole" of detail which can consume simulation modelling projects.

One of the details which is excluded from the standard MIDAS models is risk. Some consider this to be a critical omission. However I am convinced that there are many issues for which MIDAS provides very useful information and understanding without formally representing risk. Partly this is possible because of the way we address risk informally using sensitivity analysis. In solving the model for a wide range of plausible scenarios and examining how the farm system changes, it is possible to develop a feel for the importance of uncertainty about particular parameters. This is not as good as formally

and explicitly representing parameters as random variables with defined probability distributions, but it achieves many of the same things.

Optimization framework

One of the less-obvious advantages of the optimizing approach is discussed above. The more obvious advantage is the ability to quickly and automatically identify optimal responses to changes in the farming system. This is crucial in many cases. For example the introduction of lupins into the farming system in Western Australia led to changes in optimal rotations (including on soils where lupins are not grown), machinery use, livestock feeding strategies, stocking rates, and fertilizer use. In order to correctly estimate the impact of lupins on farm profit, it is essential to identify and quantify all of these changes. This is extremely difficult in a simulation framework.

A supportive institutional environment

WADA is an excellent environment for interdisciplinary work like MIDAS. It is unusual in the extent to which people from different disciplines talk to each-other. We have also been very fortunate in the level of real support given by the hierarchy of WADA. We have seen how important it is to have support from the local officer in charge, as reflected in the different success levels of MIDAS in different regions. In the Merredin office, where support has been active and long-term, the model has had a big impact on the whole office. We also benefited early on from a change in the Directorship of the Department, to one with a greater sympathy to our approach.

SPIN-OFFS AND CONSEQUENCES

As mentioned earlier MIDAS has been a catalyst for improving the profile of economists in the agricultural research community of Western Australia. For

example, they now play a central role in the formal setting of research priorities of WADA. They play an important role in CLIMA, the Cooperative Research Centre for Legumes in Mediterranean Agriculture, which devotes an entire sub program to Economic Modelling. The influence of MIDAS on people's understanding of the whole-farm system has been palpable, as reflected in the earlier quote. I believe that this has substantially improved the relevance and value of the Department's activities.

There are a number of computer systems which have arisen as spin-offs of the MIDAS/MUDAS effort. They include:

- REVS: a simple spreadsheet based tool for calculating the net economic benefits of a research project. This includes a number of considerations which are not (and should not be) part of MIDAS.
- TACT: a decision aid for within-season crop area decisions. It includes an adapted version of CERES wheat, a wide range of climatic analyses and a system for generating conditional probability distributions of wheat yield and gross margin. This was developed as a consequence of MUDAS results indicating that prediction of wheat yield is the key factor determining the optimal farm strategy under risk.
- GULP, MARG and MID: a suit of tools to ease creation, solution and communication of MIDAS models.

Other Australian states are now attempting to emulate the success of MIDAS. Currently models are under development in New South Wales, Victoria and South Australia and there is increasing interest in whole-farm modelling in Queensland. Our international profile has been sufficient to attract visitors from several countries (France, USA, UK, Syria, Iran, Thailand, Indonesia) and invitations to make reciprocal visits for consultancies.

CONCLUDING COMMENTS

After 11 years, it seems that the impact and influence of MIDAS is still increasing. I see an ongoing role for MIDAS in tackling the issues of the day in agricultural research and extension in Australia. Our level of resourcing has never been higher, but demand for our services has risen rapidly so that we are able to satisfy only a fraction of the requests received. On the national scene, we are increasingly called upon to help other states with model development. Prioritizing our own activities among the competing demands is increasingly difficult.

It is notable that MIDAS has been so successful despite our use of a very old and unfashionable modelling technique. This reflects the power and flexibility of linear programming for this type of modelling, as well as our particular strategies for building and using the models.

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Table 1. Milestones in the History of MIDAS Models

Year	Event	Staff[A]
1982	First meetings to discuss possibility of model.	0.5
1983	Initial model development.	1.2
1984	Model results extended/publicized for the first time.	1.2
1985	Develop microcomputer spreadsheets for inputs.	1.5
1986	First refereed publication.	2
1987	Book published.	2
1988	Microcomputers used for model solution.	2
1989	MUDAS (version with risk and uncertainty) developed.	3
1990	MARG (MP Automatic Run Generator) software developed.	3
1991	Serious interest from other states and overseas.	3
1992	Started giving general courses on MIDAS/MARG.	3.5
1993	Commencement of model development in other states.	4
1994	MID (MIDAS Interactive Database) approach developed.	5

[A]Estimate of number of staff (in full time equivalents) working on model development and application in Western Australia.

FOOTNOTES

[1]The MID approach, described above, is a way of allowing a limited interrogation of MIDAS in a simple, and usable framework without the need to learn the model in detail.