Towards a Common Advisory Toolkit for managing Temperate Grazing Systems

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Abstract
Computer models that simulate grazing enterprises are a powerful way to analyse the feasibility, profitability and risks of alternative management options. They have been used in scientific research for some time. Some grazing systems models have now been developed into PC-based decision support tools for graziers and their advisors. When the earliest tools were conceived, the industry did not see a need for them. However, ten years later, there is evidence of industry acceptance and that these tools can have a significant impact on industry practice. Computer-based simulation tools are still a new technology in the grazing industries but the potential for these tools to assist future profitability and sustainability of grazing enterprises is large. This paper discusses development and release of the GRAZPLAN series of tools and the possibility of a common software toolkit for the grazing industries in southern Australia.

Key words

computers, decision support tools, grazing systems, GRAZPLAN, management, profitability.

Advisory tools that deal with management of the grazing system

In grazing systems there are always a number of alternative management strategies that may be implemented to potentially improve the profitability of the enterprise. However, it is not always easy to see what management changes will be most beneficial. Indeed graziers operating essentially similar farm businesses can adopt widely divergent management paths in response to industry change. In recent times, many woolgrowers have faced a significant decline in profitability. Some have responded to this by reducing inputs such as fertilizer to cut costs, whilst others have opted to increase their investment in inputs that will enhance production per hectare and/or improve the quality and value of their products. In the former case, “cost cutting” has committed some enterprises to diminishing productivity and reduced profitability (13). In the latter case, some graziers have managed to maintain or improve their profitability despite lower commodity prices (eg. 20, 6).

Effective decision making by graziers requires a broad knowledge base. Ideally graziers need expertise in a range of disciplines (eg. animal health and nutrition, agronomy, economics, etc) and an understanding of how the disciplines interact, and impact on other aspects of the farm business cycle. They must stay abreast of new technology and be able to sift relevant information from that which is extraneous to the success of the business. Marketing and business skills are also essential for survival in a constantly changing economic environment. Even the most competent grazier can find it difficult to acquire so much expertise. Indeed, graziers commonly complain that “there is too much information”. The solution for many is to use consultants to help fill the knowledge gaps and to assist their decision-making.

Added to the “knowledge barrier” is the difficulty of managing a complex farm business in Australia’s highly variable climate. When seasonal variation in productivity and fear of exposure to severe droughts is combined with unpredictable commodity prices the result is a very volatile and risky business environment. This often has a detrimental impact on the confidence needed to increase investment in a farm. Choosing an “optimistic” business path depends on being able to quantify the consequences and risks of alternative management strategies.

Computer models provide us with opportunities to develop decision support tools for analysis of grazing systems. The tools enable the user to explore some of the biological and financial consequences of management decisions over a range of seasons. They ideally incorporate the best scientific knowledge and draw on information that is relevant to the problem being analysed. In this way, the decision support tool filters information, protects the user from "information overload" and helps to ensure that decision making is focused on the "profit drivers" of the business.

Computer-based tools for Australia's temperate grazing systems

There have been a number of computer-based models developed to explore aspects of temperate grazing systems or ruminant nutrition. Notable examples of these include SPUR (21) and NUTBAL (19). Tropical and arid zone grazing systems have also been modelled and, in Australia, GRASP is an example of such a model being used to analyse grazing practice (16). A summary of the considerable effort that has gone into modelling biological, physical and economic aspects of Australian farming systems and landscapes is provided by Hook (12). Most models have been developed for use in scientific research to integrate knowledge, or to explore complex systems where experiments would be very large, technically difficult and costly. SheepO is a good example of an early computer model that has also been used to provide district and industry level analyses of grazing management issues for the sheep industry in southern Australia (14). Most models have not been developed into decision support tools and, consequently, their use has essentially been restricted to the group that developed them.

For a number of years it has been obvious that there was potential to use simulation tools for problem solving on farms, but progress in applying the technology to farm businesses has been slow. Modelling practitioners have themselves been amongst the most vocal in denouncing the slow progress (17). However, slow progress has partly been due to the fact that the potential of the technology was recognized well in advance of there being computing hardware and software systems that were suitable for use by the people who would want to use the information (eg. 19). Quite different approaches have been taken in attempts to use computer models for decision support. For example, Stuth *et al*. (19) have built an advisory service based on their ruminant nutrition model. By contrast, the GRAZPLAN project in Australia has provided a series of decision support tools that graziers or their advisors can use. The latter approach has only been possible because computing power and portability of computers has improved dramatically in recent times.

The GRAZPLAN series of decision support tools are adaptations of components of farming systems models that had been developed by CSIRO for research (19). The GRAZPLAN toolkit is presently comprised of four commercially-available software tools: MetAccess, a weather database system for Australia (7); LambAlive , which calculates the effect of weather on lamb survival (7); GrazFeed, for application of the Australian feeding standard for ruminants (10); and GrassGro, which simulates grazing enterprises (15). Figure 1 illustrates the relationship between these stand-alone tools and a number of other models developed as part of the decision support tool development program. A number of important principles have underpinned the development of the tools.

Incremental Development

A series of tools that dealt with single, through to multiple issues in grazing management was envisaged from the start of the GRAZPLAN project in 1985. Although the development team had been using models at all levels of complexity in their research, development of the GRAZPLAN series was planned to be incremental, and this process continues today. This was important for the following reasons:
(i) Time was needed to make the step between the research models and their derivative decision support tool. It is necessary to simplify the user interfaces, minimise input data requirements and ensure that they are easy to obtain, and automate access to databases.
(ii) There were few computer-based decision support tools available to the rural sector. Single-issue tools were initially more likely to be accepted because they are less demanding of computing skill, input information requirements are modest and it is often easier to test the plausibility of model predictions and thereby gain confidence in its use.
(iii) The models used in each single-issue tool were also intended to be components of multiple-issue tools planned for later development. Release in single-issue tools provided an opportunity to test their performance and their acceptance.
(iv) The team's resources were limited. It has been difficult to attract grazing industry investment in early-

stage development of the tools, but relatively easy to obtain funds for their application. In reality, few have believed that computer-based management tools would find a role on farms.

The evolution of this process means that some single-issue tools will fall by the wayside. For instance, LambAlive is rarely used now as questions about lamb survival are best addressed using the multiple-issue tool, GrassGro, which incorporates the lamb survival model. We envisage that in the near future we

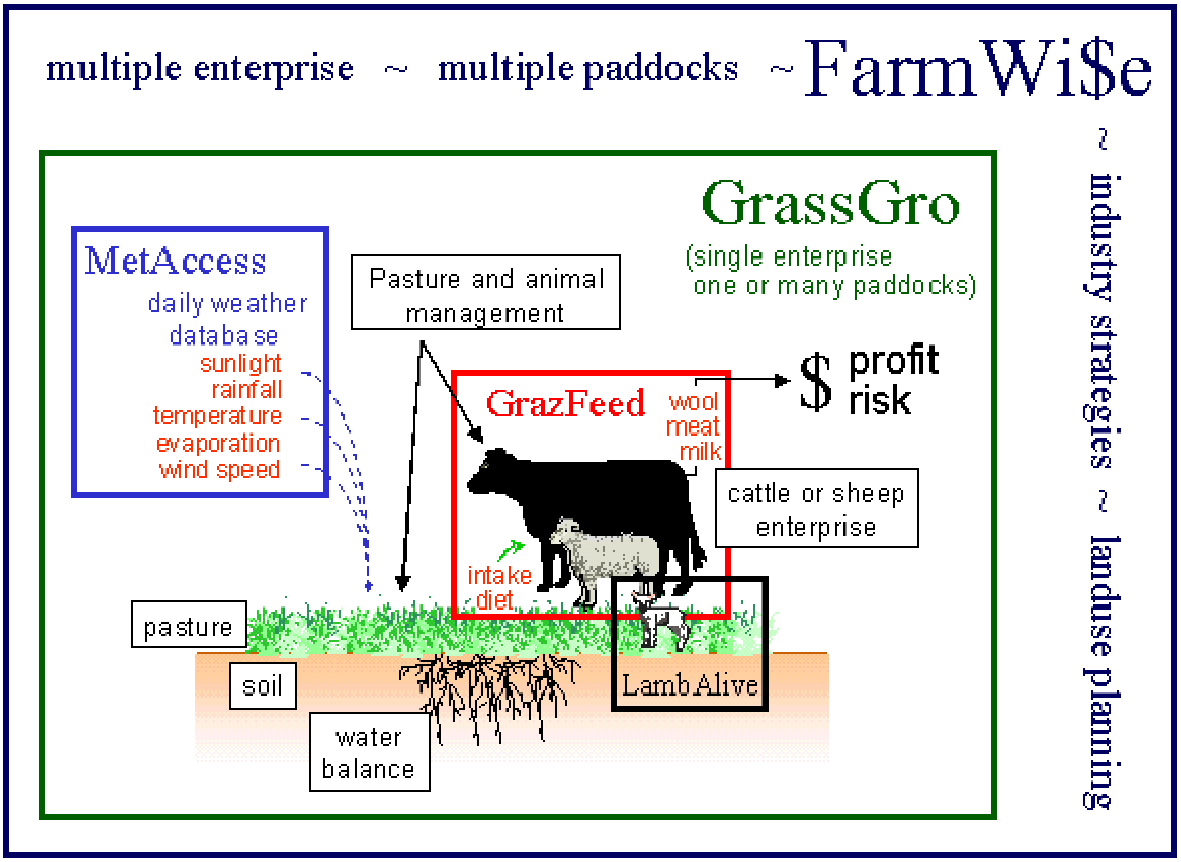

Figure 1. Schematic representation of the models and databases that are used in the various decision support tools of the GRAZPLAN toolkit.

will adapt our tools to use weather information obtained from the internet as this will provide rapid access to recent weather data.

Generic Application

Although there are successful examples of computer tools developed for specific industry applications, grazing enterprises are highly diverse in the range of environments, pasture species, breed characteristics and management alternatives. The approach, therefore, was to develop tools that could accommodate much of the diversity and thus have wide application, yet be capable of solving problems specific to individual farms.The first important breakthrough in this approach was the realisation that sheep and cattle breeds could be simulated by developing a generalised animal model that was scaled to suit the size of the breed (9). The primary scalar used is the weight of a mature female in average condition. This works reliably and, most importantly, it satisfies the requirement that the scaling parameter be easily obtained by the grazier. Pasture species are also modelled generically (15). When users of the pasture model in GrassGro select a suite of pasture species or cultivars for simulation, they select a set of mathematical coefficients that specify the plant genotypes. The phenotype of each species is then simulated by the model in response to the climate, soil and management specified for a location.

Also crucial to the aim of having generic application was access to weather data for locations across southern Australia (hence development of MetAccess), critical soil information (this remains a problem, see below) and reasonable flexibility in specification of management rules.

Has the aim of generic application been achieved? We are confident that the animal model used in GrazFeed and GrassGro gives a reasonable representation of sheep and cattle production under temperate Australian conditions. The animal model has a strong scientific basis because it is based on the Australian Feeding Standards for Ruminants (18).

The pasture plant model is also founded on good science but there is no equivalent plant standard to the feeding standards for ruminants and there are more gaps in our knowledge. Our overall aim of achieving a mathematical description of each genotype is consequently not entirely realized as yet. Some parts of the genotype description are inevitably linked to aspects of the underlying physical models and changes to the model will require revision of the species parameters.

Constraints in the management rules and design limitation of each tool restrict the range of applications that can be evaluated. Invariably we find that users of GrazFeed begin to ask questions that GrassGro is intended to explore, and GrassGro users begin to ask questions that only FarmWi$e will be able to explore. However, these are design constraints rather than knowledge constraints.

Technical Support

The computer-based decision support tool should reflect the best available knowledge of the biology and physical characteristics of our grazing systems. The models are intended to be process based but it is necessary to simplify these processes either because our knowledge of the system is incomplete, input data requirements are impractical, or because practicality dictates that the models be kept to a manageable size and suitable for use on an average computer.

Inevitably this means that the development of a decision support tool is never really complete and as new knowledge is generated, or as computer power improves, there are opportunities to improve the accuracy and predictive ability of the models. Tools that do not have enduring technical support are therefore certain to lose their industry relevance.

AN advisory toolkit common to the grazing industries?

The ultimate aim of the GRAZPLAN project is to develop software that is sufficiently flexible and reliable to be used by the sheep and cattle industries across southern Australia. The task cannot be done by CSIRO alone but will be possible if we can encourage a wider collaborative effort in software development, testing and application.

Why a common software toolkit? Simulation tools can uniquely address some of the barriers to technology adoption and can increase the rate of dissemination and adoption of new technology. For example, new information or technology often comes in discrete pieces that do not have a grazing systems context. This can make it difficult to evaluate the potential benefits. Sometimes new technology is highly technical and cannot be easily interpreted. Commonly, graziers will have real doubts about the application of a new technology to their own enterprise or are dissuaded by the difficulty of analysing the risks of adopting a new technology. Computer-based simulation tools have the potential to specifically address these barriers:
(i) Because a computer tool interprets the technology, the user can focus on the business or management

issue without being distracted by technical details.
(ii) The tool can simulate the user's own farm, climate, enterprise and management preferences. This enables the user to explore the potential of a new technology and reduces doubt about its applicability.
(iii) The physical and financial consequences of a management change or new technology can be assessed before dollars are committed. This helps the grazier assess whether the change addresses the real "profit-drivers" of the enterprise.
(iv) Unforeseen production and environmental consequences of an action can sometimes be identified.
(v) Business risks, particularly those due to climate variability, can be quantified. This assists adoption of optimistic management.
(vi) A strategic analysis of the role of a new technology may be conducted to assess its value in positioning an enterprise for the long run, or tactical analyses can be conducted to capture new production opportunities.
(vii) The latest technology or knowledge is available to the grazier whenever the underlying models are updated, potentially shortening the time between discovery and implementation.

The GRAZPLAN tools are initially targeted at consultants, but experience tells us that graziers increasingly use them independently of their advisors. When a network of users has developed, the toolkit also provides a "common vehicle" for discussing and implementing new management and technology on farms. A good example of this is the quiet revolution in nutritional management and adoption of quantitative pasture assessment skills that has occurred as a result of the partnership between GrazFeed and the PROGRAZE extension program for graziers, brief details of which are outlined later.

Decision-making versus decision-support

Tools like GrazFeed and GrassGro are most effective when used to complement existing methods of extending information and supporting decision-making. The tools are not immune from "errors" of prediction. These will occur from time to time because our scientific knowledge is incomplete, and will also occur when a user supplies incorrect input information for a simulation. Knowledge gaps in the tools are addressed by feedback to the on-going technical support mechanisms that are in place to keep the tools up to date and relevant. However, the inevitability of incomplete knowledge tempers the way the tools are promoted. In the case of GrassGro, it is only offered with a training package, users are provided with information about the scientific "boundaries" of the models and are encouraged to develop skills for conducting "reality checks" of simulation outcomes. The tools are for decision **support** and do not replace decision **making** by the grazier. However, they provide a much more comprehensive framework in which to analyse management options and business opportunities than has ever previously been available.

Tools capable of assisting fundamental change in a farm business

New technology must offer significant advantages to the grazier to justify its adoption. The following examples illustrate the sort of fundamental change in farm business management that may result when management options are tested by simulation.

Strategic Planning that Helps to Keep the Focus on the Profit Drivers

A fine wool grower on the central tablelands of NSW requested a GrassGro analysis to check the benefits of altering lambing dates between August and October to minimise lamb deaths and the need for

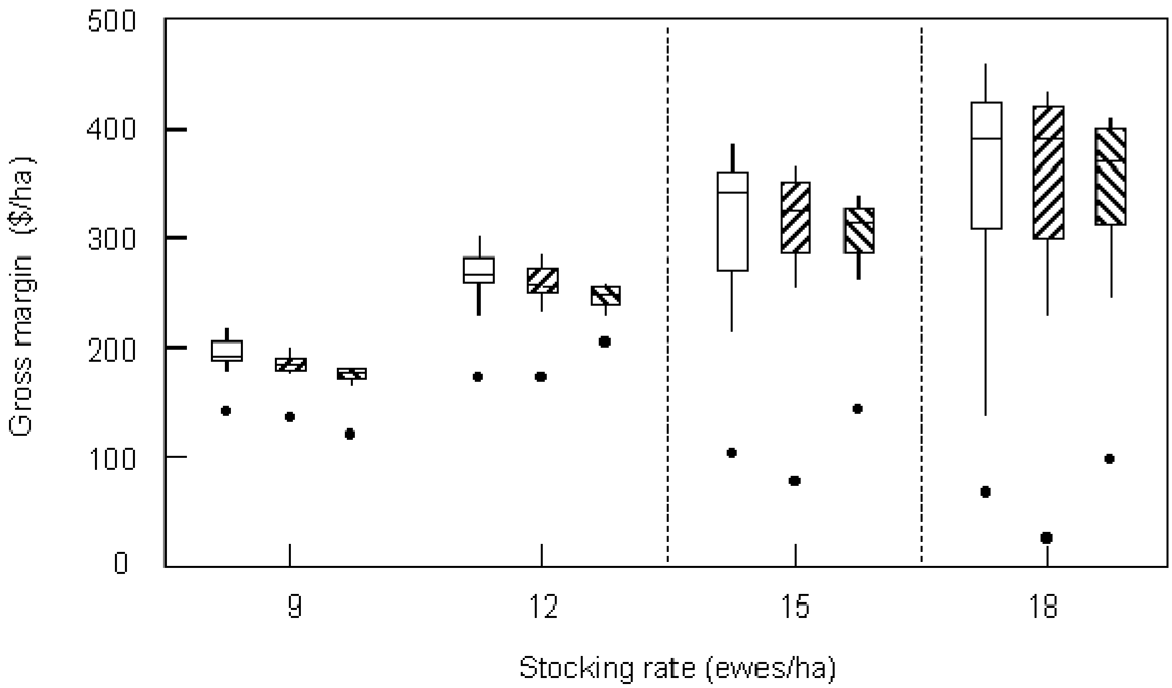

Figure 2. Box plots of gross margins for lambing dates in mid August (☐), mid September (▨) and mid October (▧) at four stocking rates. Vertical bars represent the range of all values except 1982 (a drought year) which is indicated by the dots. The upper line of the box is the 75th percentile, the middle line is the median and the lower line is the 25th percentile.

supplementing ewes in winter. The usual lambing date was early September and the grower was concerned that if lambing were delayed weaning weights may be low and might compromise the survival of weaners over summer. Mean annual rainfall was 870 mm, but at 1000 m altitude pasture growth in winter was severely restricted. In spring, pastures did not begin rapid growth until early September but remained green until mid December. A soil fertility program had been implemented and the stocking rate had been lifted above the district average of about 9 ewes/ha on comparable country, to 12 ewes/ha.

GrassGro was used to simulate a self-replacing Merino flock grazing cocksfoot-sub clover pastures at this location over 20 years (1978-97). The three lambing dates, at four stocking rates (9, 12, 15 and 18 ewes/ha) were examined.

The GrassGro analysis indicated that at the current stocking rate, later lambing would have small effects on lamb mortalities and ewe supplementation, without large consequences for lamb weaning weights. However, the differences in median gross margins between lambing dates were not significant (Fig. 2). The analysis also indicated that stocking rate could be increased and that this would have a large impact on enterprise profitability (up to ~$150/ha). At the higher stocking rates the downside risk was larger. However, with the exception of outcomes in a small proportion of years, the gross margins were as good or better than achieved at the lower stocking rates. Other management concerns such as the effects of time of lambing and stocking rate on fibre diameter profiles were also explored as part of this analysis. The producer subsequently made fundamental changes to his management objectives as a result of the analysis (4). The primary change was to lift stocking rate, in the first instance, to 15 ewes/ha. The plan is to then reassess the performance of the enterprise. The analysis helped the producer to refocus on the issues that were driving the profitability of the enterprise. The producer's confidence to proceed was

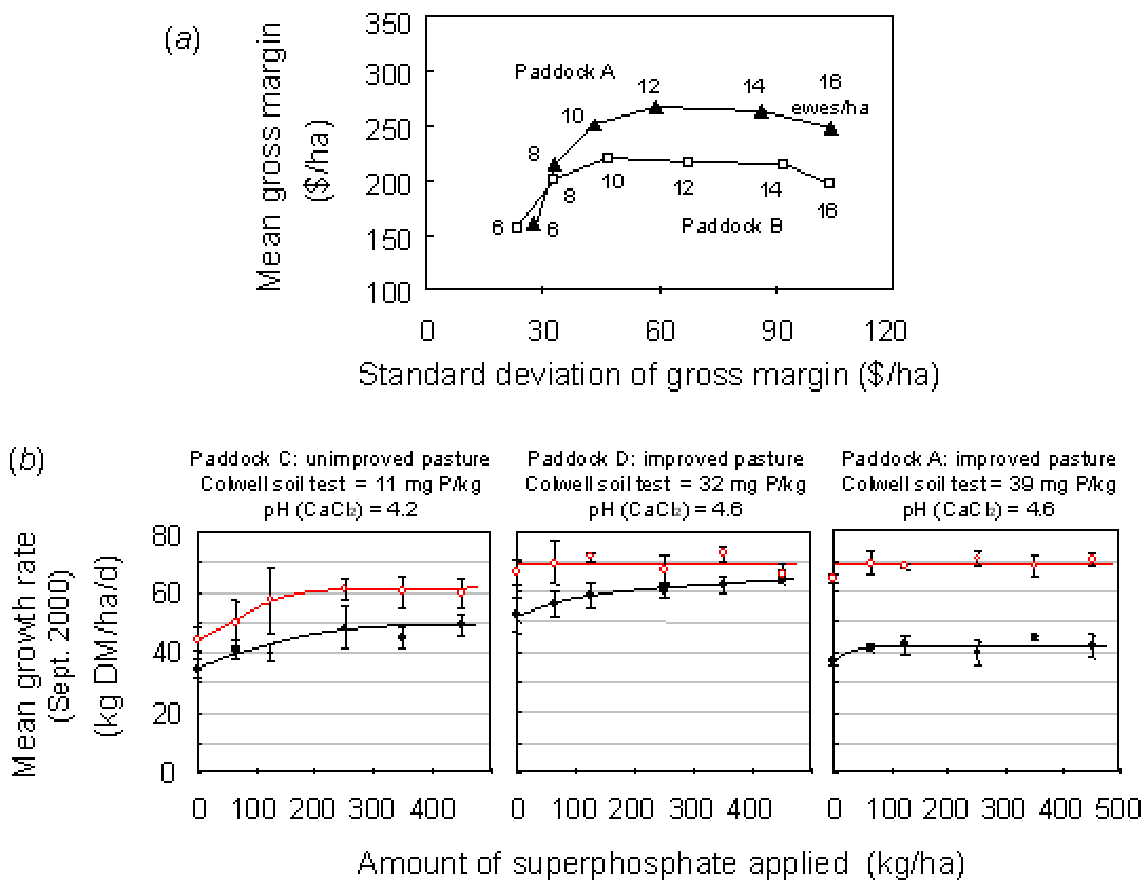

Fig 3: (a) GrassGro analysis of the potential productivity of two paddocks (A & B) at a property on the SW slopes of NSW. (b) Pasture growth in spring in three paddocks including "paddock A", in response to superphosphate applications in the absence (●) and presence (○) of 200 kg N/ha applied as urea. Bars represent 2 x standard error.

partly due to the capability of the GrassGro to analyse the consequences of management actions over a range of seasons and its ability to address concerns (such as weaning weight and fibre diameter) that may otherwise have reduced his willingness to adopt a higher stocking rate. However, the analysis also reinforced his observation that some other growers had already achieved higher stocking rates.

Fine Tuning a High Profit Grazing Enterprise

A fine wool producer running 10,000 DSE on the south-west slopes of NSW on very acid soils wanted to know how much further he could lift production across the farm. Most pastures are improved and lime is progressively being applied across the property. GrassGro was used to simulate the current grazing system and to explore management options, stocking rates and their associated business risks.

The water holding capacity, bulk density and hydraulic conductivities of soil profiles from two paddocks considered to be typical of the majority of the property (designated paddocks A and B; Fig. 3a), were measured for use as inputs for the simulations. Phalaris-sub clover pastures were simulated over 15 years (1984-1998) using GrassGro.

The producer immediately questioned the predicted potential productivity of paddock A. Although the paddock had been well fertilised, his records and experience indicated that it carried less stock than the simulations indicated. The simulation analyses were checked but no obvious error was found? A fertiliser response trial was being conducted on a number of paddocks including paddock A. The field trial confirmed that whilst the potential productivity of the paddock was high, the productivity being achieved was relatively poor and similar to that of a nearby, unimproved paddock (Fig. 3b).

The combined analyses using simulation with GrassGro and the field trial have led the producer to reassess his heavy applications of superphosphate to lift the productivity of paddock A. The analyses indicated that whilst the paddock does have a high potential productivity, the fertiliser applications were completely ineffective because they were not addressing the underlying cause of the problem, which appears to be due to restricted nitrogen fixation or availability.

Tactical Decision Making to Capture Opportunities or Minimise Losses

Livestock producers may have the opportunity to purchase additional animals for fattening and sale in favourable seasons, but this can involve significant business risk. If normal seasonal rains fail the additional animals may not reach the target weight and the main farm enterprise will be placed under increased pressure, threatening normal farm income. GrassGro can be used before a decision is taken, to assess these risks.

To illustrate this, consider the purchase by a farmer, of weaner steers to fatten for the domestic retail trade or for sale to a feedlot. The decision to purchase is made in February for an intended sale date in November. GrassGro is set up to represent the prevailing pasture conditions in the paddocks that will be used, and to describe the animals that are likely to be purchased in the following week. The possible pasture and animal production outcomes that may occur are simulated from the day of purchase to the day of sale using the historical weather record over a run of years.

Figure 4 shows the probability of achieving differing live weight outcomes given three alternative stocking rates. The simulations suggest that there is a 95% chance of reaching the minimum live weight for the domestic retail trade (330kg) if the producer grazes the animals at 2 steers/ha. This reduces to 85% and 73% respectively at 3 and 4 steers/ha. To capture a possible marketing opportunity and sell into an export feedlot the steers must reach 400kg. This can be achieved one year in two given similar seasonal starting conditions if grazing at 2 steers/ha, but there is only a 1 in 5 chance at 4 steers/ha.

This form of business risk assessment gives a measure of the variability that is due to the impact of day-to-day weather on feed supply and would normally be combined with further economic analysis when making a business decision.

Tactical simulations are not just about capturing new markets and production opportunities. They can also be very helpful when preparing a business for adverse conditions. For instance, Alcock *et al*. (2) report tactical preparations for an anticipated feed shortage due to drought.

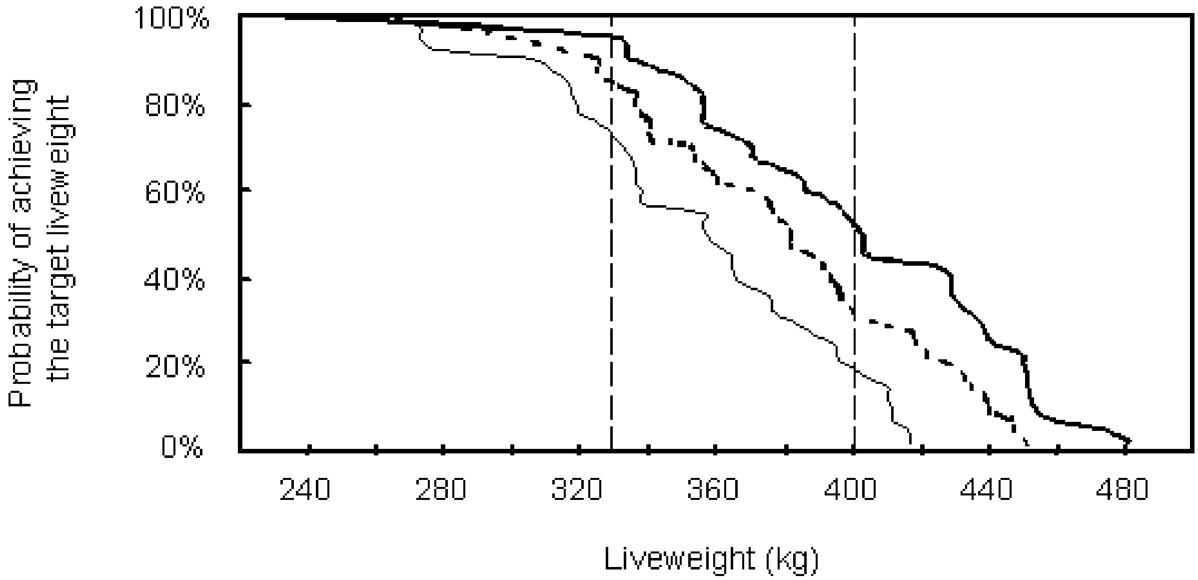

Figure 4. Probability of achieving any desired steer liveweight by 30 November at Holbrook, NSW, for stocking rates of 4 steers/ha (thin line); 3 steers/ha (dashed line) or 2 steers/ha (thick line). Minimum target liveweights for domestic trade (330 kg) or export feedlot entry (400 kg) are indicated.

A critical role for pasture agronomy

In common with all new technologies, the adoption path of the computer-based tools has a number of hurdles that must be overcome. In the case of GrazFeed, the most significant technical hurdle was the need for users to acquire pasture assessment skills. Even a seemingly small issue, such as the different techniques for cutting pasture for calibration measurements, caused a fairly major crisis of confidence in GrazFeed in its early phase of release.

Soil Profile Descriptions

GrassGro has a larger requirement for input data than GrazFeed and some inputs are more difficult to obtain. A key example is the physical properties of soil profiles (Table 1). Information is available for some districts and for some “typical” soil profiles (eg. 8, 11). A computerised soil database is also currently being prepared (H. Cresswell, CSIRO Land and Water; pers. comm.). Nevertheless, because soils are very variable across a farm, or district and because the Australian database for soil properties is so small, it is presently highly desirable that these soil properties be measured at the site to be simulated. This is expensive (about $750/site) and there are few commercial laboratories offering a suitable testing service.

The small database is a reflection of there having been very limited commercial use for this sort of soil data prior to the development of the new tools. Some graziers and advisors are tackling this problem by combining forces and concentrating on data collection at key sites. In at least three cases, PIRD grants (Producer Initiated Research and Development Projects funded by MLA or Woolmark Co.) have, or will be used to collect data for simulation work. There is now a very real need for agronomists to collect and publish soil profile data as a routine part of experiments and demonstrations so that a more representative soil database can be developed.

Pasture Production Data

An essential step when using a simulation tool is to conduct “reality checks” of the simulation outputs. Checks are intended to identify unrealistic predictions due to a failure of the model or, more commonly, incorrect specification of input data. Typical data required for reality checks are listed in Table 1. Some data will be known, or can be collected on farms. Other data require careful scientific collection and we rely on the published records of experiments in various districts. Seemingly important data, such as pasture growth rates, have not been collected in most districts and the published record is extremely poor. Routine collection of this sort of data should be part of experiments and grazing demonstrations and the data published in peer-reviewed journals. Such data now has practical importance for decision-making by graziers and their advisors.

Agronomy and Biology of Pasture Plants

Presently, users of GrassGro are limited to selecting from a menu of nine pasture species for which the mathematical coefficients describing their genotypes have been determined. Six more species are nearing release as “test versions”, and description of a further seven “desirable” and “weedy” species is in progress. Building and testing the genotype description of a species or cultivar is a demanding task which requires basic information about the biology of the plant species: eg. growth analysis, flowering responses, seed production, dormancy and germination, and seedling recruitment, etc.

More is known about the desirable exotic pasture species than about native or weedy species. Nevertheless, there are still large gaps in our knowledge of the biology of many species. We presently rely on a limited number of early studies of pasture species biology (eg. flowering by pasture grasses and clovers; (1)). Agronomic data are also needed for validating predictions of the performance of species in pastures at a range of locations.

The advent of the new tools means that biology of pasture plants and weeds is not just of academic interest. Indeed, it is now fundamental to the management of pasture systems. There is a need for more research into the biology of pasture species and the processes involved in botanical change in pastures. It is important to broaden the range of species under investigation.

Table 1. Key inputs, and data useful for “reality checks” when using GRAZPLAN decision support tools

INPUT DATA	DECISION SUPPORT TOOL
Weather location Most data is automatically accessed from a CD-ROM database compiled from Australian Bureau of Meteorology data. Users may also construct their own weather files: daily rainfall, evaporation, max/min temperatures, radiation & wind speed are required.	MetAccess GrassGro FarmWi$e
Soil profile Depths, bulk density, water holding capacity, and the saturated hydraulic conductivity	GrassGro

of the A and B soil horizons.	FarmWi$e
Pasture	
Pasture mass, digestibility and height.	GrazFeed
Pasture mass, seed bank size, species composition, (rooting depth).	GrassGro FarmWi$e
Livestock enterprise	
Breed/bloodline; mature weight of female in average condition; her wool cut and fibre diameter; fertility and mortality rates.	GrazFeed GrassGro FarmWi$e
Financial	
Costs of variable inputs; prices received for animal products.	GrazFeed GrassGro FarmWi$e
DATA FOR REALITY CHECKS	
Date and date ranges for seasonal break and pasture haying-off; seasonal pasture availability or growth rates; occurrence of waterlogging; pasture composition; typical animal liveweight gains and condition; typical supplementary feed usage.	

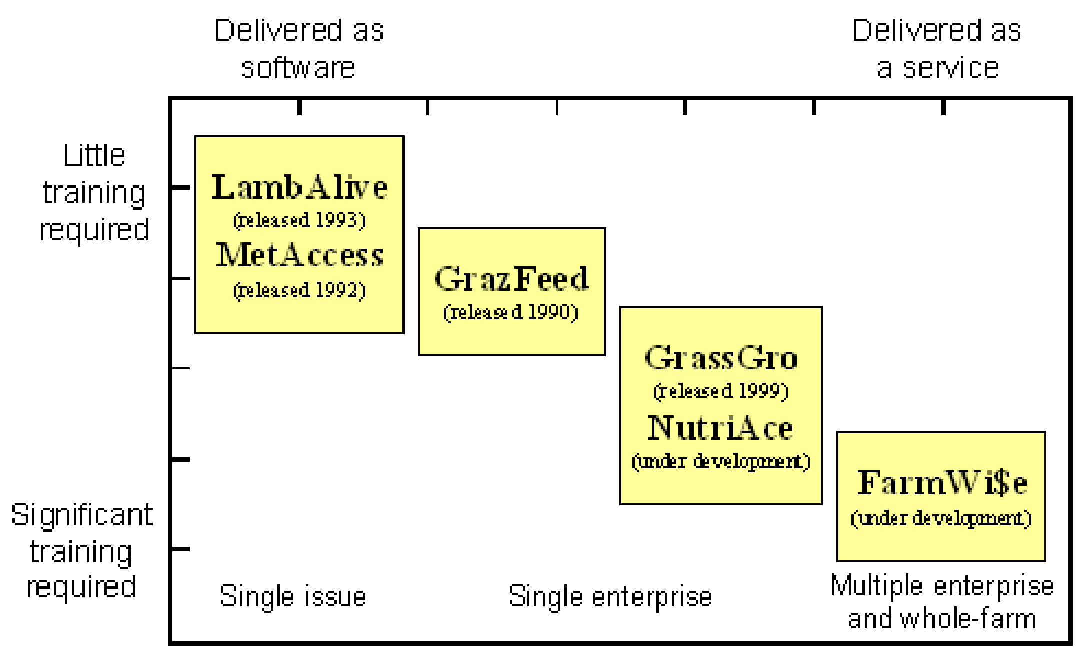

Figure 5. Schematic representation of GRAZPLAN tools and their expected market niche.

Adoption of Computer-based decision support tools by the grazing industry

We have had about ten years experience supporting the release of computer-based tools to graziers and their advisors. Most of that experience has been with single issue, tactically oriented tools which have low input data requirements and are easy to use (Fig. 5). By contrast, the multi-issue tool we are now attempting to introduce (GrassGro) requires more input data, and training is essential for informed use. Each tool is quite a different product and it is anticipated that they will occupy different market positions and will require different marketing strategies (Fig. 5).

It is valuable to examine the path of adoption of GrazFeed which was the first GRAZPLAN decision support tool to be released (Fig. 6). GrazFeed users need to be able to quantify pasture availability and quality, as they are essential inputs for the model. When GrazFeed was released in 1990, few graziers or advisors had these skills. Livestock extension officers in NSW Agriculture were the largest group of early-adopters. They established a specific program to develop their own skill base (3) and over about four years gained confidence in the reliability of predictions from the computer tool. NSW Agriculture also recognized that if graziers and land managers acquired the pasture estimation skills, there was an opportunity to develop new pasture benchmarks for grazing management. The extension vehicle they developed was the highly successful PROGRAZE program, which was first delivered in NSW in 1994 and has subsequently been extended to all southern states of Australia (5). This program promoted the use of the new pasture benchmarks for livestock production, which had in part been developed using GrazFeed, and also assisted graziers to acquire pasture assessment skills. GrazFeed was judged to be useful partly because it assisted NSW Agriculture advisors to provide consistent animal feeding advice, but also because it helped PROGRAZE participants to quickly identify the benefits of using pasture assessment skills (5). By 1997, nearly 4000 graziers had attended a PROGRAZE course. The second phase of PROGRAZE aims to reach an additional 5,000 graziers over a four-year period (Allan cited in (19)).

The net effect has been a major change in the skill base of the grazing industry and its advisory networks. Many graziers have been encouraged to use GrazFeed. Many more graziers benefit indirectly because they exchange quantitative information about their pastures with advisors who use GrazFeed. In 1992, it was estimated that GrazFeed had resulted in recurrent direct savings of $7.5M/year, to sheep graziers in NSW alone, as a result of better targeted supplementary feeding (G.C. File, NSW Agriculture, pers. comm.)

Lessons learned from the extension of GrazFeed

GrazFeed has been a pathfinder in the grazing industries. When it was first conceived the industry did not see a need for it. However, it is now relatively widely recognized and accepted. The following have contributed to its success:
(i) The well-researched and published feeding standards for ruminants (18) provided an agreed framework on which the animal model in GrazFeed was built.
(ii) The animal model contains comprehensive animal nutrition and production information but the complexity is hidden behind the user interface. The model can represent common breeds and bloodlines using easily obtained information.
(iii) The tool was designed to make the ruminant feeding standards easy to use and there were clear applications in mind: eg. determination of feed rations during drought.
(iv) The benefits from using GrazFeed are readily seen in animal performance and predictions may be checked against reality at regular intervals. Usually the result is significant cost savings which boosts the confidence of the user.
(v) NSW Agriculture recognized the value of the tool and was a product champion. This proved to be a vital step for widespread adoption.
(vi) A commercial partner (Horizon Technology Pty Ltd) handled marketing and client services, freeing the research team to concentrate on improving the science behind the decision support tool.

What will the future look like?

Computer-based simulation tools are still a new technology in agriculture. It is only in recent years that personal computers have become powerful enough to run the tools efficiently. In the near future, small hand-held computers will be capable of running decision support tools.

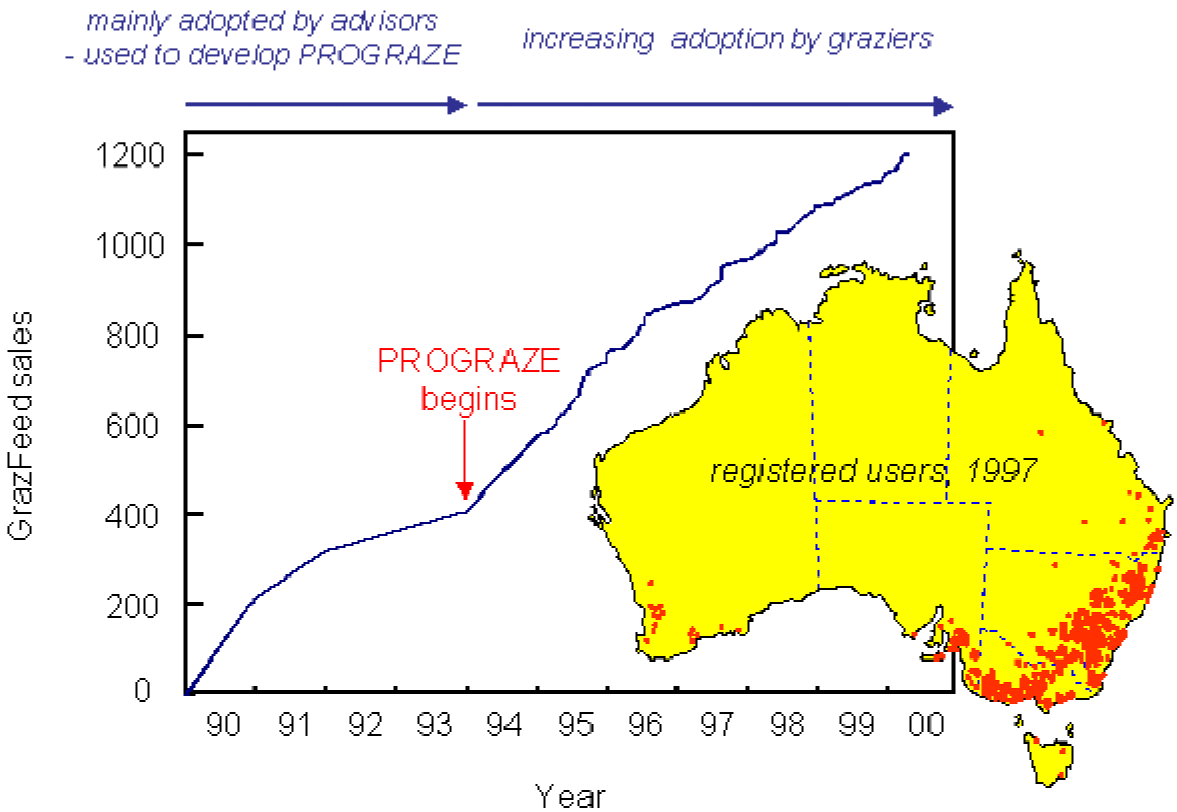

Figure 6. Sales of GrazFeed to 2000 and the distribution of owners of the software by 1997.

Growing acceptance and use of single-issue tools such as GrazFeed indicate that the technology is already providing benefits to graziers. The current challenge is to gain similar acceptance of multiple-issue tools, such as GrassGro, which deal with issues of grazing management and pasture agronomy. There is an important role for agronomists in the ongoing development of the tools and in their application for the benefit of our grazing industries. GrazFeed and GrassGro are integral parts of some undergraduate and postgraduate agriculture, and resource management courses in Australian universities. Many in the next generation of farmers, farm advisors and research scientists will begin their careers already versed in the use of this technology.

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