DroughtPlan—

Building on grazier participation to manage for climate variability

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Executive Summary

‘**DroughtPlan**’ is a collaborative project between producers across the continent, state government agencies and CSIRO, aiming to help producers to develop management strategies to deal with climatic variability. The two-year project has run in overlapping phases (‘Streams’) involving (i) detailed yet geographically-widespread consultations with producers about the information which constrains their decision-making (Streams 1 and 2), (ii) the research and development of products to meet these needs (Streams 3 and 4), and (iii) the iterative testing and improvement of these products with producers to ensure their value (Stream 5). The project has developed some significant ideas about decision support and participatory research. There has been a strong emphasis on practical evaluation of the products, and on fitting them into continuing activities like property management planning, so that they continue in use after the end of the project. To this end, DroughtPlan sought to integrate with the Property Management Planning programs in Queensland and other states, Local Best Practice programs, the Queensland South-West Strategy, as well as other research projects such as ‘Drought Alert’.

DroughtPlan has created a strong network of more than 250 producers, agency personnel and researchers across the continent. It has documented how producers respond to climatic variability in at least ten areas of the continent, with written reports on each region and a national overview. These regions were western Queensland, south-west Queensland, central Queensland, western New South Wales, Southern Tablelands NSW, Western Slopes NSW, northern South Australia, Gascoyne/Murchison WA, the Kimberley WA and central Australia NT. Between 6 and 25 producers were involved in individual or group collaboration in each region, as well as State or Territory agencies in all areas.

To meet information needs identified by producers during this process, **DroughtPlan** then developed nine products which provide a multiple approach to financial management, and to long and short-term stock management decisions. The approaches include workshop materials, leaflets, paper work-sheets, spreadsheets, complex models and motivational activities, so that most products have multiple forms. They are the ***Assessing your livestock management options*** module for Property Management Planning workshops, the **BB-SAFe** tactics evaluator, the **GrazeOn** feed budgeting system, the **Pasture Supply and Demand Calculator**, the **‘Safe’ Carrying Capacity Calculator**, the **GRASP Pasture Production Database**, case studies using the **GRASP/Herd-Econ** linked model, the **‘Decision Trees’** workshop and approach for farm business management, and a test case study with the **RISKHerd** policy analysis package. These products have been tested and evaluated (to varying extents) with industry; this process now requires on-going support beyond the two year timeframe of the project. A number of products also synthesise information across the project to help easy user access, and to document the decision support philosophy and management approach used by **DroughtPlan**.

The **DroughtPlan** project was funded under the LWRRDC-managed *National Climate Variability R&D Program*, and also supported by the Meat Research Corporation and the International Wool Secretariat, as well as the contributing research organisations and many producers. This document presents a full overview report on the project, but more details are available on many elements in their own publications, working papers, and production materials. Those publications available to date are listed in the bibliography on pages 14–16.

Acknowledgments

DroughtPlan has drawn on the skills and enthusiastic participation of many people, both formally within its ranks (identified in this report) and outside. This report's authors are the project's Management Committee, and we acknowledge with gratitude the support and help of all these people, too numerous to list. We are particularly aware of the time that has been contributed by many producers, away from their busy management schedules; most such participants seem to have found their involvement rewarding, but we record our appreciation of their help and of their strategic vision which enables them to give up time on behalf of the wider Australian grazing industry as well as themselves. We are also grateful for the vital support of state agency personnel in all regions visited (see Figure 3 on page 7).

The project would not have taken place without funding from the Federal Government through the *National Climate Variability R&D Program* managed by the Land and Water Resources Research and Development Corporation (LWRRDC), supported by the Meat Research Corporation (MRC) and the International Wool Secretariat (IWS). We thank Dr Barry White, the coordinator of this program, for his vision in successfully bringing together a conglomerate of disparate researchers and industry. Several areas of work which overlapped with other projects were supported from other sources (acknowledged below where appropriate); we are grateful for the flexibility to build synergistically on these interactions. The major resources for the project were provided by CSIRO and the Queensland Department of Primary Industries. Our project Review Committee also contributed greatly to the project. We are especially grateful for the support and ideas of Don Burnside and Simon Campbell, the external members of this committee.

Overview of the DroughtPlan project

Background and project objectives

Grazing managers in Australia have to cope with one of the world's most variable climates. In this context, current moves towards 'self-reliance' in the industry represent a considerable challenge to the tactical and strategic management of stocking rates and finances. However, climatic risk is only one of many that producers must deal with—market fluctuations, policy shifts, changes in land productivity, unexpected adjustments in personal circumstances and varying interest rates are among many others.

Thus it is not enough to simply deliver more information about climatic variability to producers; this information needs to be integrated into the whole context of farm decision-making and property management planning, including the social aspects of decision-making by humans. The need to manage all forms of risk in good *and* bad years, and to consider drought management before, during *and* after the drought period itself, is summarised in a framework for research, development and extension presented to the Prime Minister's Science and Engineering Council in 1995 (Clewett *et al.* 1995).

The overall objective of the two-year DroughtPlan project was, *with producers, to develop economically-viable drought management strategies to increase animal production efficiency whilst sustaining the land resource*. To carry this out, we:

1. cooperated with producers to identify their needs for supporting decisions related to stocking rate strategies through time;
2. documented, with producers and extension agencies, a substantial series of case studies of the biology and economics of key existing and improved strategies in different grazing lands regions of Australia;
3. developed an understanding of the links between climatic variability, production levels and biological rates (births and deaths) in grazing lands from producer and research records;
4. integrated economic, animal production and forage production models from QDPI and CSIRO to identify the response and sustainability of these strategies in relation to climatic variability, seasonal forecasts and economic conditions;
5. developed, with producers, a series of activities and decision support tools for:
    - producers to test alternative strategies on their own properties, and
    - use in property management planning activities.

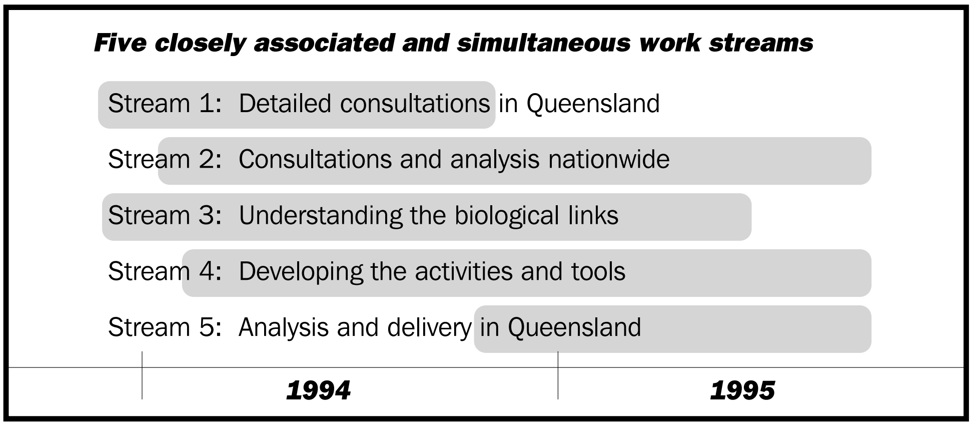
DroughtPlan has met all these objectives, as well as project milestones and evaluation criteria, as outlined below.

Project methodology

The research methodology of DroughtPlan has involved cooperating with producers nationwide to document their current management strategies and to identify their needs for supporting improved decisions about these. In response to these needs, DroughtPlan has then developed a number of products iteratively with producers; as much as possible these products have been fed into existing activities, such as property management planning, so that they will persist beyond the short lifetime of the project.

DroughtPlan emphasised participation across a huge network of skills, resources, organisations and geographic extent. Although based on two CSIRO Divisions and Queensland DPI, agencies from SA, NSW, NT and WA have also supported the project, creating a well-knit network of more than 50 extension and research personnel. Even more importantly, at least 200 producers have been involved formally, and many others informally.

Figure 1
Basic timing and management structure for DroughtPlan.



For management, the project was structured into five closely overlapping streams of work (Figure 1). **Stream 1** interacted intensively with producers in Queensland; **Stream 2** carried out less intensive work in other temperate and rangeland areas of Australia. **Stream 3** analysed links between animal condition and birth and death rates for sheep and cattle. **Stream 4** responded to needs identified by Streams 1 and 2 with activities, tools and training materials to help producers manage risk. **Stream 5** then helped producers evaluate these products.

The management team also developed various integrated products, to help raise awareness. We have documented the theory and application of participatory research in the project. Further details of the project design and implementation can be found in Stafford Smith *et al.* (1994) and Clewett and Stafford Smith (1994).

Project results

KEY FINDINGS ABOUT PARTICIPATION

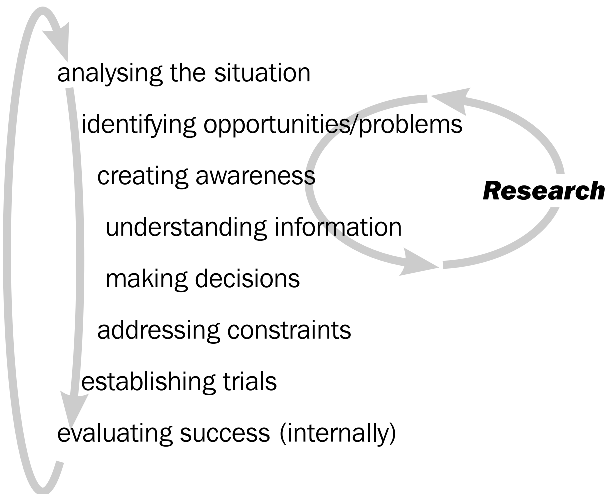
DroughtPlan was committed to participatory approaches to research; these had to be applied across 70% of Australia. As well, the project design required Stream 4 products to be defined on the basis of consultations in the first year. The project thus had to ensure that its participatory approaches were correct and that a conscientious process was applied to identify critical needs.

Considerable effort was therefore devoted to developing the processes of research and of research management, even though this was not formally prescribed in the project contract (Stafford Smith & Clark 1994). Many ideas about participatory research arose out of these discussions (cf. Stafford Smith 1995; Clark & Stafford Smith 1996; see also Section 6 on page 134), but DroughtPlan has sought to inform its work with five key points:

- the need for real participatory problem solving based on action learning principles (Figure 2) and focused on real management decisions;

- critical risky events occur rarely, so we must find ways of making the decisions about these events regularly. For example, deciding to de-stock in drought is a major, anxiety-provoking decision; but if stock numbers are assessed and adjusted every year, then the drought year response is just one end of a continuum of regular decisions. Performance benchmarks are a route into this behavioural change, as are several Stream 4 products.
- The concept of 'decision support systems' (DSS) must be interpreted more widely than traditionally, as the whole amalgam of motivation, tools, and training, using many types of tools including paper-based worksheets, learning activities, simple spreadsheets, and the occasional complex computer program (see Figure 4 on page 9).

Figure 2
Generalised action learning cycle used as model for DroughtPlan



- There is a vast diversity of people with different skills, attitudes, interests and circumstances who are involved in management. Just as a single 'optimised' management strategy will not suit all, nor will one communications and training method. Some will come to workshops, others will work at home; some will read newspapers, others will talk with their neighbours; some will use pencil and paper, others will use computers. DroughtPlan has sought to recognise this by producing multiple solutions to the major problems posed by producers.
- The traditional approach to evaluating projects has tended to stop at confirming that they produced their planned outputs. Honest participation implies that evaluation should go far beyond this to determining whether those outputs achieved genuine changes in behaviour and consequent improvements in the appropriate benchmarks of production. Such evaluation needs to be applied to individual decision support products as well as to whole projects. DroughtPlan developed a consistent suite of evaluation criteria which are being applied across the project, as described below.

All aspects of DroughtPlan have involved participation, even those which are quite basic science. For example, the Stream 3 results were initially based on research station data, but these have been greatly expanded through interactions with producers with on-property data. However, participation has been more actively embraced in some areas of the project than in others, so we are also assessing how much the project has changed research approaches and participants' attitudes (see Section 6 on page 134).

PRIORITY SETTING DURING THE PROJECT

As undertaken in the original contract, about one year into the project a major workshop collated and analysed the results of consultations with producers from Streams 1 and 2 and other sources (Clewett & Stafford Smith 1994). Some 24 issues of importance were identified; about six fell outside the scope or expertise of the project (eg. lobbying government, etc), and most of the rest could be classified into one of three major areas. These were:

- strategic stock management;
- tactical stock management;
- financial management.

Nine ‘products’ were identified under these three areas to meet many of the information and training requests of producers; these are outlined below. For each area, we sought deliberately to populate the solutions with a variety of different approaches. A few other issues were relevant to the project but of lower priority and beyond current resources (see Clewett & Stafford Smith 1994; Section 4 on page 36). These may be important for future work.

PRODUCTS

Here we outline the results from DroughtPlan. Fuller details about each Stream and product are in the attached appendices, where the principal participants in each area are also identified.

Stream 1 comprised collaborations with producers in south-west, central and western Queensland, at varying levels of participatory intensity. Where possible the interactions have been on-going. Most notably, for example, producer groups in Central Queensland have developed best practice statements of how they cope with climatic variability and other management issues, and have established benchmarks which can be monitored in future (eg. Calliope Shire reports; Clark 1994). Their reports and priority lists, along with those from other regions, were collated and provided as input to Stream 4 (see Section 1 on page 17).

Stream 2 complemented Stream 1 by extending collaboration with producers across the continent, with the goal of ensuring that the results of DroughtPlan were not unduly biased to the conditions of a few local regions. The intensity of group participation employed in Central Queensland would require huge resources at this national scale so an individual-oriented approach was employed. This gave a high level of participatory involvement but without the long-term group support. Stream 2 therefore tried to link with other regional activities which could maintain on-going involvement (see Section 2 on page 24).

Detailed analyses of current and possible future management approaches of individual properties were carried out in nine regions, including two temperate areas in NSW (Figure 3 on page 7). Once producers were happy with the results for their own property, a regional summary was developed with more than 30 generalised case studies (Buxton, Eddy *et al*. 1995–6). Key management issues included alternative options for build-up after drought, diversification, changes in flock and herd structure, reproduction and mortality management during drought, and long-term stocking levels. Producers were a critical part of this process, as were personnel from Queensland, SA and NT Departments of Primary Industry, NSW Agriculture, and Agriculture WA.

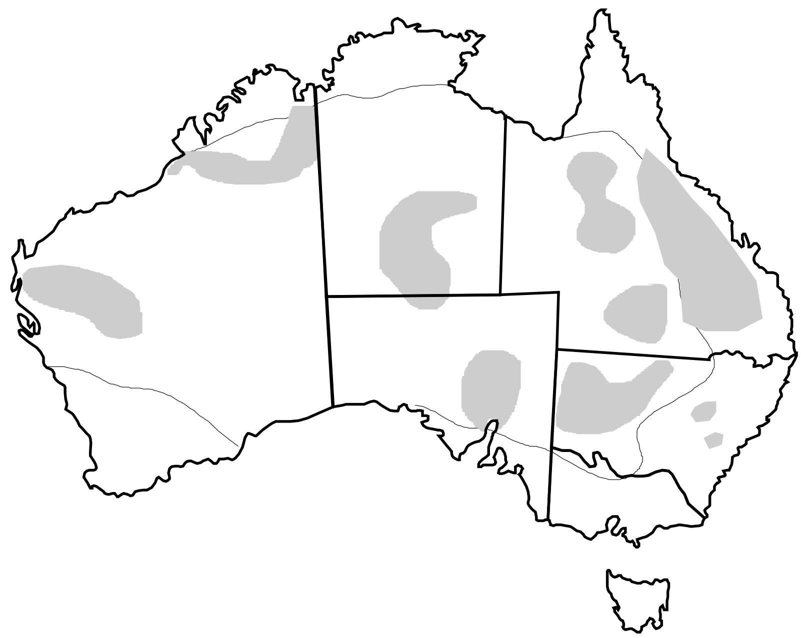
Information needs and constraints were identified for Stream 4; some products from Stream 4 have thus been extended to regions outside Queensland. A national overview of the regional reports has been combined with data from a previous RIRDC-funded project on drought (Buxton *et al.* 1996); it has producer and policy summaries. Aside from the need for products such as those developed under Stream 4, this overview:

- confirms the importance of multiple approaches to information provision,

- identifies the build-up phase after droughts as being a critical time when our knowledge is inadequate,
- highlights the need for benchmarking; and
- notes that many of the areas where regional restructuring is currently focused are, ironically, where per head productivity is reasonable.

Figure 3

Main areas of Australia in which DroughtPlan activity has taken place; except for the south- to central eastern Queensland area, these are also the Stream 2 regions.



Stream 3 provided new scientific information on the relationships between climate variability and the biological rates of sheep and cattle. Even before DroughtPlan, it was clear that this information was needed to answer some of the questions that producers were asking about managing climatic variability as part of the whole enterprise. Past production research has invariably assessed outputs in terms of wool growth or liveweight gain (Clewett 1994); yet the success of real enterprises also depends on mortalities and, usually, births.

Based initially on research station data, Stream 3 has developed predictors of these biological rates in response to animal condition and liveweight gain (Moore *et al.* 1995). In a world-first, these were then extended to on-property conditions with the assistance of producers, where other factors like management skills, disease control and episodic outbreaks (eg. fly strike) confound the picture. More work is needed here in the future, but the initial results are promising for prediction (Pepper *et al.* 1996) and are sufficiently good to use in case studies based on Stream 4 products (see Section 3 on page 31).

Stream 4 serviced the participatory demands of the other Streams (see Section 4 on page 36). It focused mainly on providing nine products which are now being commercialised by QDPI to ensure effective distribution. Each is briefly mentioned under the three general topic areas below (Figure 4 on page 9) (see the separate reports in Section 4 for more details). The boundaries between the topics are not fixed—tactics are limited by the strategies in place, strategies are only as good as the tactics used, and financial management should not be divorced from biology. The headings simply identify the main focus of each product.

Tactical stock management

Faced with a dry year, a manager does not have the option of altering long-term stocking strategies or investing off-property. Therefore there is always a need for good short-term decision-making. However, these decisions need to be familiar and made regularly, rather than being unpractised in the face of once-in-a-working-lifetime catastrophes. The umbrella product for tactical decisions is therefore a set of workshop module materials titled ***Assessing your livestock management options*** which can be used in Property Management Planning workshops (see page 47). These materials aim to make the act of choosing between alternatives a familiar, regular event. The following products contribute in different ways to this process, either as modules in workshops, or as other means of training, or for use by individuals. They are supported by various case studies, and existing materials such as **Australian Rainman** and **RANGEPACK Herd-Econ**.

BB-SAFe (buy/breed-sell/agist/feed evaluator) allows users to compare the costs of different stock reduction and build-up options on their property. The logic can be followed through on paper worksheets or in a spreadsheet, and it gradually builds up the complexity of the assessment so that users can have confidence in the calculations (see page 59). ***'Decision Trees'*** (see page 65) is a complementary approach.

GrazeOn helps producers think about forage budgeting, establishing potential stock numbers over periods of three months to three years, initially in Mitchell grasslands. It is integrated with various existing activities about recording, so that monitoring, prediction and feedback become part of normal management (see page 52).

The ***Pasture Supply and Demand Calculator*** effectively implements the Feeding Standards of Australia for northern Australian conditions for the first time, but does so in the context of specific concerns of producers about feed deficits during the dry season, which has resulted in immediate uptake by industry (see page 73).

Strategic stock management

The longer term aspects of decision-making affect what tactics are available at any given time. Again DroughtPlan has sought to work with property management planning to contribute our expertise to that on-going work. ***Assessing Your Options*** workshop modules also incorporate strategic considerations. Producers repeatedly identified the importance of stocking rate policy—this may be expressed in many ways but comes down to asking what levels and what strategies of varying stock numbers over time are appropriate.

The ***Carrying Capacity Calculator*** is a community-owned approach to assessing safe stocking levels, pioneered in south-west Queensland. Robust scientific models of property productivity are linked to the manager's expectations using producers as consultants to their peers (see page 79). DroughtPlan has helped to develop this further and has evaluated its application in other regions. This and other tools are assisted by the ***Grasp Pasture Production Calculator*** database which collates production parameters for all major pasture communities in Queensland and some elsewhere in the continent. This tool provides a probabilistic assessment of how El Niño affects pasture production to assist with decision-making in the same way that RAINMAN is doing with rainfall, in workshops and on-farm (see pages 85 and 123). The extent to which the use of seasonal forecasts can improve enterprise viability has been unclear; the linked ***Grasp/Herd-Econ*** model is a research tool for developing relevant case studies about this question which can then be used as examples in workshops and other materials (see page 91).

Financial management

DroughtPlan has responded to the known poor financial management skills of the industry, linking with several existing activities also doing this (Farm Business Management program, etc). The project has contributed to financial skills workshop development, and several of the products mentioned above have proved useful to help improve financial management skills.

Additionally, ***'Decision Trees'*** help people compare alternatives in dry years, by working through the decision tree of options over time, and their financial implications. As a motivational workshop activity, it establishes an analytical skill which can be used in any question, but it has also been implemented as a spreadsheet (see page 65).

Industry frequently expresses concern that taxation and other policy instruments do not meet their expressed intents of encouraging sustainable management. We therefore also developed ***RISKHerd***, a collaborative effort with the earlier LWRRDC-supported project *CWE2: Paddock Planning to Minimise Land Degradation* by one of this report's authors, Dr Mark Stafford Smith. This is a proof-of-concept tool to analyse the whole production system all the way through to analysing policy issues, including taxation (Stafford Smith *et al.* 1995). This now requires further application to problems of concern to the industry (see page 96).

The Stream 4 descriptions above are very brief but serve to illustrate that each topic has deliberately been approached with multiple solutions or many different forms, such that the matrix diagram (Figure 4) is justified.

Figure 4
Matrix showing multiple approaches to different management problem areas in Stream 4. More ticks indicate more complete filling of the cell.

	Financial	***Tactical***	***Strategic***
		Management	
Workshop activities	✓✓	✓✓	✓✓
Leaflets & reports	✓	✓✓	✓✓
Spreadsheets, etc	✓✓	✓✓	✓✓
Case studies, etc	✓	✓✓	✓✓

Stream 5 developed from Stream 1 to take Stream 4 products back to producers repeatedly to test and refine them (see Section 5 on page 100). It is carrying out a thorough evaluation of all products (see next section), in particular in terms of the effect of the Pasture Supply and Demand Calculator on benchmarks of best practice Central Queensland grazier groups. The process of Stream 5 is continuing beyond the end of the project, in-as-much as resources permit, since the real impact of products will only be determinable years later.

There are also several **project-wide generic products**, including a review of the developments in the philosophy of decision support and participatory processes which have occurred during the project (see Section 6 on page 134). A **booklet** is being produced to identify and place the available DroughtPlan products in the context of other projects, so that producers, workshop facilitators and extension managers alike can see where to obtain different skills and materials (see Section 4 on page 36). A number of scientific papers are also in preparation.

Evaluation

Much decision support work falls down because evaluation is not followed through, or is confined to confirming that the project milestones are met. Yet action learning principles and true participation oblige us to evaluate whether behavioural change has really occurred (Figure 2 on page 5). This idea has been developed in DroughtPlan as an essential part of ensuring the integrity of Stream 4 and 5. A five-stage process of evaluation was defined and applied to individual products, workshop activities and the project as a whole:

(i) Verification;

(ii) Validation;

(iii) Change in Reaction;

(iv) Change in 'KASA'—knowledge, attitudes, skills and aspirations; and

(v) Change in Practice.

Project evaluation usually stops at (ii) and product evaluation at (iii) or (iv) at best. In the lifetime of DroughtPlan we have formally tested all five stages only for one or two products where benchmarks had been established in central and south-west Queensland, although there is some less formal evidence for other products (see Executive Summary on page 1). Stage (v) for the whole project obviously requires review in some years' time; even then it will be difficult to disaggregate the effects of DroughtPlan from other projects. However, sufficient evaluation measures are now in place that, if a review was sought in five years, then this assessment should be possible.

The results of this evaluation inevitably vary across the project—all products were not equally successful at meeting their objectives. More details about individual products are provided in their respective sections, as well as Sections 5 (page 100) and 6 (page 134); the strength of the deliberate multiplicity of approaches in DroughtPlan is that less success in some elements does not jeopardise the whole. Here we apply the evaluation process to the whole project.

(I) VERIFICATION

At the project level, 'verification' means confirming that project management functioned correctly and all formal milestones were met. Some detail on this is provided under each Stream Report, but in general DroughtPlan performed well. A milestone report was submitted and accepted at the end of project year one. In brief:

1. Stream 1 was completed during year one so that it could provide input to the Stream 4 planning workshop for year two. The outcomes were produced, with reports on Central Queensland benchmarks and on DSS needs. The Stream 4 workshop was held two months behind schedule but was otherwise completed correctly.

2. Stream 2 documented the response of case study strategies to climatic variability across the continent as planned, actually producing reports on two more regions than it was committed to, and has produced a national overview report. It mostly ran about one month behind schedule; one temperate region still has some studies to be completed but with funds available for the outstanding work. Its reports were all passed back to producers to comment on before they were finalised, so the last few regions had not quite been finalised at the end of the formal project in order to obtain this level of local ownership. In conjunction with Stream 4 products, it has developed ways for producers to assess alternative strategies and tactics.

3. Stream 3 met its first year objectives dealing with research station data completely; there were delays in collecting on-station data in year two, but by the end of the year this too had been analysed. More data could profitably be added to these analyses, but the existing relationships are available for use in other studies.

4. Stream 4 coordinated a project-wide workshop early on, then spent year one collating consultative information about producer needs. Its planning workshop for year two was slightly behind schedule but a complete suite of products was defined and implemented as reported in the respective Sections. The format of these differed slightly from that expected by the contract, but their success is testament to the value of having flexible contract expectations where genuine client participation is intended to drive a project. By the end of the project, strong links with PMP had been created; some products have been released, while others are near completion in at least a test region.
5. Stream 5, as the evaluation and implementation phase of Stream 4, was really dependent on the format of Stream 4 to determine precise outcomes. At the general level, considerable evaluation has taken place under the aegis of Stream 5, especially after a major workshop in month 21, and will continue. However, some of the very specific case studies suggested in the contract have been overtaken by events. Thus Stream 5 has delivered an equivalent outcome but in slightly different forms to that originally envisaged.
6. Management was identified as a further component in the contract. The Management Committee has functioned regularly (phone hook-ups or physical meetings every three months throughout) and mostly smoothly, with valuable interaction with the Review Committee. Additionally the project undertook a review of research and research management methodology in year one which contributed greatly to 'action learning' about the process of research and management.

(II) VALIDATION

Validation involves ensuring that meeting the formal milestones of the project does indeed also meet its objectives. The objectives identified in the project contract have generally been met, as indicated in the following summary:

1. *Thoroughly analyse and publish case studies of drought management strategies for many regions of Australia, with 'benchmark' descriptions of best practice;*

   Achievement: nine regional reports under Stream 2, plus local best practice reports under Stream 1, plus various other inputs to the Stream 4 workshop, plus the Stream 2 National Report have clearly met this objective. These reports contain many analysed case studies and more are proceeding using GRASP/Herd-Econ and RISKHerd.

2. *A better understanding of the effects of nutrition (and hence stocking rates) on stock reproduction and mortalities;*

   Achievement: the Stream 3 results and two reports have substantially advanced our understanding in this area, to the point where some relationships can be used in predictions. Further collation of on-property property records would now be justified, however.

3. *Procedures designed by producers to assist on-property assessment of the value of different strategies;*

   Achievement: several of the Stream 4 products have precisely addressed this objective although in the light of participation during the project we would now probably place more emphasis on helping producers learn about the principles of comparing strategies and tactics rather than simply using tools on property. Producers were significant but not complete contributors to the design of Stream 4 products.

4. *The ability of producers to rapidly evaluate options for their production systems using decision support tools;*

   Achievement: the decision support tools here include the leaflets, worksheets and software produced by the project. A considerable amount of actual training of producers (or their advisers) has occurred during the project. We have further assisted people with learning the skills to carry out comparisons themselves even if it does not involve using software. This objective will be met more fully over coming years as the products are used more widely.

5. *An understanding of how seasonal forecasting can be used to assist sustainable grazing management;*

   Achievement: in conjunction with the Australian Rainman project, further assessment of seasonal forecasting has occurred within DroughtPlan, and the GRASP/Herd-Econ case study has begun to explore more explicitly when the forecasts are useful and when they are not. The interpretation of rainfall into pasture growth is one important element of this (Stream 4 product GRASP Pasture Production Calculator).

6. *Integration of the national Australian modelling efforts in grazing lands.*

   Achievement: there has been a significant bringing together of models of grazing lands, as evidenced by the GRASP/Herd-Econ/RISKFARM link, and the involvement of AusFarm in the project, which brought the national feeding standards to the tropics in the Pasture Supply and Demand Calculator. Through DroughtPlan and the National Drought Alert project, we have made some connections with other modelling of grazing systems, in particular in WA. There are further opportunities for integration ahead.

The project contract also claimed the following benefits could flow from DroughtPlan, the success of which can now be debated:

1. *The identification and evaluation of drought management strategies in terms of animal production, financial returns, pasture condition and, in some areas, soil loss;*

   Achievement: many strategies have certainly been identified and assessed with the expert input of producers (eg. see *ca*. 30 case studies in Stream 2 reports); the linking of GRASP with Herd-Econ (which necessitated the Stream 3 research) has enabled more formal evaluation of environmental impacts to be carried out, with an initial case study of this completed. The methodology now exists to extend these case studies to many more regions, and to policy instruments with RISKHerd.

2. *Identification by producers and extension personnel of the best practices that lead to sustainable and profitable grazing land use;*

   Achievement: the Stream 1 reports represent a remarkable set of benchmarks against which adaptive management can be assessed; and for future evaluation of industry changes, the Stream 2 reports contribute less formal surveys.

3. *A calculation of the potential benefit for the nation of adopting these practices;*

   Achievement: these calculations have yet to be completed, but a series of case studies was carried out with the tools developed from DroughtPlan.

4. *Methods of delivery of these practices to individual producers.*

   Achievement: Stream 4 and 5 provide this benefit, with on-going mechanisms established through Property Management Planning and other process. Perhaps as importantly, DroughtPlan has also developed new concepts about the process of participation in research by, and consequent delivery of results to producers. These should have great value in subsequent projects, whether in research or management, and whether from the point of view of research funding or project management.

In fact the project has considerably exceeded many of its contractual requirements. In most areas, delivery has been on time. There are a handful of individual items which have not been achieved; most of these relate to changing priorities defined by the flexible way in which year two priorities were dependent on year one consultations, and reflect the priorities identified by industry during that consultation. However, a number of achievements do depend on continued support of Stream 4 products, especially where they have been tested in one region and now need extension to elsewhere. In many cases DroughtPlan has established a framework for this to occur, but on-going support is not yet guaranteed in others.

(III) CHANGE IN REACTION

Change in reaction can be assessed at two levels: first, among the 'client' group of producers, and second among the project participants themselves.

- Although we have not sought a great deal of producer feedback to the project as a whole, reaction has been positive and DroughtPlan has a considerable recognition level in regions where we have worked. Stream 1 documented the fact that producers involved in workshops found them useful. Stream 2 received numerous spontaneous accolades for its reports in letters from producers involved as collaborators (at least eight such comments can be documented). More than a third of producer collaborators responded to draft reports without prompting, and another third had significant comments to offer when contacted. This indicates that those producers found the engagement valuable and thought-provoking. Individual products in Stream 4 have also had good receptions as outlined in later Sections.
- Action learning principles applied to the project itself caused us to reflect on the objectives and approaches to research in a workshop in year one. This highlighted the fact that one implicit goal of the project was also to change our own institutional outlooks. There is some evidence that project participants are now much more aware of participatory research methodology. Given the identified importance of participatory problem solving approaches in R&D today, this is also a valuable outcome. More change of this nature could yet be beneficial (see Section 6 on page 134).

(IV) CHANGE IN KNOWLEDGE, ATTITUDES, SKILLS AND ASPIRATIONS (KASA)

Change in KASA is harder to assess, since it requires a baseline for comparison, and may only occur some years down the track. As outlined in Section 5, it was possible to determine that some members of industry had acquired new KASA in a few areas, especially in central Queensland where there were existing benchmarks. Circumstantial evidence, based on follow-up inquiries after the Stream 2 regional reports, suggests that several individuals (eg. a pastoralist setting up a new discussion group), groups (eg. three Landcare groups requesting visits to meetings) and government agencies (eg. a fulfilled request for a training course) were specifically acting to capitalise on their involvement in the project in some cases.

As with change in reaction, there is also some evidence that project participants now have a more favourable disposition towards using participatory research methodologies, and have been prepared to apply consistent evaluation techniques across most of the project (see Appendices 1 and 2 on pages 146 and 148 respectively for contributors and DroughtPlan contacts). One participant wrote up an action learning reflection on what *he* had done and learned because of DroughtPlan, which included things he could do to improve his delivery of assistance to graziers. Once again, this is a valuable outcome, and once again more change of this nature could be beneficial.

(V) CHANGE IN PRACTICE

Confirming that there has been widespread change in industry practice (let alone that it can be attributed to a single project) is hardest of all, especially in the absence of prior benchmarks. Again there is evidence that specific practices are changing in Central Queensland in response to the Pasture Supply and Demand Calculator. The reports in other regions will provide a benchmark against which future change might be measured. The project participants *can* claim to have recognised the need for such information and established a set of data which can help future assessments of behavioural change, both in industry and in relation to the research community's approaches to participatory problem solving.

Adoption and future directions

The design of DroughtPlan has deliberately sought to integrate good basic science (eg. Stream 3, some Stream 4 products) with the delivery of applications (Stream 4) and support for adoption through participation (Streams 1, 2, 5). Hence we cannot deal with adoption as a separate issue.

However, the long-term nature of proper evaluation highlights the somewhat ludicrously short term of DroughtPlan—it was expected to promote major long-term changes in just two years, and do so with genuine, time-consuming participatory approaches. Not surprisingly, there are numerous areas which should be followed up to maintain the momentum towards adoption. This includes most notably the Carrying Capacity Calculator, GrazeOn, RISKHerd, Pasture Supply and Demand (by developing a formal set of Northern Australia Feeding Standards), the Grasp Pasture Production Calculator and the 'Decision Tree' approach, and further development of case studies using Grasp/Herd-Econ.

Most important of all, though, is the message that repeatedly comes back from producers—that "people are always coming out to talk and take information away, and never return anything to us". Participatory research directly addresses this problem by involving producers as partners. This has great rewards in terms of better targeting and better uptake, but it is time-consuming and it creates legitimate expectations. ***Most powerful among these is the expectation that, having demanded participation, R&D bodies will not then cut off the resources needed to maintain involvement***, at least in the absence of demonstrated project failure.

A form of DroughtPlan should therefore continue to provide for on-going evaluation and application of the results to date. This would be one clear way for funding bodies to ensure that the vital network developed in DroughtPlan does not evaporate as people turn to their own affairs.

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SECTION ONE

Stream 1: Intensive participatory research about managing climatic variability with pastoralists in Queensland

JEFF CLEWETT AND RICHARD CLARK

Objectives

- to document benchmarks of best practice of producer groups in Central Queensland and the priority issues identified by producers concerning management of climatic variability;
- to develop recommendations for producing decision support products in Stream 4 that includes a property management planning module, software and printed materials.

Summary

The priority issues identified by producers to improve management of climatic variability were collated from a range of activities and information, including intensive participatory interaction with four groups of beef producers in central Queensland, the results of drought workshops with producers through the remainder of Queensland in 1992, and producer information collected throughout Australia in the course of Stream 2 activities. The three categories of priority issues were: (i) improvements in farm business management (including financial planning, marketing, and enterprise analysis), (ii) improvements in strategic property management (this included improved skill in assessing sustainable stocking rates, matching herd or flock structures to seasonal patterns of pasture growth, and holding on-farm reserves), and (iii) improvements in tactical property management (such as breed, buy, sell, feed or agist decisions, and use of seasonal climate forecasts).

The resulting recommendations for developing decision support were that a range of nine products be developed to address the above issues and meet the diverse needs of industry. It was also concluded that processes of adult education and participatory problem solving were central concepts; thus the most effective products would link workshop activities with supporting printed materials and computer software.

Introduction

The two objectives of Stream 1 were achieved firstly by interacting with producers and producer groups throughout Queensland and other parts of Australia in the first six months of the project, and then secondly by distilling producers' priorities and recommendations at a DroughtPlan workshop in November 1994 (Clewett & Stafford Smith 1994).

The experiences and perspectives of four groups of beef producers (in the Morinish, Kunwarara, Gogango and St Lawrence areas of Queensland) regarding drought management were recorded using the Local Consensus Data (LCD) technique during August and September 1994 (Clark & Paull *et al.* 1994, Clark & Walmsley *et al.* 1994, Clark & Wright *et al.* 1994, and Clark & Dodt *et al.* 1994). In each group there were 7 to 15 experienced graziers with a total of 40 graziers participating in the discussions. A broad range of drought management issues were discussed and recorded, including drought policy recommendations, planning, recovery from drought, climate forecasting, property size, and management of stock (selling, feeding, stocking rates, early weaning, agistment), water, cash, pastures, risk, fodder conservation, pests, fences, off-farm income, investment and diversification.

The recorded experience and perspectives contained in these reports provides a 1994 benchmark of each group's view of best practice. These benchmarks can be used by the group in various ways, but in particular can act as a reference document against which the group can assess changes in knowledge, attitudes, skills, aspirations and practice.

In addition to the central Queensland activity, the views of a group of wool producers in the Eulo area of south-west Queensland were sought in relation to their decision-making processes when managing a drought (Drysdale & Gaffney 1994). This process identified producer views on drought options, critical times to act, critical factors in decision-making, and 'Decision Trees' as an approach to the decision-making process.

Priority issues identified by producers

At the DroughtPlan workshop in November 1994, issues identified by producers as being factors which would enhance the management of climatic variability were based on:

1. the 'Best Practice' reports from four beef producer groups (40 experienced producers) in Central Queensland as mentioned above;
2. results from five workshops on drought management held in 1992 just prior to the start of DroughtPlan, at Charters Towers, Longreach, Emerald, Gayndah and Dalby (Armstrong *et al.* 1992); these were attended by more than 70 producers and several DroughtPlan staff; and
3. results from a national survey of 2,259 primary producers throughout Australia (42% being beef or sheep) on their use of risk management strategies, including the methods applied to manage production risks caused by climate variability (Chudleigh 1993).

These reports were augmented by:

4. the Stream 2 report on issues from pastoralists in western Queensland and (then) draft information from other regions (Buxton 1994) (further Stream 2 reports completed after the workshop subsequently consolidated these needs);
5. the Stream 1 report on mulga lands drought strategies (Drysdale & Gaffney 1994);
6. views of farm financial councillors (memo from Ed Collis, 1994);
7. findings of QDPI wool industry staff on decision support needs (Clewett 1992); and
8. results from the DroughtPlan workshops on modelling animal production (Clewett 1994) and decision support (Stafford Smith & Clark 1994).

The issues identified were classified into the following broad categories:

- business management;
- strategic property management;
- tactical property management; and

- external issues (issues outside the immediate domain of DroughtPlan but still of great importance because they are agents of change).

While the issues in each category are listed in the following sections, we recognise that no list will ever be complete. However, we are confident that all important items with wide geographic support are listed here, even if some less important items are too. The items are listed in the order in which producers seem to rank them, although no absolute measures should be inferred from this since many have different priorities in different places and at different times. Thus, we believe that the critical generalities are correct even if one might quibble about some details.

BUSINESS MANAGEMENT

Enhancing business management skills was the highest priority issue. This encapsulated both financial management issues and business management issues relating to strategic and tactical grazing management. Taxation and other government policy areas were high on the agenda of many reports. Sub-issues of business management (with priority dependent on the individual) include:

- Improved record keeping and use of records in physical and financial planning;
- Improved marketing—analysis of livestock markets, location, specification;
- Improved skills to financially assess tactics and strategies (including impacts of seasonal variability);
- Improved financial planning and borrowing skills;
- Improved skills in enterprise analysis (eg. value off farm reserves, diversification, purchase of additional land, improving existing land);
- Improved knowledge of taxation and income smoothing; and
- Improved negotiation and communication skills.

STRATEGIC PROPERTY MANAGEMENT

The issues in this category relate to long-term property management objectives and are thus tempered on a seasonal basis by short-term tactical issues. Matching herd structure to market requirements was a high priority of producers. The three issues central to DroughtPlan were:

- Improved skill in assessing sustainable stocking rates was the highest priority. Optimum stocking rates need to recognise climatic risk, total grazing pressure and financial pressures on cash flow, and to balance returns per hectare, returns per head, and the short and long-term impacts on the pasture resource;
- Matching herd/flock structure to seasonal patterns of pasture growth; and
- Holding on-farm reserves such as water, pasture, grain, hay and top feed (mulga). The main questions were which ones, how much and how the reserve is used.

Further issues were: water harvesting and management of irrigation supplies, and distribution of stock on the property and consequent utilisation of feed in paddocks at different rates and by different classes of animals.

TACTICAL PROPERTY MANAGEMENT

The tactical issues identified below relate to improving skills that enhance decision making on timely adjustments to the number (up or down) and type of animals grazed or fed in response to seasonal conditions:

- Sell/feed/agist decisions—when, which and how many stock, what and how much feed, what cost/price?
- Breed or buy decisions—when, what, how much?

- Short term feeding programs—least cost, how long?
- Assessing standing feed at the end of the growing season and then making appropriate adjustment to stock numbers—monitor and market accordingly;
- Using seasonal climate forecasts to improve breed/buy/sell/feed/agist decisions;
- How to anticipate fluctuations in feed supply resulting from climate;
- Using a market driven approach, not just selling; and
- Maintaining the ability (financial, animal and feed resources) to respond to improved seasonal conditions for recovery from drought or taking advantage of seasonal conditions that are well above average.

EXTERNAL ISSUES

The following 'external' issues were listed as factors causing change in the grazing industry, and therefore of consequence in deliberations on development of decision support for managing climatic variability:

- Stream quality (river quality, sediment, blue/green algae);
- Government policy or international conventions—drought policy and self reliance, economic sustainable development, National Greenhouse Response Strategy, desertification, National Forest Policy, Rangelands Strategy;
- Maintaining biodiversity;
- Animal welfare;
- Changing consumer preferences; and
- Social issues (health, education, disease control).

These issues are beyond the skills or resources of the current DroughtPlan project but (a) must inform the process of developing some of the DroughtPlan products and (b) may be relevant to further work.

Recommendations for developing decision support products

The process used to decide what products (workshop activities, printed materials, software) to develop to meet the priority issues listed above was to firstly, list and discuss a suite of potential products that could be developed for the matrix in the table below.

Category/Issue	*Potential product—delivery mechanism*
• Enhance business management eg. risk analysis	• Producer workshop activity: eg. simple exercise or detailed planning
• Strategic management decisions eg. sensible stocking rate	• Printed materials: eg. technical information or decision process leaflets
• Tactical Management decisions eg. breed/buy/sell/feed/agist	• Computer software: eg. databases, spreadsheets, bio-economic models
	• Video, multi-media CD-ROM, Poll Fax

Small group discussions and plenary sessions were held on each of the issue categories and product types (workshops, printed materials, software). Software products were ranked on their feasibility for development. Clewett and Stafford Smith (1995) give details of the discussion points raised in these sessions. Concepts of how to address the priority issues were further explored by considering action plans needed to develop products. It was by this process that priorities and recommendations for product development were distilled.

The workshop sessions and subsequent discussions resulted in the following conclusions:

- Processes of adult education and participatory problem solving are central concepts of the project, and thus developing effective producer workshop activities is central to product development. Without this concept, resource products such as printed materials and software will have limited success;
- Priorities for developing decision support products follow the priorities identified by producers;
- A balance and diversity of products is required which gives:
  - equal priority to tactical property management, strategic property management and business management, and
  - several methods for addressing each issue (as in the matrix above);
- Printed materials and software products should have stand-alone capacity; and
- Linkages with other projects should be strengthened to develop synergies and avoid duplication of effort (eg. links with developments in other LWRRDC-supported climate variability R&D projects and with the PMP module 'Managing for Climate').

Two producer workshops were identified. They should augment existing workshop activities with producer groups involved in the LCD process in central Queensland, and the property management planning and farm business management initiatives at a number of centres throughout Queensland and in other states. In total, nine products were identified, grouped under the two workshops as follows.

PRODUCT 1: PRODUCER PMP WORKSHOP 'ASSESSING YOUR LIVESTOCK MANAGEMENT OPTIONS'

This workshop (initially called 'Stocking for Profit') was to be developed in partnership with producers to address the following strategic and tactical management issues:

- Sustainable stocking rates (strategic);
- Managing stock numbers over time (strategic with some overlap into tactical); and
- Breed/buy/sell/agist/feed options (tactical).

The workshop activities would be supported by a range of products including a workshop manual containing:

- printed materials describing workshop activities and software products;
- printed resource materials such as existing technical information leaflets; and
- notes and overhead transparencies for workshop facilitators.

The following spreadsheets would be developed to support the workshop activities:

Product 2—a sustainable stocking rate calculator (printed 'back of envelope' work-sheet plus computer spreadsheet to be carried out in collaboration with Charleville staff);

Product 3—a 'Decision Tree' package (process leaflet with spreadsheet template) for comparing risks and returns; and

Product 4—a BB-SAFe (breed/buy-sell/agist/feed evaluator) calculator spreadsheet.

These spreadsheets were to have paper based worked examples, and be supported by:

Product 5—a data base of simulated historical pasture growth to rapidly assess climatic risks and opportunities—this product is similar to RAINMAN but calculates pasture growth using GRASP/ GRASSMAN equations;

Product 6—a bio-economic simulation model that links the existing GRASP and Herd-Econ models using results from Stream 3 to provide detailed analyses of both strategic and tactical options;

Product 7—a 'Nutritional Balance Analyser' that was to be produced by further developing the GRAZPLAN models and which would help assess the gap between feed supplies and feed demand on speargrass beef properties in Central Queensland; as well as,

— case studies investigating the utility of seasonal climate forecasts as a decision making tool (as a product of Stream 5).

This suite of activities and products for strategic/tactical management is substantial and would require several days to work through. However, time demands on producers is well recognised, and thus workshop activities and use of supporting resource materials were split into half-day segments so that producers have flexibility in selecting/combining activities to suit their needs.

PRODUCT 8: FARM BUSINESS MANAGEMENT WORKSHOP

This workshop (initially called '*$$$ From Downpours and Dust*') aims to enhance business management knowledge and skills. It has some similarities to the first workshop but focuses more on the impacts of climate variability on financial management and enterprise planning. The workshop:

- uses activities and products form workshop 1, but,
- extends workshop activities to consider enterprise planning, taxation, income smoothing and cash flow management, by linking DroughtPlan activities to Farm Business Management activities, commercial software products, and the project, *Analysing Drought Strategies to Enhance Farm Financial Viability*, based at University of New England.

This activity was also to result in the development of a set of printed workshop activities, and:

Product 9—a set of tested and documented procedures that link the GRASP/Herd-Econ bio-economic model to the financial analysis RISKFARM model for case studies that evaluate alternative grazing and herd management practices.

Evaluation

Verification and validation: The project's formal milestones for Stream 1 were achieved, although the workshop in October 1994 to establish recommendations for decision support was moved back a month to avoid clashes. Outputs required from Stream 1 were:

1. A report describing benchmarks of current best practice for managing climate variability as defined by Central Queensland LCD producer groups, and highlighting opportunities for improved practice.
2. Recommendations by producers and project staff regarding:
    - changes to existing decision support tools;
    - development of new decision support tools; and
    - content of a module for use in PMP activities to assess risk.

Item 1 above was achieved through the four reports of Clark *et al.* (1994).

Item 2 was achieved with recommendations reported in three DroughtPlan Working Papers: (i) an analysis of constraints to modelling animal production and reproduction (Clewett 1994), (ii) recommendations on general approaches to decision support (Stafford Smith & Clark 1994), and (iii) recommendations for development of the nine specific DroughtPlan products (Clewett & Stafford Smith 1994).

In establishing the priorities for developing new decision support tools the contributions and value of existing tools were taken into account. The decision to develop new tools was based on current producer needs not being met by existing decision support tools and activities. Thus, the new tools were specifically designed to build on past progress and current producer needs. This is most clearly shown in Plate 1 (page 45) which illustrates how the DroughtPlan products link with each other and with:

- existing activities used by producers to understand their production system (eg. through record keeping, GRASS CHECK, and access to climate information);
- existing workshops in property management planning and farm business management;
- existing computer based decision support products such as AUSTRALIAN RAINMAN and RANGEPACK Herd-Econ, and
- new products being developed in other projects, such as National Drought Alert in the LWRRDC-managed National Climate Variability R&D Program.

Reaction, KASA and Practice: The reaction of producers and staff to the content of Plate 1 has been favourable and often prompts an interest in finding out more about the DroughtPlan products. DroughtPlan staff gained considerable change in KASA and practice from involvement in Stream 1. Change in industry KASA and practice is specifically addressed in the reports for Streams 2, 4 and 5.

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SECTION TWO

Stream 2: Research with pastoralists to define alternative drought management strategies all across Australia

ROSEMARY BUXTON, DAVID EDDY, MARK STAFFORD SMITH, ANDREW MOORE, PLUS NUMEROUS PRODUCERS AND AGENCY PERSONNEL AROUND THE CONTINENT

Objectives

(i) to document, with producers and extension agencies, a series of case studies of the biology and economics of key existing and improved strategies in different rangeland (5+) & temperate (2+) regions of Australia;

(ii) to document the response of these strategies to climatic variability;

(iii) to develop, with producers, a series of procedures by which producers and their advisers can test these strategies on their own properties, using RANGEPACK Herd-Econ and GrazPlan, and other packages where relevant (overlapping with Stream 4).

Summary

In the event, Stream 2 completed consultations in seven rangeland and two temperate regions, visiting between 6 and 12 properties in each region, as well as interacting with local extension agencies and, often, groups of pastoralists other than those specifically visited. From these visits, a short report was prepared for each property about the current operation and potential future options related to managing climatic variability; this was returned to the producer concerned to check its accuracy and provide some immediate feedback. A regional report was then prepared for each of eight of the regions, describing its general characteristics of management, and incorporating three to six case studies of specific issues that were seen as important there. This was again checked by the collaborating producers and extension personnel, and then released publicly.

From the accumulated wisdom of all the discussions and regional reports, recommendations were made to Stream 4 regarding the information needs across the continent. Additionally, follow-up interactions in the regions allowed some of the products from Stream 4 to be taken outside Queensland, so that this was the principal means by which DroughtPlan networked with property and financial management and planning processes nationwide. Stream 2 also collected some on-property data for Stream 3, and developed a database of financial and biological inputs which could be used in case studies elsewhere in the project. Finally, the major implications of all the reports and analyses are collated into a national report (Buxton *et al.* 1997) and two scientific papers (Buxton & Stafford Smith 1996, Stafford Smith & Buxton 1997).

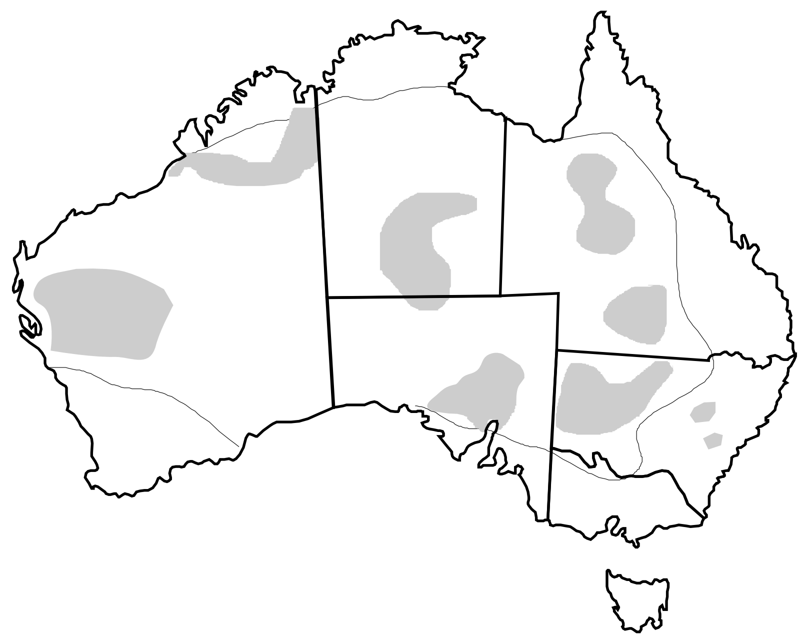
Background

Stream 1 of DroughtPlan sought to carry out very intensive participatory problem solving approaches in some regions of Queensland. This enabled the project to genuinely involve producers in the research process, through identifying and testing products that would help their decision-making. However, these group activities are labour and resource-intensive, and require a long-term commitment to support and follow-up. The quandary facing DroughtPlan was to ensure that products were nationally useful when the project could not provide the resources nor guarantee the follow-up across the rest of the continent. Hence Stream 2 provided the geographic extension to Stream 1 by adopting a different methodology. The work was still intensely participatory, but one-to-one with a few producers who represented a diversity of management approaches in the different regions. With this more personal approach it was possible to ensure that the producers obtained something quickly in exchange for their time and information, at the same time as obtaining a reasonable picture of the issues that they faced.

Approach

Most of Stream 2 occurred in the rangelands, with a lesser proportion making comparative studies in areas with temperate pastures. The regions are shown in Figure 5 (and identified in the list of regional reports at the end of this section). In all regions a compatible methodology was applied. In consultation with local extension personnel and producer contacts (eg. resulting from previous surveys—Stafford Smith 1993), 8–15 interested producers were identified, representing a reasonable diversity of management approaches and property resources for the region. Each was sent a letter outlining the purpose of the project, emphasising that they should only become involved if they felt they would get something useful from the interaction, and in exchange we would be asking for access to their biological and some financial information (with appropriate confidentiality controls), as well as their expert opinions about management, for wider circulation. Thus, we were open about what we believed they might gain from the process, and what the project was seeking in exchange.

Figure 5
Regions where Stream 2 studies took place



About five weeks was spent in each region, during which agreeable producers were visited for one to two days. During this time, a general picture of their operation was built up and entered into RANGEPACK Herd-Econ. This picture represented the particular combination of resources, goals and circumstances that drove individual producers, rather than some averaged regional amalgam. Before departure there was usually time to check that the model was operating sensibly, and in discussion some key problems or future options were identified which could be tested. Within one to two weeks, a short report on the enterprise's basic response to climatic variability plus the response of one or more options was returned to the producer for checking. A follow-up visit or discussion by phone checked details. Local extension officers were often involved in this process; many of these have followed up the results (Queensland, SA and NT Departments of Primary Industry, NSW Agriculture, and Agriculture WA).

After the regional visit, a concise regional report was written, providing a general description of the area and an outline of the approaches to managing climatic variability (within the broader aspects of property management) used by those visited. Other sources of data were drawn upon, but these reports are not true surveys; rather, they seek to highlight key issues of concern in the different regions. The identity of individual properties was protected, but three to five generalised case studies pertaining to these key issues were appended to each regional report, accumulating to some 30 case studies in total. The reports were returned to the producer collaborators as drafts to be checked. There was a high degree of spontaneous response to these, with valuable corrections, after which they were released as public documents for other producers in the region and elsewhere (see listing under Buxton and various others, Eddy and various others in the References). There has been a substantial demand for these reports from many sources, and some key results have been published formally (Buxton & Stafford Smith 1996).

The accumulated wisdom from the collaborations provided input to Stream 4 design early in DroughtPlan, and then support for different priorities later on. Thus some products that dealt with drought tactics which were only seen as moderately important in central Queensland were given higher priority in areas with less climatic reliability. On the other hand, products dealing with safe stocking rates were seen as important throughout the continent and were given weight accordingly. Follow-up in various regions has helped local extension personnel to access the DroughtPlan product network. The similarities and differences between regions are also providing the basis for a national overview report (Buxton *et al.* 1997, Stafford Smith & Buxton 1997). Finally, where producers had biological records that they were happy to share, these were passed on to the on-property analyses of Stream 3.

Some results

While there are certainly common factors and options that apply across the grazing industries, the most obvious outcome of Stream 2 is confirmation of the diversity of conditions and consequent options across the rangelands and temperate areas, as well as notable differences between rangelands and temperate areas. The regional reports have identified the management options used for handling climatic variability in different areas. Table 1 on page 27 illustrates the options found in the studies in each region, although it hides the great differences in costs that these may have (see Buxton *et al.* 1997). It is clear, however, that regions closer to the edge of the rangelands have many more options open to them, with this trend most notable in the temperate areas of NSW.

Taken as a whole, the many producers involved in DroughtPlan identified three general areas related to property management where they felt better information and training could help them cope with climatic variability (see Stream 4). These were strategic management of long-term stocking levels, tactical management of stock numbers between years, and business management skills. The detailed needs in all three areas were illustrated by the case studies. For example:

Strategic stock management: there are opportunities to improve cash flows at lower stocking rates in many regions of the rangelands, but these are only apparent when a realistic analysis is made of the effects of climatic variability (Table 2 on page 28). These results depend on the assumptions about production responses at different stocking rates made by collaborators and we are beginning to develop an objective basis for these assumptions, linking producer knowledge with some independent scientific assessments (see sections on GRASP, HerdGRASP and the Carrying Capacity Calculator).

Tactical stock management: faced with a drought-in-progress, there are many options for reducing stocking pressure then building it up again afterwards. It is generally true that small adjustments in these tactics can have big financial ramifications, but different approaches are appropriate in different regions so detailed generalisations are dangerous (hence see the section on **BB-SAFe**). One common finding is that it is advantageous in a short-term financial sense to build up again as fast as possible after drought (Buxton & Stafford Smith 1996). In many areas pastoralists suspect that this result conflicts with longer-term environmental values, but we lack the data to evaluate this.

Enterprise business management: strategic approaches to business management suggest that there are many valuable opportunities in diversification, which are likely to become increasingly important to rangelands enterprises. The survey found a vast array of forms of diversification across the country (Buxton *et al.* 1997). However, diversification should only be undertaken after a thorough strategic look at the current business to ensure that it is already operating optimally, since small changes here can often be as good as diversification, yet be much easier and less risky to implement.

Table 1
Grazing strategies observed to be used to respond to drought in different regions.

	Western Queensland	SW Queensland	Western NSW	Kimberley	South-Australia	Gascoyne, Murchison	Central Australia
Supplementary feed	✓	✓	✓	✓		✓	✓
Feedlot on property	✓	✓	✓	✓		✓	
Feedlot off property	✓						
Wean early		✓	✓	✓		✓	
Sell	✓	✓	✓	✓	✓	✓	✓
Shoot	✓					✓	
Agistment	✓		✓		✓	✓	✓
Send to 2nd property	✓		✓			✓	✓
Cut top-feed		✓					
Don’t join ewes/cows		✓	✓		✓	✓	
Change flock/ herd structure				✓			

Table 2

Summary of improvement in average cash surplus as a result of lowering the total grazing pressure for individual stations in various rangeland regions (initial stocking rate calculated as the average hectares per animal equivalent over 40 years of climatic variability).

Region	Average annual cash surplus (initial stocking rate)	Initial average stocking rate	Reduction in stocking rate	Average annual cash surplus (lower stocking rate)
Kimberley, WA	$522,653	12.0 ha/AE	23 %	$720,090
SW Queensland	$87,508	1.5 ha/DSE	40 %	$148,209
Gascoyne, WA	$65,819	7.4 ha/DSE	20 %	$97,534
South Australia *	$9,239	9.1 ha/DSE	40 %	$18,616

* in this case achieved through removal of feral animals; initial stocking rate is sheep only, with reduction caused by the removal of rabbits.

Finally, it is worth noting that there are even greater differences between the temperate regions and the rangelands than there are among rangelands regions themselves. These differences include, of course, higher stocking rates (4–20 DSE ha^{-1} compared to 4–20 ha DSE^{-1}); a greater diversity of marketing options (including vertical integration to knitted garments, and many local saleyards as well as more distant markets); more reliable despite variable rainfall (the range of annual rainfall totals varies around 50–150% of the mean compared to 20–350% of the mean at Alice Springs, for example). As a result, cash flow fluctuations tend to be dominated by the value of production rather than volume, compared to the rangelands; supplementary feeding is much more common in drought (and is used to cover winter feed deficits most years anyway, often supported by the opportunity to make hay or silage on-property); drastic de-stocking is unusual; and, there is little carry-over effect of one year's operation on the next.

Stream 2 contributed to identifying the information needs and constraints for Stream 4. Some products from Stream 4 have thus been extended to regions outside Queensland. Additionally, the national overview:

- confirms the importance of multiple approaches to information provision;
- identifies the build-up phase after droughts as being a critical time when our knowledge is inadequate;
- highlights the need for benchmarking; and
- notes that many of the areas where regional restructuring is currently focused are, ironically, where per head productivity is reasonable.

Evaluation

Stream 2 has met or exceeded its contractual objectives, as indicated below. However, it is hard to establish other evaluation measures. Future work should establish 'best current practice' benchmarks in various regions, to quantify long-term changes in management.

1. **Verification:** Stream 2 had two external milestones and five internal project milestones. These were all met although (i) most work ran one month behind schedule due to initial delays in appointments, (ii) the temperate regions were carried out part-time and finished three months behind schedule (but still on budget) and (iii), in the spirit of participation, some regional reports were still being checked by producers at the time of the project Final Report and so were finalised after the end of the project.
2. **Validation:** Stream 2 was contractually committed to producing the following outcomes:
   - 7+ regional reports (current strategies and thorough analyses with respect to climatic variability);
   - Train extension personnel/key producers in each region in philosophy and packages;

- Upgraded DSS tools with ‘recipe procedures’ to make their use simple for testing these strategies (and drawing on Stream 3 outcomes);
- National overview report and direct input into Stream 4; and
- Publications of results.

These outcomes have been met or exceeded, with nine regional reports. Training of people regionally has occurred, but on-going effort is required to ensure that they stay linked in to the network that DroughtPlan has established. DSS tools are reported under Stream 4 rather than here. A national overview (Buxton *et al.* in prep.) will be published by LWRRDC and two journal publications (Buxton and Stafford Smith 1996; Stafford Smith and Buxton in prep.) will complete the documentation.

3. *Change in reaction*: The majority of producers involved in Stream 2 collaboration have responded positively. Perhaps the best measure of this is that about a third of these busy people spontaneously provided feedback on the draft of their region’s report (often several pages of letter), while at least another third had significant comments to make when contacted by phone; less than a third provided no response. Additionally, at least one extension person in each region followed up in some way, with six (so far) making the effort to attend subsequent DroughtPlan-related meetings and further pursue contacts.

4. *Change in KASA*: No formal assessment of this has been made to date. However, in three regions, producers have spontaneously sought more input from our project staff, usually on behalf of groups in which they are involved.

5. *Change in practice*: This is hard to assess in the absence of baseline data. However, one pastoralist has actively pursued the establishment of a discussion group as a result of the interactions, and two existing discussion groups are known to have dissected their regional reports and case studies. Some 12% of producers actually stated that they would change their management as a result of the project, but there has been no follow up yet to confirm this.

   The most encouraging development of this side of the project is that several pastoral groups have taken up the information, since this extends the information beyond the small core of collaborators with whom we worked and provides a mechanism for the information to enter a long-term decision support process.

Conclusions

A common thread running through the Stream 2 studies is that it is vital to put strategies and tactics, or any management options, into the whole property financial context. In the past we have tended to analyse either the economics or the biology. But the two are inseparable—the biology and the management determine the numbers, which link with market conditions to determine the economics. Second, climatic variability is such a fundamental driving force in the rangelands that any assessments which fail to take account of it are at best of dubious relevance to the pastoralist, and at worst seriously misleading. Managing risk is ultimately a whole-of-enterprise exercise, combining environmental and financial factors. Third, a large part of the richness of management approaches to coping with the complex environment of the rangelands is reflected in the differences between individual properties. While it is not possible to take an individual-based approach to all studies, the understanding of motivation and decision-making can be greatly impoverished by ‘district-average’ studies.

Hence, it is to be hoped that case studies of the nature undertaken in Stream 2 will continue to be carried out with producers, and that these will be placed in an appropriate regional and national framework. Used in a complementary sense to other biological and socio-economic research, these studies provide a pathway through which priorities may be set with integrity and results may be applied with vigour.

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SECTION THREE

Stream 3 Developing predictors of reproduction and mortality rates in extensive pastures

ANDREW MOORE, PAT PEPPER, DAVID MAYER, GREG MCKEON AND MIKE FREER

Objectives

(i) to develop an understanding of the links between climatic variability, production levels and biological rates (reproduction and mortality) from producer and research records across the continent; and

(ii) to define appropriate relationships for use in assessing the economics of the resulting herd dynamics and alternate management strategies.

Summary

Climatic variability and stocking rates in the grazing lands of Australia have a major influence on animal mortality and reproduction. This study aimed to quantify those effects so that the key ‘biological rates’ of mortality and reproduction could be predicted. Details can be found in Moore *et al*. (1995) and Pepper *et al*. (1996).

For sheep, successful models predicting reproduction and mortality from animal characteristics were developed, with liveweight and age being the crucial predictors. However, liveweight is not often recorded on sheep properties. Hence the pasture production model GRASP was used to estimate climatic and pasture measures for Mitchell grass (*Astrebla* sp.) pastures, from which marking and mortality rates could be predicted. Age of the ewe, measures of favourable conditions for pasture growth over the previous two years, and the availability of dry matter at joining proved to be major predictors. Predictions were improved with the inclusion of a measure of frost on the pasture during the crucial joining to marking period together with other grass quality measures. These prediction equations were then tested against independent data from commercial properties and the model successfully validated for Mitchell grass communities. However, the inclusion of climatic variables in addition to pasture measures indicates the need for further research to evaluate the responses to the growth of forbs. Further testing on properties with other vegetation, such as Mulga and chenopod shrublands, was undertaken to examine the potential of this approach. Whilst further work is needed to produce a better model for other pasture areas, the reproduction and mortality rates estimated for Mitchell grass communities can be used with some confidence.

For beef cattle, liveweights were also the key predictor of biological rates in the research stations data, along with age, breed, lactation status and weight changes of the animals. From beef producers' properties, an adequate number of validation data sets were collated, which included these key predictors of liveweights or body condition scores. The observed patterns in the producers' data differed significantly from those found in the research stations data, upon which the predictive models were formed. Mortalities on the producers' properties were about twice those predicted, and conception rates (per oestrus cycle) were only around 0.64 of the estimates. Acquisition of beef producers' data is ongoing, particularly from the Northern Territory, with a view to fitting separate models for these. In the interim, the above calibration rates applied with the research station model can be used to predict the likely range of biological rates on-property.

These cattle and sheep studies are valuable links in attaining whole enterprise models. When these are in place, a wide range of topical issues can be addressed, including stocking rate strategies, drought management and recovery, tree clearing, effects of improved pastures and breeds, and different enterprise mixes.

Approach

Reproduction, mortality, animal and property description data were collated from research stations and commercial properties. The GRAZPLAN mortality and conception submodels (Freer *et al*. 1997), which had been developed in southern Australian regions, were tested for northern Australian conditions. Empirical relationships were also developed to predict the probability of mating, pregnancy and mortality from data describing the characteristics of the animal (eg. breed, age, liveweight, condition) at relevant times. These relationships are detailed in Moore *et al*. (1995).

Independent data from commercial properties were collated to validate the models. Adequate data were available for beef properties, but there was a paucity of liveweight data on sheep properties. Hence, it was planned to use the grass production model (GRASP) to simulate liveweight from climatic data and soil and management parameters and use the above relationships, to predict reproduction and mortality. Difficulties in adequately simulating liveweight change led to the approach of developing models to predict lamb marking and mortality rates from climatic, soil moisture and pasture estimates from GRASP.

Results and discussion

For research data with sheep, a re-parameterised GRAZPLAN process model, with an empirical equation to predict the probability of ewes mating, predicted the probability of pregnancy well (86% variation explained) but the GRAZPLAN model to predict mortality did not apply. Empirical models explained 88% and 78% of the variation in pregnancy and mortality rates respectively. However, a crucial predictor in these models was liveweight, which was not readily available in the validation data from producers' properties.

Empirical models of reasonable accuracy (R^2 = 81%, 63% respectively) were also developed using only climate inputs and simulations of soil moisture and pasture growth for Mitchell grasslands. A reasonable validation was achieved with independent data, for both lamb marking rates (Figure 6) and ewe mortalities (Figure 7). Full details of these validation analyses are listed in Pepper *et al.* (1996). The application of this model to properties in mulga communities in Queensland and to New South Wales and South Australia was not successful. Nevertheless, preliminary analyses demonstrated that sheep vital statistics can be related to climatic and pasture measures.

Figure 6
Validation of lamb marking rate (lambs/no. ewes joined)

(Note: Points joined by lines in both Figures 6 and 7 show the range of possible predictions for cases where the age of animals was only recorded as a range)

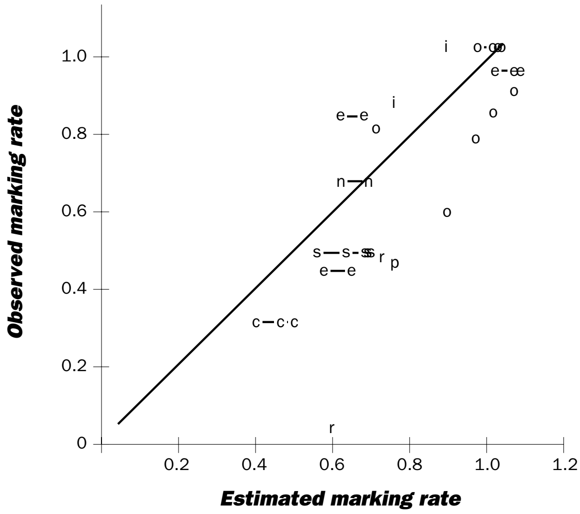
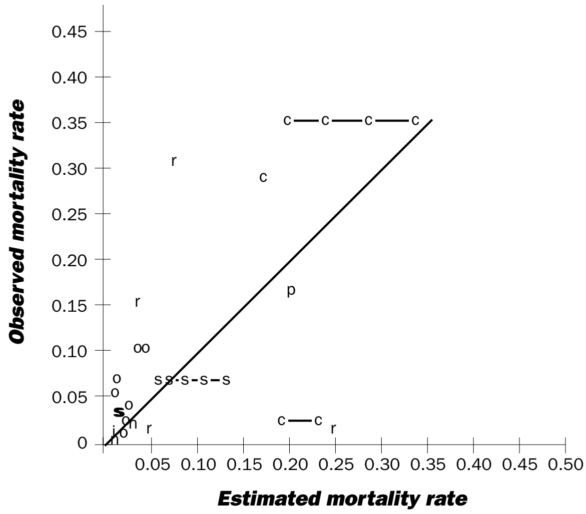


Figure 7
Validation of ewe mortality (joining to marking)



For cattle, conception and mortality models explained 82% and 67% respectively of the total variation in the research stations data. When these predictions were applied to the data from commercial properties, good relationships were found between the predicted and observed values (Figures 8 and 9 on page 34), however these fits departed significantly from the expected line. Mortalities on the commercial properties were about twice those predicted from the research station data, and conception rates were only around two-thirds of the estimates. Both results probably reflect the higher levels of management on research stations, as compared to average commercial conditions. This is then associated with the lift in herd performance observed on research stations. Further producer data are being sought across northern Australia. Until sufficient coverage is achieved to justify separate statistical models for producer properties, re-calibration from the research stations models may be used to estimate biological rates in the beef industry.

Figure 8
Mortality rates for beef herds

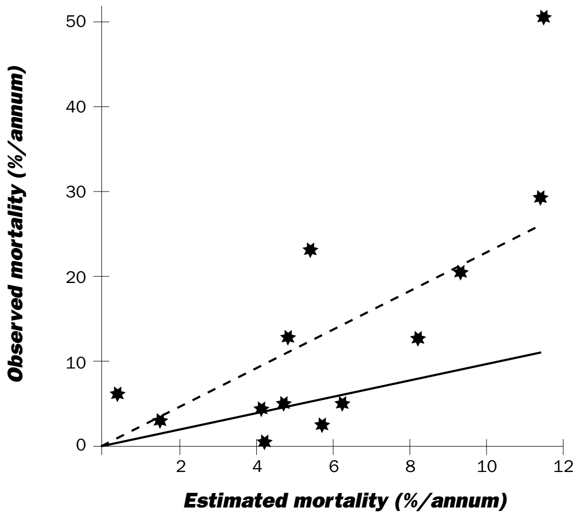
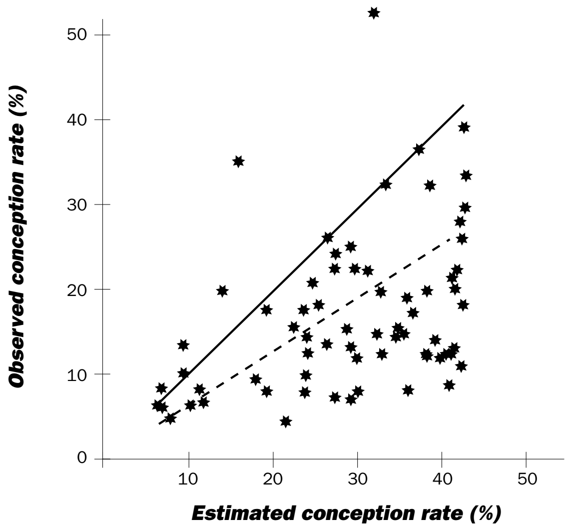


Figure 9
Conception rates for beef herds



Evaluation

OUTCOMES

Outcomes were to be explicit relationships for reproduction and mortality rates which account for feasible and necessary input variables, with report and publication on same.

KEY MILESTONES

Month 6

Research station data collated; first meeting held; short internal report; Sources of producer data identified; QDPI extension staff trained in paddock assessment.

Month 12

Second meeting held; internal report on efficacy of 'detailed' models with respect to research station data.

Month 18

Producer data & simple relationships collated into report; Likely relationships (simple & detailed) provided to Streams 2 & 4.

Month 24

Relationships (simple & detailed) finalised; publication submitted; Section of Final Report provided to Management Committee.

All these steps were achieved, although one outcome of the work was to identify that further information needs to be collected from on-property conditions to resolve the inconsistencies between the research and commercial station results.

Conclusions

Re-calibrations of the estimated biological rates for beef cattle should form the basis for predicting industry performance. For sheep grazing Mitchell grass pastures, reproduction and mortality rates can be successfully predicted from climatic and pastures measures in most cases. The approach was also shown to have potential for other pasture communities, but requires further work.

These models are of a general form, and can be linked to other simulation models (such as GRASP), which simulate the effects of climate and management (ie. stocking rate) on live weight gains. Hence, when all the key factors have been integrated, this whole system can be used to investigate the available range of management options, focusing on sustainability as well as profitability.

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SECTION FOUR

Stream 4: Development of decision support products

JEFF CLEWETT AND COL PAULL

Objectives

To produce a suite of decision aids to meet the information needs of clients, given that:

- this may involve extending existing packages or developing new ones;
- the suite is not limited to a single item or type of item;
- decision aids are primarily but certainly not exclusively software-based; and
- the clients are focused on producers but also encompass government agencies, agribusiness and educational institutions at least.

The precise products were to be determined by consultation.

Summary

Stream 4 developed nine products (workshop activities, printed materials and computer software) as a result of the recommendations from Stream 1. These aimed to meet the needs of adult education and participatory problem solving, and to provide multiple approaches to financial management, and to strategic (long-term) and tactical (short-term) stock management decisions. All products are in the process of publication or commercialisation so that benefits from the DroughtPlan project will be on-going. The products are*:*

- **Assessing your livestock management options**: a Property Management Planning workshop for producers;
- **Carrying Capacity Calculator***:* a software package to assess long-term suitable stocking rates for the Mulga lands of south-west Queensland;
- **GrazeOn**: a pasture budgeting software package to assess short-term stocking rates on Mitchell grass;
- **Grasp: Pasture Production Calculator**: a software package to assess effects of El Niño and climate variability on native pastures in Northern Australia
- **Pasture Supply and Demand Calculator:** a software package to assess nutrition of beef cattle on speargrass in Central Queensland;
- **BB-SAFe**: **buy/breed-sell/agist/feed evaluator:** a farm business management spreadsheet to assess livestock options in managing the impacts of climate variability;
- **RISKHerd**: A research tool linking Grasp through Stream 3 results to the Herd-Econ and RiskFarm models to assess grazing and government policy options;
- **'Decision Trees'**: a producer workshop and process for comparing the likely outcome of options in farm business management; and
- **DroughtPlan brochure**: a short guide to products and their links with other decision support materials.

Background

Stream 4 of DroughtPlan aimed to develop a suite of decision support products to assist management of climatic risk in grazing systems. The criteria used to develop these products were based on five central concepts as follows:

- clients of decision support products form a diverse group from many viewpoints including: geographical, occupational (land-holders, educators, scientists, agribusiness), knowledge and skills, and values concerning attitude and aspiration;
- a range of products is needed to meet the above diversity;
- product development must integrate with existing projects, and in particular should integrate with adult education approaches being used in property management planning and participatory problem solving to identify local best practice;
- directions for product development must respond to needs identified by Streams 1 and 2 of DroughtPlan, and results from Streams 3 and 5 where appropriate; and
- commercialisation of products to ensure effective distribution, and on-going benefits from the project.

While this work stream of DroughtPlan has a focus on producing products (*outputs*), the single *outcome* measure of success is that producers and service providers use the decision support products as part of their processes in situation analysis and problem solving to identify improved management options. The aspiration and ability to integrate the new products from DroughtPlan with currently-used methods and products are thus key factors in achieving a successful outcome. The combination of outputs required from Stream 4 were:

- **a module for property management planning workshops** that is developed in collaboration with client groups, describes a set of producer workshop activities and provides the linkages to paper or computer-based decision support tools and case studies, and is used to explore better management of climate risk in grazing systems;
- **leaflet-based worksheets** which can introduce people to risk related concepts through either qualitative or simple quantitative analyses of an enterprise; and
- **computer-based tools** which allow more complex analyses through the use of biophysical models and farm business management spreadsheets to evaluate alternative strategies.

Approach

Product development occurred through a process of three stages: needs analysis, team building and product design, implementation with appropriate feedback from end users, and finally commercialisation, distribution and adequate evaluation. While the first two stages were completed within the two-year time frame of the DroughtPlan project, the third stage of commercialisation and distribution is an on-going activity by the Queensland Department of Primary Industries. Release of products is occurring during 1996–97.

A series of five major workshops were conducted over the life of the project. The first workshop (November 1993) set some overall directions for product development and commenced the process of integrating DroughtPlan with existing projects. The second workshop in May 1994 (Clewett 1994) concentrated on animal production modelling and set parameters for developments in Stream 3. The third workshop in September 1994 reviewed concepts in the development, application and evaluation of decision support (Stafford Smith & Clark 1994). The fourth workshop in November 1994 completed the needs analysis, defined the suite of DroughtPlan products and formed action plans for product development (Clewett & Stafford Smith 1995). The final workshop in August 1995 concentrated on familiarisation and training, methods of evaluation, and planning to complete the development of products.

Results

Some 24 issues were identified as being of importance to producers in managing climate variability (see Stream 1 on page 17). They were grouped into the following three main areas:

- financial management;
- strategic management options; and
- tactical management options.

Within these three areas, a suite of nine decision support products were developed that included a balance of workshops, printed materials and computer software to meet the diverse needs of clients. The suite of nine products is listed in Table 3 on page 40 with each product described in the subsequent sections. While each of these product is a stand-alone item, the following concept is a central finding of the DroughtPlan project.

> *Development of effective decision support requires an integrated balance of workshops, printed materials and software that has diversity to meet the various needs of end users but can be smoothly combined in a participatory problem solving workshop environment with producers.*

The integration of DroughtPlan products with those previously developed in other projects to create an overall suite of products that is useful to producers in managing climate variability is shown in Plate 1 (page 45). This suite of products is forming a substantial set of tools and processes to evaluate alternative management options in property management planning.

Development of products within DroughtPlan was greatly enhanced by integrating with a number of other projects so that real synergies were achieved. This led to a large and effective team of producers, extension staff and scientists involved with development (see key people involved in product descriptions in the following sections). A second major finding to emerge from the development of products in DroughtPlan was:

> *Projects seeking to develop effective decision support products require an integrative team approach that proactively involves people, collaborates across projects, and bridges the needs of producers, adult education processes in extension, and findings from research.*

This integrative framework to address management of climate risk was proposed to the Prime Minister's Science and Engineering Council Meeting on Sustainable Agriculture (Clewett *et al.* 1995). Projects integrating with the DroughtPlan team to develop products included:

- The joint National Landcare Program and Queensland Government South-West Strategy Project, *Appraising Safe Carrying Capacities for all Properties in South-West Queensland* (Johnston *et al*. 1996);
- Property Management Planning initiatives in Queensland, including Farm Business Management workshops for producers;
- The *National Drought Alert Project* (supported by National Climate Variability R&D Program) (Brook *et al*. 1996);
- *Evaluating the risk of pasture and land degradation in native pasture in Queensland* (a RIRDC-funded project) (Day *et al.* 1997);
- *Adaptive management for sustainability in Mitchell grass rangelands* (a National Landcare Program project) (Cobon & Pinington 1996);
- Sustainable Beef Production Systems Project (MRC-funded) (Clark 1996); and
- The RISKFARM project, *Analysing Drought Strategies to Enhance Farm Financial Viability*, by NSW Agriculture and the University of New England (supported by National Climate Variability R&D Program)

Evaluation

The original outcomes were to be dependant on consultations, but were to include:

- a property management planning activity for risk management, including appropriate decision-making aids;
- some paper-based activities;
- some spreadsheet-based activities; and
- a link between GRASP and RANGEPACK Herd-Econ.

These have all formally been met and exceeded, with the Stream running largely on time according to its five internal milestones. The final process of publication and distribution is taking a considerable period after the end of the main project, but this is partly because the process of evaluation of the individual products with producers (see following sections) was on-going making it difficult to finalise some products, and partly because the products were integrated with other processes which were running at their own speeds. Despite this, all products have or soon will be delivered to users, and their individual evaluations are described in the following sections.

Conclusions and future directions

Stream 4 of DroughtPlan has achieved its goals of needs analysis, integration, team formation and product development. However, the processes of commercialisation, distribution, evaluation and extension of products to other regions must continue. These processes are vital if DroughtPlan is to achieve significant outcomes in terms of gaining widespread adoption in the grazing industry of practices that are more effective in managing climate variability.

It is recommended that a second stage of DroughtPlan be formed to pursue the above.

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Table 3
DroughtPlan 'Decision Support Products' to enhance management of climate variability in grazing enterprises [a]

Product	Application	Key Authors [b]	Workshop/Printed/Software		
1. ***Assessing Your Livestock Management Options***: Property Management Planning workshop for producers	✠ ❖	Rus Tyler Damien O'Sullivan Ross Ballin Jim Herbert	✓	✓	
2. **Carrying Capacity Calculator** To assess long-term suitable stocking rates for the Mulga lands of SW Queensland	✪	Peter Johnston Greg Pinington Ian Beale		✓	✓
3. **GrazeOn:** Pasture Budgeting to assess short-term stocking rates on Mitchell grass	❖	Dave Cobon Greg Pinington		✓	✓
4. **Grasp: Pasture Production Calculator** to assess effects of ENSO and climate variability on North Australian native pastures	✪ ❖	Greg Pinington Jeff Clewett		✓	✓
5. **Pasture Supply and Demand Calculator** To assess cattle nutrition on spear grass in Central Qld	✪ ❖	Andrew Moore Richard Clark	✓	✓	✓
6. **BB-SAFe**: **buy/breed-sell/agist/ feed evaluator** Spreadsheet to assess drought tactics in grazing businesses	✠ ❖	Joseph Breen Mark Stafford Smith Damien O'Sullivan		✓	✓
7. **RISKHerd** Research tool linking Grasp, Stream 3, Herd-Econ and RiskFarm models to assess grazing and policy options	✠ ✪ ❖	Mark Stafford Smith Greg McKeon Dave Butler Pat Pepper Nick Milham		✓	✓
8. **'Decision Trees'** A process for comparing the likely outcome of options in farm business management	✠ ✪ ❖	Jim Gaffney	✓	✓	
9. **DroughtPlan brochure** A guide to products and links to other decision support materials		Col Paull Alan Peacock Jeff Clewett		✓	

a All products are in the process of publication and distribution and are for use by producers, agribusiness, educational institutions and professional agriculturalists, except RISKHerd which is a research tool.

b Producers and many other people in QDPI and CSIRO also contributed to developments.

Key to applications:

✠ Useful for economic analysis in farm business management

✪ Useful to assess strategic management decisions (long-term, 5–10 years)

❖ Useful to assess tactical management decisions (short-term, three months—two years)

Appendix 4A: Integrating the products

This appendix reproduces the draft leaflet (text, not layout) which summarises the positioning of the DroughtPlan products in relation to each other and other sources of decision support (see also Plate 1 on page 45).

TOOLS TO HELP GRAZIERS MANAGE FOR CLIMATIC VARIABILITY— THE DROUGHTPLAN PRODUCTS

The DroughtPlan project was a nationwide initiative aimed at developing, with graziers, profitable and sustainable strategies to manage for rainfall variability.

Introduction

Although the DroughtPlan project involved mainly staff in CSIRO and QDPI, agencies from South Australia, NSW, Northern Territory and Western Australia also contributed. At least 200 primary producers were involved formally, and many others informally.

Grazing managers in Australia have to cope with one of the world's most variable climates. However, producers must deal with many other risks in addition to the climatic one. Thus, information about climatic variability needs to be integrated into the whole context of farm decision-making and property management planning.

After consultation with producers, nine 'products' were produced to meet many of the high-priority information and training requests of producers. These can be grouped into three areas of management, and are briefly described below. The relationships between these products, and other related tools, are shown in Plate 1 (page 45).

Tactical Stock Management

There is always a need for sound short-term (three months to two years) decision-making. However, these decisions need to be familiar and made regularly, rather than being unpractised in the face of once-in-a-working-lifetime crises. The following products help with such decisions:

BB-SAFe (buy/breed-sell/agist/feed evaluator) allows users to compare the costs of different stock reduction and build-up options on their grazing businesses. The logic can be followed through on paper worksheets, or in a spreadsheet. The package gradually builds up the complexity of the assessment so that users can have confidence in the calculations. ***'Decision Tree'*** analysis (see Appendix E on page 65) is a complementary approach.

GrazeOn: Pasture Budgeting for Better Grazing Management. This package, initially developed for Mitchell grass areas, helps graziers to decide potential short-term stock numbers for periods of three months to three years. It is integrated with various existing recording activities, so that monitoring, prediction and feedback become part of normal management.

The ***Pasture Supply and Demand (PSD) Calculator*** effectively implements the Feeding Standards of Australia, for northern Australian conditions, to address producers' concerns about feed deficits during the dry season. It was developed initially for assessing nutrition of beef cattle on spear grass in central Queensland. A producer workshop is available.

The umbrella product for tactical decisions is a set of workshop module materials titled ***Assessing Livestock Management Options***, which can be used in Property Management Planning workshops. These materials aim to make the act of choosing between alternatives a familiar, regular event. The above products contribute in different ways to this process, either as modules in workshops, or as other means of training, or for use by individuals. They are supported by various case studies, and existing materials such as AUSTRALIAN RAINMAN and RANGEPACK Herd-Econ.

Strategic stock management

The longer term (five to ten years) aspects of decision-making affect what tactics are available at any given time. The following products assist with strategic stock management decisions:

The ***Carrying Capacity Calculator*** is a community-owned approach to assessing safe long-term stocking rates, pioneered in south-west Queensland. Robust scientific models of property productivity are linked to the manager's expectations using producers as consultants to their peers. DroughtPlan has helped develop this further and has evaluated its application in other regions.

The ***Carrying Capacity Calculator*** and other tools are assisted by the ***Grasp Pasture Production Calculator*** database which collates factors influencing production for all major pasture communities in Queensland, and native pastures in other parts of northern Australia. This tool provides a probabilistic assessment of how El Niño affects pasture production, to assist with decision-making in the same way that AUSTRALIAN RAINMAN is doing with rainfall. It can be used in workshops and on farms.

The extent to which the use of seasonal forecasts can improve enterprise viability has been unclear. The linked ***Grasp/Herd-Econ*** model is a research tool for developing relevant case studies about this question, which can then be used as examples in workshops and reference material.

Assessing Livestock Management Options workshop modules also incorporate strategic considerations. Producers repeatedly identified the importance of stocking rate policy; this may be expressed in many ways, but essentially they asked what stocking pressures and what strategies involving varying stock numbers over time were appropriate.

Financial management

The project has contributed to financial skills workshop development, and several of the products above are useful in these.

'Decision Tree' analysis helps people compare alternatives in dry years. It represents a process for comparing the likely financial outcomes of options in farm management involving uncertainty. As a motivational workshop activity, it establishes an analytical skill which can be used in addressing any question. It has also been implemented using a spreadsheet.

Industry members frequently expresses concern that taxation and other policy instruments do not meet their expressed intents of encouraging sustainable management. We therefore also developed ***RISKHerd*** which is a research tool to analyse the whole production system, including grazing and government policy options. This now requires further application to problems of concern to the grazing industries.

Conclusions

The above products, except ***RISKHerd,*** are suitable for use by graziers, agribusiness, professional agriculturists and educational institutions. All of them offer printed material. In order to make the decision process easier, computer software is available for all individual tools, except for ***'Decision Tree'*** analysis where a spreadsheet may be used.

Development of products was linked with existing activities in the above three areas. The boundaries between the topics are not fixed; tactics are limited by the strategies in place, strategies are only as good as the tactics used, and financial management should not be divorced from biology. The headings simply identify the main focus of each product.

Each management topic has been addressed using a range of approaches and possible solutions. Hence there are considerable overlaps in the functions of the different products. Often there is no 'correct' product, or sequence of products, that needs to be used to arrive at a sound management decision.

The evaluation of products with producers, and modification of them, will continue. Some tools developed for a particular region need to be adapted for use over a wider area.

For further information contact:

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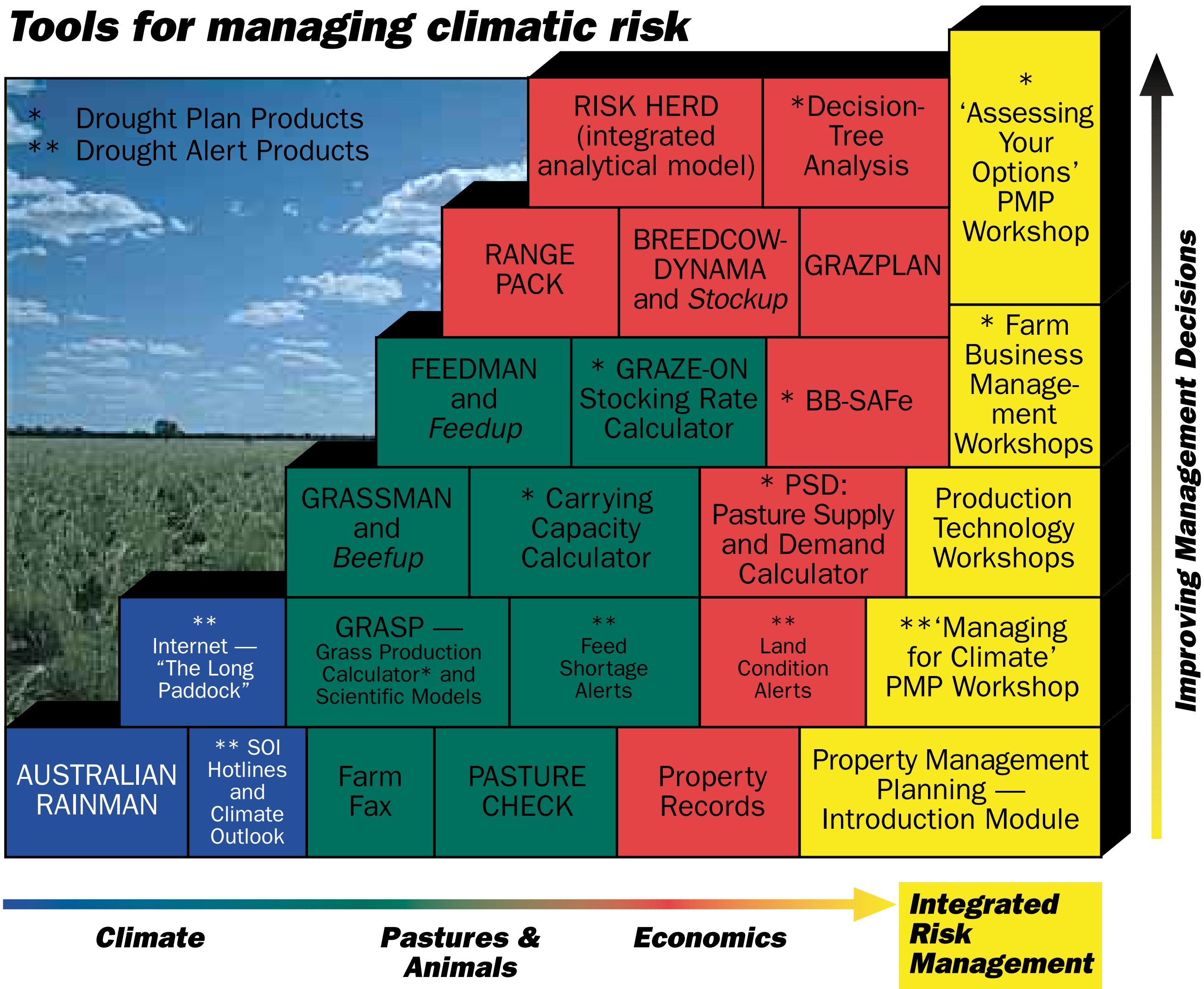
BB-SAFe	Damien O'Sullivan, Phone: (07) 160 0717
GrazeOn	David Cobon, Phone: (076) 658 4431
PSD Calculator	Andrew Moore, Phone: (08) 8303 8485 Richard Clark, Phone: (07) 4923 8100
Carrying Capacity Calculator	Peter Johnston, Phone: (076) 54 4210
GRASP Pasture Production Calculator	Jeff Clewett, Phone: (076) 88 1244
'Decision Trees'	Jim Gaffney, Phone: (076) 88 1257
GRASP/Herd-Econ & RISKHerd	Mark Stafford Smith, Phone: (08) 8950 0162 Nick Milham, Phone: (02) 6391 3613 Greg McKeon, Phone: (07) 3896 9548

Plate 1
Diagram of how DroughtPlan products integrate with others to form a suite of decision support tools for Property Management Planning



Appendix 4B: 'Assessing your livestock management options'—a 'Property Management Planning' workshop

RUSS TYLER, DAMIEN O'SULLIVAN, ROSS BALLIN, JIM HERBERT, COL PATON, DEL CHAPMAN, VICKI-LEE HANSEN, RUSS SARBOOROUGH, TRISH CAMERON, JEFF CLEWETT AND MARK STAFFORD SMITH

OBJECTIVE

To develop a module for a property management planning workshop that:

- is used to explore better management of climate risk in grazing systems;
- provides producers with a systematic approach to climate risk management;
- encourages producers to continuously assess their management options;
- describes a set of producer workshop activities, procedures and decision tools; and
- is developed with producers and integrates with existing extension operations.

SUMMARY

One of the main problems with management of climate variability is the lack of forward planning by many producers. Since a drought situation develops gradually, producers are often well into a drought situation before any planning is considered. Early planning can minimise the effect of drought. To date there has not been a structured procedure available to producers to help them plan for and during drought.

This workshop was developed to help producers plan to manage climatic risks, particularly drought. As drought should be considered a normal occurrence in the grazing industry, the package has been developed in such a way that producers can use it at any time to assess their management options.

The package has been developed jointly by DroughtPlan and Property Management Planning (PMP) staff in DPI and will be marketed to producers as part of an on-going property management planning workshop series. The workshop manual is being published by DPI as a loose-leaf binder containing facilitator's notes, fact-sheets, worksheets and a paddock log book. The workshop program provides linkages to the other products developed under the DroughtPlan and Drought Alert projects.

BACKGROUND

Producers have long been encouraged to plan their strategies for managing climate variability well in advance of any drought situation. Their argument against planning is that each drought is different and you can never predict when it will rain. To date there has not been a written format that producers can use or adapt to their own situation. Many decisions, particularly in times of drought, are made 'on the run' without considering all the options available.

The concept of developing a workshop module evolved from a general recognition of the need to improve both strategic and tactical approaches to drought within the over-all context of planning in property management. Initial titles for the workshop were *Stocking for Profit* and *Drought Management*. With the collaboration of additional PMP staff, it was decided to change the name to ***'Assessing your livestock management options'*** so that it could be used at any time in the broader context of managing climate variability rather than focusing on managing drought as a single issue.

APPROACH

The need for a systematic approach to drought planning was recognised by two groups, the DroughtPlan and PMP teams. It was decided to make a joint approach. Producers who had developed methodologies for managing drought were asked for suggestions and these suggestions were combined with those of the working group.

It is important and necessary to develop an approach for use in all seasons because it is often difficult to create enthusiasm among producers to improve management of climate variability in the absence of drought. Workshops were identified as the best introductory mechanism for the planning approaches, which producers needed to be encouraged to use frequently when making management decisions. Other criteria used to form the workshop program were that it could be:

- completed in one day;
- adjusted so that it was relevant to local needs and seasonal conditions;
- conducted with a focus on participatory problem solving;
- supported by a loose-leaf binder containing facilitator's notes and a set of fact and worksheets that could assist producers to evaluate options; and
- integrated with other PMP workshops.

RESULTS

The one-day ***Assessing your livestock management options*** workshop program begins with a series of exercises on goal setting and analysis of the current situation. It then cycles through discussion of possible options and problem solving by evaluating alternative options. The concluding section evaluates the progress producers may have made as regards (a) acquisition of improved knowledge and skills, and (b) an improved approach (attitude and aspirations) to managing climate variability. Further details of the program structure are shown in Figure 10 on page 49.

A loose-leafed workshop manual is being published by the Queensland Department of Primary Industries within the overall framework of PMP. It contains:

- *facilitator's notes,* describing desired outcomes and methods for conducting workshop sections;
- *fact-sheets* for each section of the workshop that give a brief outline of management options and information on pastures, animals and economics (example in Figure 11 on page 50);
- *worksheets* for producers to assess their current situation, assess alternative options and evaluate progress towards their goals (example in Figure 12 on page 51); and
- a *paddock log-book* for producers to use in their every day management for noting condition of feed, stock and water.

The work-sheet series provides an easy-to-use and step-wise method of working out the costs and returns of options such as dry season or drought feeding. These worksheets can be used by themselves, or in combination with a range of other decision support products, including software developed in DroughtPlan (eg. GrazeOn, GRASP, BB-SAFe and 'Decision Trees') and other products such as AUSTRALIAN RAINMAN, RANGEPACK, Drought Alert maps and spreadsheets used in Farm Business Management workshops.

Figure 10
Sample workshop program and content

	Section	Content	Facilitator's Note
1	Introduction	• Facilitator provides	
2	Goal Setting	• What type of animal do you want to produce, etc?	
		• Short-term/long-term decisions	Note 1
3	Define current situation	• Introduce workshop analysis sheets	
		• Exercise to assess 'What is your current situation?'	Note 2
4	Identify/discuss options	• Group discussion/brainstorm	
		• Personal experiences	
		• 'Pros & Cons' exercise	Note 3
6	Mapping and selecting options for current situation	• Using 'Decision Trees'	Note 4
7	Work through selected options	• How often do you need to reassess?	Note 5
		• What situation would cause you to reassess your decision	
		• Use of decision support tools to assess options (eg. GRASP, PSD Calculator, BB-SAFe)	Note 6
		• The feel of change ('Paradigm' video, exercise on change, discuss change)	
8	Evaluation and future directions	• Evaluate benefits of workshop regarding changes to knowledge, attitudes, skills, aspirations and practice	Note 7
		• Discuss other workshop opportunities	

List of Facilitator's Note Sheets

Note 1 Linkage to general PMP concepts

Note 2 Description and use of factsheets and worksheets

Note 3 Exercises to expand perceptions, focus on key issues

Note 4 Description and use of 'Decision Tree' methods to rank options

Note 5 Working through options on paper without software

Note 6 Description and use of software products to assess alternatives

Note 7 Linkage to evaluation methods to assess progress of producers

Facilitators will adjust exposure to the range of software products depending on needs and circumstances. Producing the workshop manual as a loose-ring binder has enabled facilitators to add or delete sections; the main modifications relate to geographic region, seasonal conditions, enterprise mix, and local topics of interest. While the contents of the ring binder will cover the basic resource materials required, it is likely that facilitators will add their own resource materials to suit local situations.

Figure 11
Sample factsheet for 'Assessing your livestock management options' workshop

FACTSHEET 5

Dry Season and Drought Feeding

Decide the aim of your feeding program. Is it to:

- Have cattle alive at the break in the season?
- Maintain weight of the cattle herd?
- Make a slight weight gain?

Which form of feeding will suit your program?

• **Maintenance:**	Start early in the season Long feeding period Low cost/hd/day—	 Cattle in fair condition. Plenty of paddock feed. Feed 150g of protein/hd/day. Protein meal. Blocks. Urea\Molasses roller drum. Urea\Salt dry licks.
• **Survival:**	Cattle poor Limited paddock feed Feed energy and protein—	 Grain. Fortified molasses. Whole cottonseed. Feed 1 to 3 kg/hd/day. High cost of feeding for a short time.
• **Consider:**	Labour and equipment, cost of feeding. Environmental effects on land while feeding is occurring. Your capacity to maintain the program.	

EVALUATION

The workshop has been evaluated by staff and producers with feedback being used to improve content, presentation and outcomes. Testing was initially confined to southern Queensland and will continue in this mode until the full range of DroughtPlan products have been published and evaluated within the context of the ***'Assessing your livestock management options'*** workshop.

CONCLUSIONS

The workshop methodology in extension has proven to be an effective mechanism because it enables a participatory problem-solving environment. It provides producers with the opportunity to build on their knowledge, skills and approach to managing climate variability.

Figure 12
Sample worksheet for 'Assessing your livestock management options' workshop

WORKSHEET 5

Dry Season and Drought Feeding

Ingredients	***$/Tonne***	***Mixture (kgs)***	***Costs $***
		Total wt:	**Total Cost:**

Total cost ÷ total kg
Cost/kg = $

Feeding Rate:	kg/hd/day	
Cost:	$/head/day (Feeding rate kg x cost/kg)	$
Estimated Days Feeding:		days
Estimated Total cost/hd:		$/hd

Linking development of the ***'Assessing your livestock management options'*** workshop to the PMP campaign will enable the workshop to be promoted within the PMP environment and to thus have an on-going life over a wide geographic area long after the DroughtPlan project has terminated. Similarly, embedding the other DroughtPlan tools within the ***'Assessing your livestock management options'*** workshop will ensure that they are properly directed and provided with on-going exposure.

Development of the workshop has also greatly helped to consolidate linkages between research and extension staff.

Appendix 4C: 'GrazeOn'—Pasture budgeting for better grazing management in Mitchell grasslands

DAVID COBON AND GREG PININGTON

OBJECTIVES

1. To develop a tactical grazing strategy with potential to produce ecological and economic sustainability in the Mitchell rangelands.
2. To develop a decision support package which uses a feed budgeting approach to estimate the capability of pastures to carry a sustainable level of grazing animals for up to three years.

SUMMARY

GrazeOn uses a feed budgeting approach to estimate the capability of Mitchell grasslands to run animals for defined but short (0–3 years) periods of time. Various concepts are embedded in GrazeOn's calculations to ensure that its recommendations are sustainable—the pasture monitoring program is designed so that pasture condition is controlled, grazing pressure incorporates domestic and non-domestic animals, spatial aspects of grazing behaviour are used to estimate utilisation of paddocks, and animal intake is adjusted for physiological state, animal size and pasture greenness. GrazeOn also allows users to be progressive and champion the use of technology such as climate and pasture growth forecasting by incorporating the outcomes into feed budgeting. This approach opens windows of opportunity for drought preparedness and risk reduction.

The GrazeOn package (Cobon & Pinington 1996) is produced in software and printed formats. Users without computers are guided through a series of calculations which estimate the carrying capacity of a paddock. The package is applicable to some 500 pastoralists on the Mitchell grasslands (nearly 20% of Queensland by area, running *ca*. 6M sheep). The use of GrazeOn should mean that the Mitchell grasslands will have lower domestic animal numbers with higher per head productivity (worth $3.9M) during dry seasons or when pasture condition is poor. During good seasons or when pastures are in good condition, greater animal numbers should permit higher production ($6.2M). GrazeOn should also enable pastoralists to restore and maintain good pasture condition. This would reduce the need for supplements and hence the cost of maintaining animal production during nutritional droughts ($5.8M). Good condition pastures also reduce the required destocking during drought, thus reducing the cost of restocking ($4.8M). GrazeOn could increase on-property income, particularly during good seasons.

Preliminary evaluation of GrazeOn among pastoralists indicates that it is practical, progressive and addresses important issues in the Mitchell grasslands—including pasture monitoring, total grazing pressure, drought preparation, feed budgeting and maintaining useful records. Although GrazeOn is currently designed for Mitchell grasslands, its principles are applicable to any arid or semi-arid areas with highly variable rainfall and defined periods of pasture growth, so it could be developed for rangelands nationwide.

BACKGROUND

Overstocking of Mitchell grass rangelands (32.8 m ha, 19% of Queensland) has led to vast areas (43%) being invaded by woody weeds or unpalatable pasture species. Set stocking of properties is the management principle commonly adopted which has clearly contributed to land degradation, loss of desirable species and reduced animal production. The high variability of mean annual rainfall (CV = 49%) predisposes the region to extreme inter-seasonal changes in forage production; such systems are most likely to be sustainable under adaptive stocking regimes.

GrazeOn is a grazing management strategy which determines a grazing capacity at the end of each growing season, based on a number of factors including the biomass of pasture. GrazeOn uses pasture biomass to calculate grazing capacity (hd ha^{-1}) but makes adjustments according to the quantity of pasture which is available to domestic stock. It also adjusts the grazing pressure by taking into account the condition of pasture, selection preference of stock for different pasture species, consumption of pasture by non-domestic stock, spatial distribution of grazing pressure and inter-seasonal forecasting of pasture growth.

GrazeOn is unique in Queensland because its assessment of grazing capacity takes into consideration a whole range of factors (mostly measured objectively) which make an important contribution to the capability of the resource to run domestic livestock without causing permanent degradation. The factors which make GrazeOn unique are:

- it adjusts carrying capacity according to the objective measurement of pasture condition;
- it provides a mechanism to adjust carrying capacity according to the area of paddocks which are under or over-utilised by grazing;
- it incorporates the use of climate and pasture growth forecasting (eg. SOI, Rainman, Grasp);
- it assesses the extent of non-domestic grazing pressure and adjusts carrying capacity accordingly;
- it makes allowance for the difference in palatability of pasture species, the changes that occur throughout the year and the selection preference for these species by animals;
- it considers the lesser pasture constituents, which at times make up the highest proportion of the diet and make a significant contribution to animal productivity;
- it makes adjustments to the quantities of pasture livestock eat in relation to physiological state, size and pasture greenness; and
- it has a mechanism to budget for pasture for more than one year which acts as a safety factor to allow for future drought and hence reduce risk.

METHODOLOGY

The expertise to develop GrazeOn came from other projects and from expert opinion. Current management practices of graziers in the Longreach and Julia Creek Mitchell grass areas have been compared against GrazeOn under conditions of climatic variability to assess the economic performance of the different strategies on the same properties. This was investigated to examine the economic benefits of implementing GrazeOn at the property level compared to current management. RANGEPACK Herd-Econ was used to examine these aspects; however, stock numbers were set according to four season types rather than an estimate of pasture biomass so the extent to which stock were traded may overestimate that which occurs in practice. A more accurate comparison between strategies could be made with the *Grasp/*Herd-Econ linked model.

DESCRIPTION OF PRODUCT

GrazeOn is produced in software and printed format. It allows pastoralists to estimate the capability of their pastures to run animals for periods up to three years, but more commonly from the end of each growing season for 12 months. Plate 2 (page 57) shows the screens through which the user is required to provide details on:

- paddock size and the proportion not utilised by domestic animals (Paddock Name Screen);
- the estimated population of kangaroos on the property (Property Details Screen);
- pasture biomass which is assessed by comparing photo standards with biomass in the paddocks (see light green screen on colour print);
- pasture condition which is assessed by measuring the frequency of Mitchell grass at permanent sites (see light green screen on colour print); and

- the grazing time in which all available pasture either disappears or is consumed by animals (see light green screen on colour print).

GrazeOn then calculates the number and stocking rate for each animal type (see light blue screen on colour print). In order to mix animal type and class together in the same paddock GrazeOn uses the concept of a Utilisation Index (see purple screen on colour print). The user enters the number of animals of the type that will run in that paddock until the Utilisation Index equals zero. GrazeOn then identifies the extent to which that paddock is under or overstocked by comparing the GrazeOn estimate to present stock numbers in the paddock, which are entered by the user (dark blue screen).

This process is completed paddock by paddock, then GrazeOn makes a stocking recommendation for each paddock and the whole property (see brown screen on colour print).

BENEFITS TO INDUSTRY

The figures in this section aim to provide realistic estimates of the economic benefits of applying GrazeOn across the Mitchell grasslands. The ecological benefits of improved pasture condition as a result of the implementation of pasture monitoring and lower stocking rates during drought are difficult to estimate in economic terms. They include the sustainability of production and effects on destocking in the face of drought.

1. GrazeOn will produce lower stocking rates (SR) in dry seasons and on pastures in poor condition. Increased productivity of sheep result from lower SR's and the relative economic benefits of reducing SR have been shown by Newman (unpublished data). Newman studied 12 properties in the Longreach area between 1985 and 1990 and found gross margin ($/hd) to increase with decreasing SR. The economic implications of reducing the SR by 0.3hd/ha (from 0.9 to 0.6 hd/ha) is a efficiency gain of $2.30 per head, equivalent to **$3.9m** (adult sheep on *Astrebla* in Queensland, 6m; 43% on poor condition *Astrebla*, 2.6m, Tothill & Gillies 1992, one-third reduction in sheep numbers to 1.7m; $2.30 x 1.7m = $3.9m) to the wool industry in the Mitchell grass areas of Queensland.

2. GrazeOn will produce higher stocking rates in good seasons and on pastures in good condition. The economic implications here are to maximise income per hectare. Pasture monitoring will show the effects that high SR's are having on pasture condition and changes can be implemented to suit management goals. If 20% of *Astrebla* pastures in Queensland were in good condition and stocking rates were increased by one-third then the actual extra income to the wool industry (considering the reduction in per head productivity) would be **$6.2m** per annum (based on Newman data and 6m adult sheep in *Astrebla* pasture in Queensland).

3. (a) The pasture monitoring in GrazeOn should enable pastoralists to manage in such a way that producers pastures in good condition. Good pasture condition may reduce the need to supplement during nutritional droughts (Cobon & Peart 1995) to maintain body condition for joining and wool growth (provision of urea on dry *Astrebla* pastures stops a reduction in wool growth). Supplementation of nitrogen (urea) during these times costs the industry in the Mitchell grasslands of Queensland over **$2m** per annum. These supplement costs could be saved by the industry if pastures were in good condition. The high quantity of *Astrebla* in pastures of good condition enables sheep to obtain adequate levels of nitrogen in the diet at a time when other pasture species are of poor quality. Nutritional droughts (N is the major limiting nutrient) occur in most years usually from September–December (when early storms are expected) especially in pastures in poorer condition. Furthermore, the reduction in wool growth (1 g clean wool day^{-1} for 12 weeks—see Lorimer 1981, Cobon & Peart 1995) and staple strength (5N/ktex; 0.5c kg^{-1} reduction—ABARE 1993) as a result of nutritional droughts and unsupplemented sheep (see Roberts 1989) are estimated to cost the wool industry in the *Astrebla* areas of Queensland **$3.7m and $80,000** yr^{-1} respectively.

b) Good pasture condition may reduce the extent to which producers need to destock during drought (Cobon & Peart 1995). For example, a producer might normally destock his wethers and old ewes (50% of flock) during drought. However, if pasture condition is good, a producer may need only destock old wethers and old ewes (10% of flock). If the net cost to destock then restock after drought averages $2/hd then the potential saving to the wool industry (*Astrebla* grasslands, Queensland) as a result of drought would be *ca.* **$4.8m**.

4. At the property level GrazeOn provides the potential to produce greater income compared to the management many are currently implementing. Using Herd-Econ to indicate the economic performance of the current management strategies, four properties in the Mitchell grasslands were compared to the performance generated by implementing GrazeOn on those properties. More than 40 years of climatic variability the GrazeOn strategy produced up to twice the average income of current management. The majority of this benefit occurs by making the most of opportunities generated by good seasons. This does not include changes in the per head production of animals nor take into consideration the ability to restock post-drought or destock pre-drought, which are important practical considerations in implementing any trading strategy. However, this indicates the potential for economic improvement using an active trading strategy.

APPLICATION

GrazeOn has been developed for the Mitchell grasslands although the principles on which it is based are applicable to most of Australia's rangelands, especially those pasture types which are reasonably resilient. It is a tactical management tool which may be applicable in all arid and semi-arid grasslands where climate is highly variable and has a major effect on pasture biomass and botanical composition. Specifically, GrazeOn has application for:

- pasture budgeting in rangeland systems;
- monitoring the condition and trend of pasture;
- demonstrating the impact kangaroos and horses have on available biomass and stocking rate;
- preparing pastoralists for drought;
- demonstrating the extent to which paddocks/properties are under or overstocked; and
- maintaining useful pasture and paddock records.

FUTURE

- Implement a promotion and marketing programme for GrazeOn in the Mitchell grasslands.
- Assess the potential for developing GrazeOn for other rangeland pasture communities.
- Develop GrazeOn for use in the channel country.

EVALUATION

Preliminary evaluation (see Section 5 on page 100 for details) among GrazeOn cooperators and Advisory Committee pastoralists suggests that GrazeOn:

- adopts a practical approach to feed budgeting;
- uses a practical method of assessing pasture biomass and frequency;
- represents a practical approach of incorporating total grazing pressure into management;
- adopts a useful approach of mixing stock type and class at the paddock level;
- represents a practical approach to controlling condition of pastures; and
- provides a mechanism for pastoralists to interpret climate forecasts, predict the onset of pasture deficits and adjust stock numbers prior to the onset of drought.

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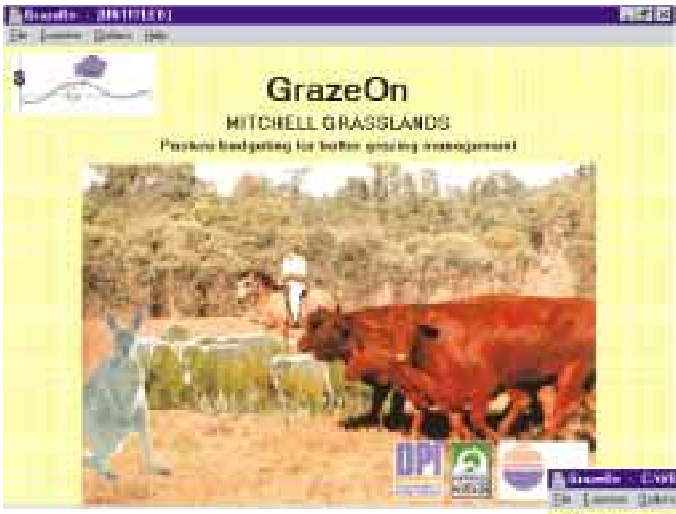
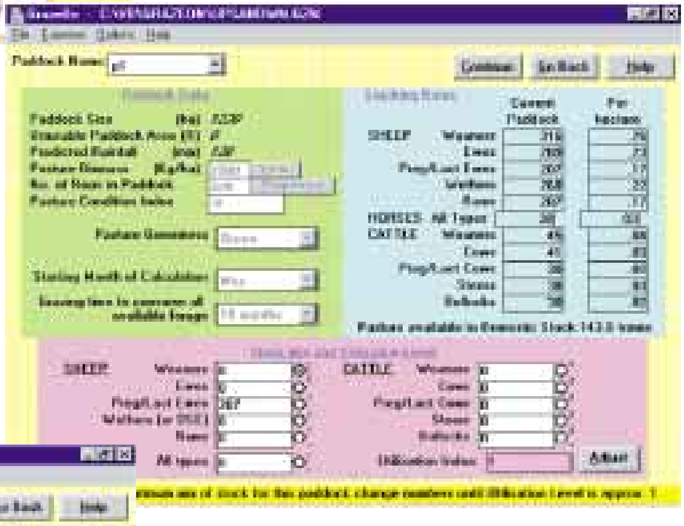
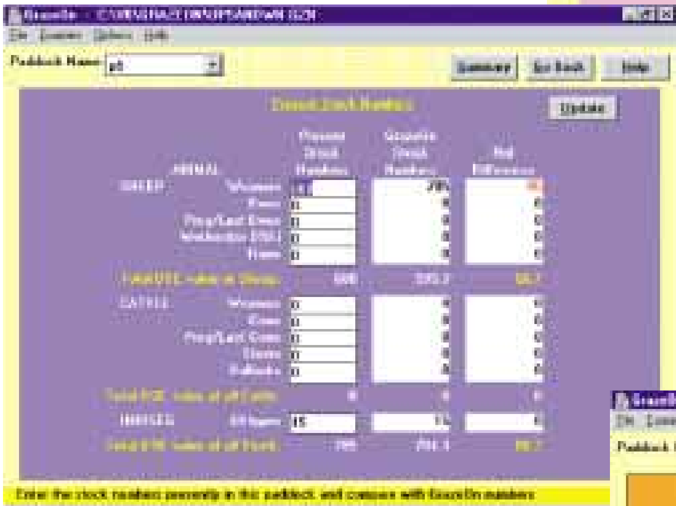
Plate 2
Screens from GrazeOn



- Total grazing pressure (horses, sheep, cattle and kangaroos)
- Property and paddock identification
- Attach identifying photos
- Data inputs for each paddock



- Assessing pasture attributes
- Assessing the forage demand by kangaroos
- Opportunity to manage for drought



- Stocking rates of cattle, sheep, horses
- Mixing cattle, sheep and horses in paddocks for optimum utilisation of pasture

- Recording numbers presently in paddocks
- Assessing the extent of under or over-grazing
- Help notes for each screen

Appendix 4D: BB-SAFe—buy/breed-sell/agist/feed evaluator

JOSEPH BREEN, MARK STAFFORD SMITH, DAMIEN O'SULLIVAN, ROSEMARY BUXTON

OBJECTIVE

To develop a spreadsheet-based tool which can:

- be used in workshops to promote understanding of the issues that need to be included in the economic comparison of different drought management tactics; and
- perhaps be used to carry out comparisons of different drought management strategies at an intermediate level of complexity and accuracy on-farm.

SUMMARY

BB-SAFe is an approach to learning about what costs should be systematically taken into account when comparing drought management tactics. Arising directly from producers' suggestions in late 1994, it was first programmed in Microsoft Excel™, then converted to paper worksheets. Its design is incremental to enhance learning, and it is intended mainly to be applied in workshops where users can be quickly led through the concepts by a facilitator. However, it has been tested mainly with individual producers so far: the response has generally been positive though there have been problems with setting up the program and, in the absence of the explanatory leaflet and paper worksheets, with grasping the purposes of the program. These problems should be overcome in workshops. Some surveyed producers had used the package for decision-making and several were interested in continued involvement. Minor development is needed in response to suggestions from these users, and thorough testing in Property Management Planning and Farm Business Management workshops will complete its evaluation.

The BB-SAFe spreadsheet program (Breen & Stafford Smith 1997) is intermediate in complexity between the *Assessing your livestock management options* workshop and the full use of a program like RANGEPACK Herd-Econ. It is also complementary to the 'Decision Trees' approach, which adds the sophistication of staging decision making to the single time-step concept of BB-SAFe. Thus these tools provide an integrated approach to a variety of levels of complexity in responding to assessing options for the management of stock numbers during and after drought.

BACKGROUND

Whilst it is strategically important to be operating at an appropriate level of stocking to handle climate variability, at some stage producers still face the tactical need to respond to a particular dry period. The producer survey of Stafford Smith (1994) catalogued the tactical options that can be used to alter stocking pressure during a drought, and, if necessary, during building back up afterwards. Different collaborators nominated different factors which helped them decide between these options, but one finding was that few people took account of all the implications. The Stream 4 workshop in November 1994 also reported the perceived need by producers for a better methodology for deciding between drought management tactics.

The major tactics in drought involve either reducing numbers or increasing feed availability. They can be catalogued as:

- selling stock;
- agisting stock;
- destroying surplus stock;
- transferring stock to a second property, if this is available;
- feeding stock in a central location (ie. on-property survival feedlot);
- feeding stock in the paddock with supplements; and
- feeding stock in the paddock with cut feed (eg. mulga), if available.

Under any scenario, there may be stock deaths above the normal level. After drought, therefore, numbers may need to be re-built, and this may occur by:

- breeding back up; and
- buying stock in.

BB-SAFe compares any one of these options, or a combined set, against a baseline of doing nothing. Each option has associated costs and benefits, such as the cost of feed or mustering or damage to the environment, and benefits of reduced stock deaths or sale income. These costs and benefits are systematically listed to ensure that decisions are based on all factors rather than an immediate short-term perception. Additionally, the cost of several options (eg. feeding and agistment) depends on how long the dry period lasts; it is possible to examine alternative periods for this to look at how different options respond to this aspect of climatic uncertainty.

APPROACH

The full comparison of all options, allowing for any combination, any time period and any sequence of staged decisions, is inevitably very complicated. If automated it would be unlikely to ever account for all factors that drive decision-making on a particular property. The goal for BB-SAFe was therefore agreed to be materials and a tool which could help to provide producers with the skill to do their own decision-making. Consultations suggested that products should be developed which could be used in a workshop (or perhaps as a self-help course) to lead people through the following steps:

1. Recognising that there are many options to choose from (ie. people often have their preferred ‘pet’ options and do not necessarily review other alternatives very often);
2. Realising that there is a systematic set of costs and benefits associated with alternative individual actions (eg. people may not correctly allow for build-up recovery costs, or may omit to factor in environmental costs);
3. Understanding how the riskiness of different prospective time periods of drought could affect alternative options (eg. feeding options are much more sensitive to increases in drought length than selling options);
4. Developing towards a more sophisticated combinatorial approach to options (ie. most people do not sell OR feed but use some combination); and
5. Using a spreadsheet to ease the pain of manual calculations if so desired (ie. we needed to make paper worksheets available, but match these to a spreadsheet version since some of the calculations, especially the build-up costs, are quite complex).

BB-SAFe: the buy/breed-sell/agist/feed evaluator—was therefore devised as a tool to assist staged learning, primarily in a workshop environment. It starts from a very simple comparison of options, gradually becoming more complex, detailed, and risk-conscious.

What BB-SAFe does not do: it does not allow for a stepped response to drought, since this is handled by the ‘Decision Trees’ approach; it is still simplified (eg. approximated build-up calculations, no breakdown of losses by class and age group) as the full complexity can be handled (for considerable extra training investment) by RANGEPACK Herd-Econ. It handles drought as a departure from the normal operation with feeding for survival only (ie. no changes in stock value through feed-lotting).

APPLICATION

BB-SAFe comprises three elements, plus documentation:

1. A set of paper worksheets, which allow a producer to enter values and total up the costs of different options. These worksheets cover:

1.1. A simple table of options by key cost categories, where a producer can enter the costs against each option of interest, and sum them up. This soon leads to questions like, “how can I assess the costs in each category?”

1.2. A more complex table of options against the items which make up each key cost (ie. expanding the calculations for each cost in the previous point), including allowing for an estimate of the length of drought and stock losses; the options are still exclusive—that is, only one is considered at a time. The full build-up calculations (which are quite complicated by hand) are avoided. This leads to questions like, “what if the time period or prices were different?” (this can be examined by recalculating the whole sheet again by hand), or “what if I want to do some combination of these options?”

These lead naturally to suggesting that the tedium of hand calculation can be replaced by doing it on the computer. However, for those who do not wish to do this, the basic messages of the key options, their key costs, and the idea of explicitly comparing them against each other, have already been communicated.

2. A set of Microsoft Excel™ spreadsheets, driven entirely by macros, which mimic the paper versions but allow considerably more complexity and ease of comparing options, providing the producer is comfortable with a computer. Through a menu, users can access six spreadsheets (Plate 3 on page 63, shows the opening screen and a report from option 2.6—see below):

2.1. A simple table which directly mimics the layout of 1.1; this can familiarise the user with the computer and confirm that calculations come out the same (or be skipped by experienced users). Each cell, column and row is annotated with help.

2.2. As 2.1, but with all entry controlled through a single point, to minimise the experience needed to run the spreadsheet.

2.3. A series of screens which mimic 1.2 in several steps; the user chooses an expected drought period, then enters the main costs and benefits, and the program calculates the outcomes. The build-up breed/buy options are handled fully and should be a major focus of exploration in a workshop, so that people understand and accept them. The program automatically selects the cheaper of the two options. The results should be close to those obtained by hand, but can be graphed and subjected to a simple sensitivity analysis.

2.4. Similar to 2.3 but introducing the idea of different scenarios by having three possible drought periods—best, worst and medium cases. 2.4 does three sets of 2.3, but allows options-by-scenarios to be plotted and assessed against each other, so the user can see how each option responds to this aspect of risk.

2.5. This spreadsheet allows the user to build a combined scenario, for example with some selling, some agistment, some feeding, to calculate a single net cost outcome for this combination. This can be saved for comparison against other combinations.

2.6. As for 2.5 but allowing three time periods; sensitivity analysis can be performed.

3. A short workshop facilitators’ manual, leading them through becoming familiar with BB-SAFe, and suggesting how the materials might be used in a workshop given different skill levels, time commitments, equipment availability. The notes also suggest evaluation questions.

Documentation includes an introductory leaflet outlining the idea, and a manual which lays out all the screens to be encountered in the computer spreadsheet version, with the functions of all the buttons, etc. This manual is also completely available on-line (with full search facilities, etc) through the Windows™ help facility from the spreadsheet itself. For users outside a workshop, the manual could provide a learning session by itself, although it may not be as rich an experience as carrying this out in a workshop.

EVALUATION

The product need was identified in November 1994; CSIRO produced a prototype set of sheets and programs by January 1995; some feedback from QDPI extension personnel resulted in changes with several updated versions of material released up to August 1995. A further version including facilitator's guide was circulated in September 1995. This documentation proposed the following evaluation questions:

To presenters: Are you happy to present these worksheets and program? Is it worth continuing to refine the product? if so, what improvements can you see which would help presentation and clarity? Did you get useful answers to the following questions to producers?

To producers: After this workshop exercise, can you identify the costs and benefits that you ought to be including in assessing any one particular drought management tactic (eg. selling—muster and transport costs, net sales proceeds, environmental benefits of fewer stock, reduced losses in remaining stock, costs of buying or breeding back up)? How will this workshop exercise change your approach to the next drought period? How can the worksheets or program be improved for you?

Press releases in southern Queensland identified 15 people who were interested in assessing the package and who were sent copies of the program and manual; 11 of these completed and returned a questionnaire (full report in O'Sullivan, 1996). The feedback was positive about the concept but often negative about the ease of installation and getting to understand why to use it. A key suggestion is that there could be a worked example for people to use to see the scope of the package. Some of these problems should be overcome when it is used in workshops as planned, and in conjunction with the paper worksheets, but no feedback is yet available from workshop conditions. Materials have now been handed over to QDPI to continue evaluation and appropriate marketing.

1. **Verification:** the calculations and approach were checked by economists in early 1995 and some errors caught. A misunderstanding about its applicability outside rangelands drought conditions (with survival feeding only) was cleared up and some terminology changed.
2. **Validation:** responses from agency personnel and individual producers indicate that the general information captured in it meets the originally-expressed need; responses have also been positive from agencies outside Queensland.
3. **Change in reaction:** three respondents wanted to participate in further testing of the package.
4. **Change in KASA:** six questionnaire respondents felt that they were able to identify the costs and benefits of different options after using the package, while three still found some confusing; four respondents used the package to contribute to real-life decision-making.
5. **Change in practice:** not yet tested

CONCLUSIONS

Proper workshop evaluation of the product has yet to occur, and it may still appear as too much black box. This is hard to determine until it is used properly. Meanwhile it has correctly and usefully captured the key elements of tactical decision-making options for the level of complexity at which it is aimed.

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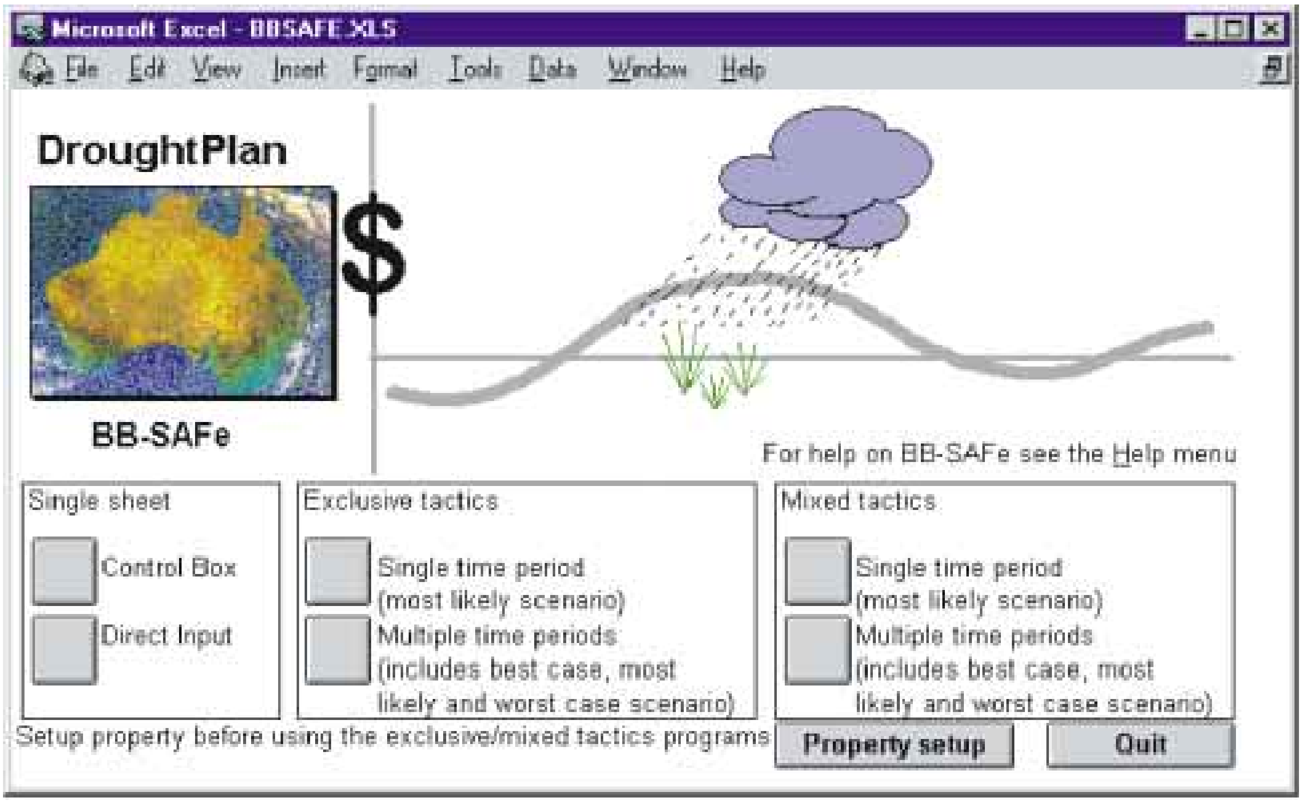
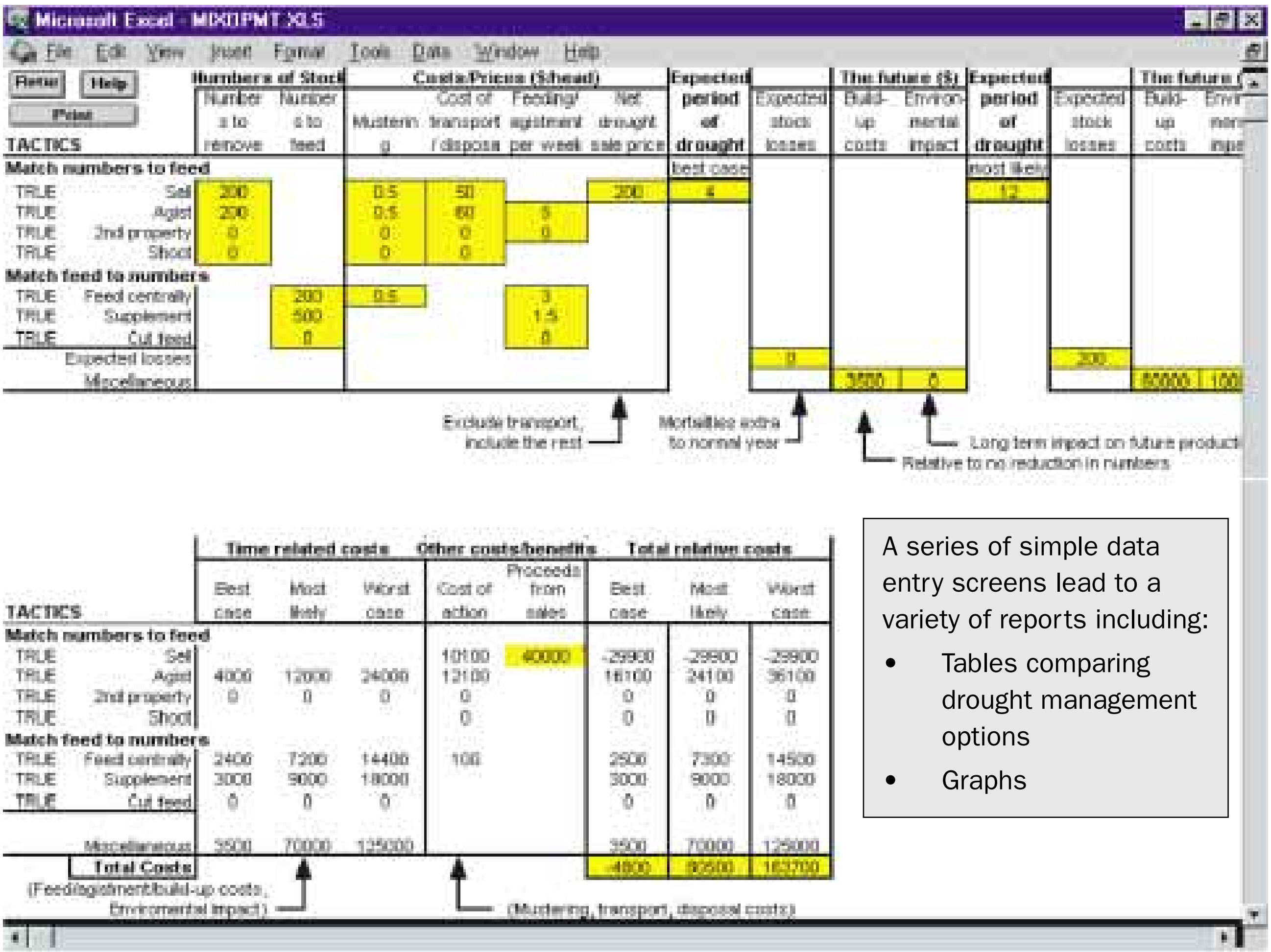
Plate 3

The BB-SAFe spreadsheet—(a) the opening menu screen, (b) a summary report for a complex mixed option.

(a)



(b)



Appendix 4E: 'Decision Trees'

JIM GAFFNEY

OBJECTIVE

Investigate the relevance and potential of 'Decision Trees' for drought-related decisions.

SUMMARY

The focus of Stream 4 of DroughtPlan was the development of a suite of products to meet the needs of clients when planning for, coping with, and recovering from drought. 'Decision Trees' are a key part of a formal procedure for decision making under uncertainty and their use was therefore evaluated by:

- a case study analysis of drought management strategies for a sheep property in the St George area of southern Queensland using solver routines in a spreadsheet to provide values for the 'Decision Tree';
- development of the 'Decision Tree' approach with producers at three farm business management workshops (Mongorilby, Eulo, and Wandoan) involving more than 40 primary producers;
- organising a one-day professional development workshop with Prof. Danny Samson for 50 extension staff in March 1996 in Toowoomba; and
- preparing a 'Decision Trees' brochure.

The 'Decision Tree' concept is useful at two levels:

- at the *conceptual* level, 'Decision Trees' concept helps bridge the communication gap between land users, extension officers, and researchers, by providing a common frame of reference; and
- at the *operational* level, the concept both ensures a comprehensive view of the decision problem, and helps provide a structure for an otherwise very confusing analysis.

The major limitations to the operational use of the approach are the need for prior knowledge of whole farm budgeting principles, probability concepts, computer spreadsheets, and animal performance under fluctuating feed supply conditions. The value of these findings depends on their successful extension to **all** concerned with better land use decisions in the face of high climate variability. Some early success in this regard occurred during the DroughtPlan project.

BACKGROUND

Anderson and Hardaker (1973) describe the problems of decision-making in relation to drought, and illustrate a systematic procedure of decision analysis for dealing with this difficult problem. The operational tool in decision analysis is the 'Decision Tree'. They provide a simple example to answer the question "*Things have turned dry. What should the grazier do?*", using the following systematic procedure to derive the 'Decision Tree' and corresponding pay-off table in Figure 13 on page 66:

1. List what could be done (ie. sell or feed);
2. List what could happen (ie. the drought could be long or short);
3. Draw 'Decision Tree' (to keep track of all the possible combinations); and
4. Budget the resulting 'pay-off' if each possible act-event combination does occur.

   The preferred act cannot yet be simply identified, because it depends on whether the drought is long or short. Hence the decision must be made on the basis of probabilities.

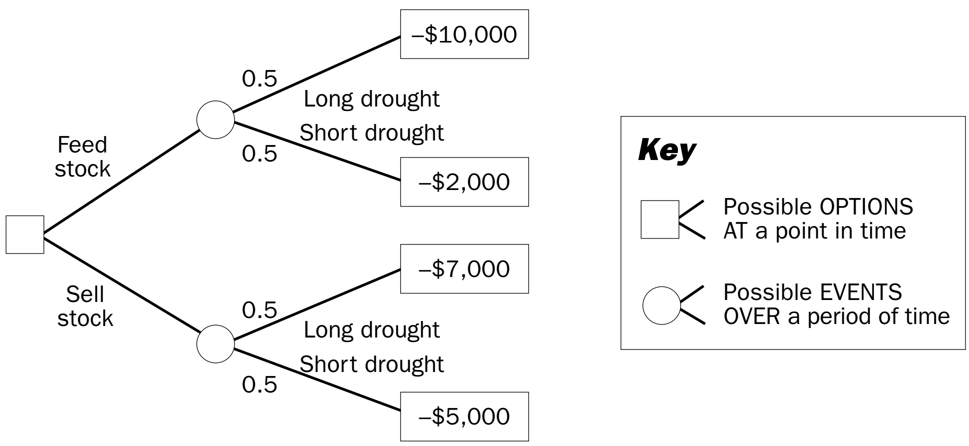
5. Assign the probabilities to the events, and hence to the pay-offs, and hence identify the highest expected pay-off, allowing for personal preference.

The vital role of increasingly reliable seasonal forecasting in helping establish good guesses about the future is especially clear with the help of the 'Decision Tree' framework. From a development and extension point of view, the issues about 'Decision Trees' were:

- How difficult is the concept to apply in realistic situations? (where there are many more alternatives, and many more drought length possibilities); and
- Why has the approach not been taken up already?

Figure 13

A simple 'Decision Tree' for a decision in drought, illustrating the key elements of a decision—the acts or options, the uncertain events, the pay-offs for each act-event combination, and the probabilities of the events. The associated Pay-Off Table highlights the distribution of pay-offs associated with each action—the ultimate basis for choosing what to do.



Pay-Off Table

		Actions	
Events	***Probabilities***	***Feed***	***Sell***
Long Drought	0.5	–$10,000	–$7,000
Short Drought	0.5	–$2,000	–$5,000

APPROACH AND RESULTS

A series of learning exercises were undertaken to achieve mastery of the concept in real world decision settings. Decision problems relating to drought fall into strategic and tactical categories (post-drought recovery being part of the tactical problem), both of which needed to be met in developing decision support products for use by graziers. The strategic issue is the long-term enterprise mix; for the grazier this relates to the classes and numbers of animals run. It amounts to a pre-drought planning problem where drought is but one of several seasonal outcomes that the grazier must anticipate. The tactical planning problem arises where a drought appears imminent, or has set in. The question is "given the current situation, what is the next best move?"

Modelling the strategic decision problem

Previous work had been done using tree diagrams to model the risky annual patterns of seasonal outcomes, thereby providing an exhaustive set of 'what if' scenarios in which to evaluate alternative farming systems. The choices (the alternative farming systems) and the possible seasonal outcomes (the events) were readily recast in the 'Decision Tree' format to provide a framework for the evaluation of alternative grazing management strategies under climatic risk (cf. the example in Halter & Dean 1971). A real world application of this approach was attempted in partnership with a St George grazier but not completed because of other commitments. Points learned included:

- The intended *tactical* adjustments (when surpluses or deficits in the pasture feed supply arise) are constrained by the stocking rate *strategies*—that is, there are preliminary tactical choices contained in well-formulated strategic plans.
- The model can easily be expanded to more descriptive climate scenarios using composites of half years, or seasons, with varying numbers of events in each case.

Modelling the tactical decision problem

Tactical issues were initially raised and discussed in a workshop on drought with graziers at Monogorilby. Next, Anderson and Hardaker's (1973) format was translated into a sequence of operational steps using the 'Decision Tree' framework in consultation with extension officer Andrew Drysdale, who is also a former grazier with three years of drought survival under his belt. The approach was tested on butcher's paper with a group of Eulo graziers (Drysdale & Gaffney 1994). They found no difficulty with the method but regarded the example as simplistic. Figure 14 on page 68 shows the resulting tree which was presented in a paper to a producers' conference in Wandoan.

The steps to systematic tactical decision making in drought are:

1. Describe the average out-of-drought state of the property and estimate the annual operating profit (this makes clear the out-of-drought state the decision maker is aiming to return to, necessary for determining the least cost approach to coping with drought);
2. Estimate the maximum likely period for which the drought could persist;
3. List the possible earlier points in time at which the drought could break;
4. List the adjustment actions that could be taken ***now*** to cope with the anticipated short-fall in feed supply (ie. do nothing, sell, feed, agist, etc, made specific to classes and numbers);
5. List further adjustment actions that could be taken at later points in time;
6. For each point in time at which the drought could break, list the post-drought options for restoring the property to its out-of-drought state;
7. Use a 'Decision Tree' to integrate all these elements of the decision problem;
8. Evaluate the pay-offs for each alternative as the profit foregone due to the drought, or as the total costs from now to the point of eventual return to the out-of-drought state; and
9. Assign probabilities and solve for the option with the least expected cost.

Pursuing realistic analysis with the computer

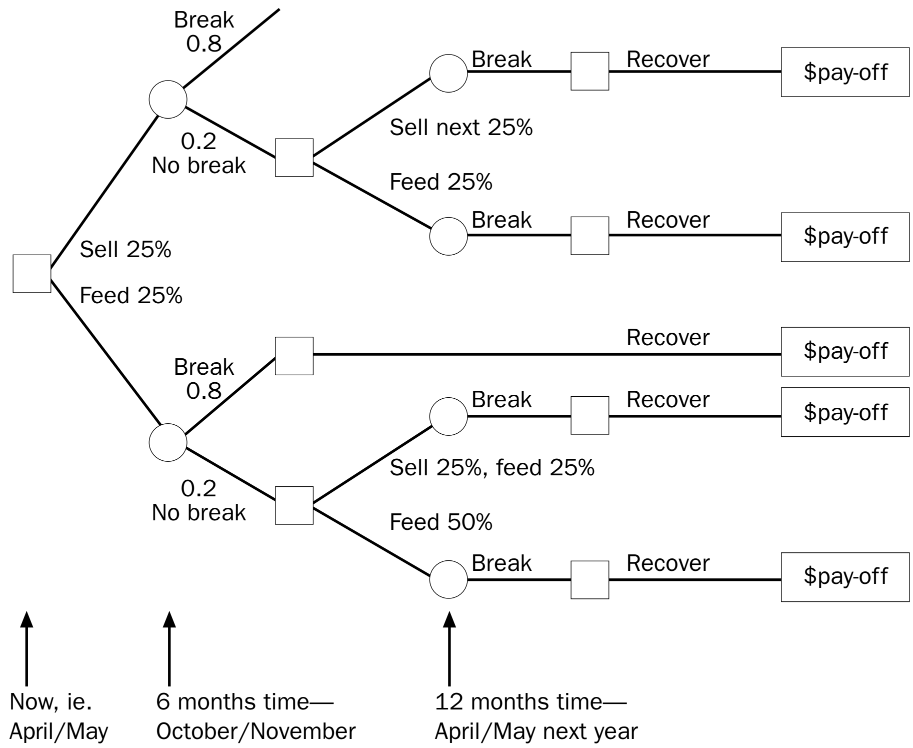
Both the Eulo and Wandoan learning exercises were concerned with whole farm analyses of the decision settings. However, the options and events considered were kept very simple. To include realistic numbers of options and the whole farm setting in an economic analysis means a large number of calculations, which requires a computer. Using Microsoft Excel™ with its 'Solver' option or Kennedy's (1986) GPDP (general purpose dynamic programming) package, the three possible forms of computer aided assistance for solving realistic 'Decision Tree' problems were:

- the discrete, stochastic formulation of the linear programming model;
- the recursive optimisation used in dynamic programming formulations; and
- multiple discrete whole farm budgeting methods using a computer spreadsheet.

All three were tested, aiming at the clients' need for a quick yet comprehensive analysis of decision problems in drought. A simple tactical decision model using Solver in Excel™ worked well and was fast, making it an excellent tool for workshop learning on tactical decision making. However, a model of a bigger system was very slow (each run of the large whole farm model took two hours) rendering it useless as an operational tool. A simple version of Toft and O'Hanlon's (1979) DP model was built and successfully run using Kennedy's (1986) GPDP package; limited time meant this could not be developed further. Finally, the tactical decision problem arising after a disappointing summer for a farming and grazing property at St George was analysed using whole farm budgeting; 32 options were analysed in Excel™, each spanning two years (drought and first post-drought years), with each year feasibility-tested for total feed supplied and total feed demanded. The procedure was simple but tedious (see full report for diagram). The key finding was that it was impossible to get either realistic estimates of feed supplies for different climatic scenarios, or, once gained, how the livestock performance would relate to these.

Figure 14

The tactical 'Decision Tree' used at Wandoan for combinations of selling and feeding over time. It assumes a probability of 0.8 that the drought will break in six months, and it is sure to at 12 months. Note also (i) the diagram highlights the fact that in order to decide what to do NOW, we must look ahead to the consequences of the possible actions, events, reactions, and further events; and (ii) this model is flawed in omitting the "*drought breaks any day now*" event—always a possibility, and an important reason why graziers delay instigating significant adjustment measures as the drought unfolds. (Key as for Figure 13.)



EVALUATION AND EXTENSION IMPLICATIONS

How easily is the process made operational? Not very! Even to get to the level of application achieved during the project required competency with a wide range of techniques—this probably explains why the approach has failed to be adopted earlier. Additional findings were:

- the widespread inability among extension and research scientists to articulate the farm business management decision problems that their clients face makes it difficult to focus their professional skills on clients' needs (eg. as acknowledged by Stone 1995); 'Decision Trees' can act as a unifying communications framework to reduce this problem;
- despite the operational short falls, the concept of the 'Decision Tree' is useful for providing a comprehensive framework for decision problems associated with drought. In the process it highlights the role of biological research in providing the data to estimate the pay-offs, and the role of probabilities in influencing the final choice that is made. This, in turn, helps to determine the value of seasonal forecast information; and
- much better information is needed about the effects of feed supply on animal performance.

An extension programme was undertaken to help train scientists and extension officers in the concepts, culminating in a one day professional development and training seminar on decision analysis conducted by Prof. Danny Samson from the University of Melbourne in March 1996 for 50 officers and a few producers. Over a five month period prior to the seminar participants were mailed a series of private study exercises with model answers, as a stepwise introduction to the concepts of decision analysis and 'Decision Trees', to maximise the benefit of the seminar itself. Very favourable feedback was received both in respect of the Seminar, and of the private study exercises. Several drought extension officers are now incorporating 'Decision Tree' modelling in their drought planning workshops. A brochure summarising the value and relevance of the 'Decision Tree' concept for drought decision-making was prepared and circulated (Plate 4 on page 71). The 'Decision Trees' brochure and the above training program will contribute to the on-going benefits that producers receive from the DroughtPlan project.

CONCLUSIONS AND RECOMMENDATION

Uncertainty and complexity are essential characteristics of decisions related to drought. The 'Decision Tree' process helps with both. It empowers the user with the skill to "know what do you do when you don't know what to do". Operational limitations remain but could be addressed.

Recommendation: a follow-up extension programme is warranted to accelerate understanding of the 'Decision Tree' process by all those concerned with better land use in the face of high climate variability. The programme would be highly focused on risk management, and would employ adult/action learning principles to maximise its chance of success. It would alert people to the fact that simple methods can solve very complex problems. It would be readily accepted because none of the steps involved is beyond a practicing farmer, extension officer or research scientist.

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Plate 4
The 'Decision Trees' brochure, front cover

Keeping on top of drought decisions

Summer's been dry, autumn's still dry.
What should I do?
Which way should I go?
⇔ *Do nothing*
⇨ *Feed stock*
⇳ *Agist*
⇦ *Sell stock*
Will it rain soon? or are we in for a long drought? What if ...? What if...?

Worry, and more worry, leads to stress

Making decisions is stressful when
- you have a lot of choices
- you don't know what will happen
- the result can mean personal disaster.

You can reduce stress by taking a cool systematic approach —list the overall problems and handle each one in turn.

Use the 'decision tree'.

Appendix 4F: Pasture Supply and Demand (PSD) Calculator

ANDREW MOORE AND RICHARD CLARK

OBJECTIVES

The aim was to develop and evaluate a tool that could assist producers to manage the nutrition of cattle grazing native black spear grass pastures in the highly variable climatic region of Central Queensland, and thus provide a medium for producers to:

- learn about the principles of matching monthly pasture supply and demand; and
- understand and use the principle of first limiting factors in nutrition to improve production.

SUMMARY

The Pasture Supply and Demand (PSD) Calculator is a software package for managing the nutrition of beef cattle grazing black speargrass pastures, which was developed in response to needs expressed by producers in Central Queensland *Local Best Practice* groups. The PSD Calculator is a simple-to-use Windows™ application that requires the following inputs: monthly rainfall, nutrient content and digestibility of pasture in a paddock, cattle type, stocking rates, weaning weights, liveweight change and the mating and weaning periods. Computations by the Calculator out can be separated into those which deal with pasture supply of energy, crude protein and phosphorus, and those concerned with demand by livestock for these nutrients. Months when energy, protein or phosphorus become most limiting to livestock nutrition are shown graphically.

The PSD Calculator has been formally evaluated with two groups (25 producers). Producers have shown great interest in the Calculator, which has stimulated the measurement of the inputs needed to make the outputs more meaningful. This means a change in practice—from little measurement of animal growth rates, rainfall, pasture digestibility and major nutrient supply to a measurement of all of these at a paddock scale. The Calculator has stimulated awareness and understanding of the relationship between pasture quality and quantity in meeting herd nutrient demands.

BACKGROUND

Knowledge of perceived local best practice for managing the nutrition of cattle grazing native black spear grass pastures in the Central Queensland region was documented in 1992. Limits to these practices arose from poor understanding of key principles about pasture and cattle nutrient supply and demand. The PSD Calculator was developed because producers in five Local Best Practice groups asked for a tool to assist in optimising the management of pastures and nutrition in the context of seasonal rainfall expectations and predictions. There was concern about:

- Over-use of pasture at critical times in pasture growth stages because of a lack of understanding of herd energy demands and pasture seasonal digestible energy supplies (eg. the relationship between new [digestible] growth and old [indigestible] grass growth); and
- Wasteful 'shotgun' administration of nutrient supplements because of a lack of understanding of the principles of first limiting factors in nutrient supplementation (eg. the impact of the degree of pasture digestibility on the total nutrient intake and demand).

APPROACH

The following process was used to develop the PSD Calculator:

- evaluate the needs of producers;

- design and develop software in response to the above needs;
- evaluate the software against the above needs; and
- commercialise software to ensure effective distribution.

The first step identified the need for a software tool that would be useful in a participatory problem solving context to help producers understand and develop skills in managing the nutrition of beef cattle in a variable climate. Producers with properties on black spear grass were chosen as the test case for this study. The main criteria for the software identified in the second step were: simplicity of operation, challenging to knowledge and skills but understandable, use of input data that are readily available to producers, graphical output, and use of Windows™.

RESULTS

The resulting software is the PSD Calculator, a simple-to-use Windows™ application (see Plate 5 on page 77, and Moore & Clark 1997). Inputs to the program and its computations can be separated into those which deal with pasture supply of energy, crude protein and phosphorus, and those concerned with demand by livestock for these nutrients. The procedure is as follows:

	Supply Side	***Demand Side***
User inputs	On the first screen (see Plate 5 on page 77), users enter monthly rainfalls and the average dry matter digestibility, nitrogen and phosphorus content of the pasture in a paddock.	The second screen allows users to choose a cattle breed and enterprise (breeder cows or steers) and to enter cattle stocking rates, weaning weights, the mating and weaning periods and the rates of liveweight change of the stock in each month.
Program computations	The rainfall figures are used to estimate the growth of pasture in each month (this part of the Calculator should be set up by an expert user before it is used in a workshop). Then the monthly pasture growth and quality information is used to estimate the amounts of metabolisable energy (M.E.), crude protein and phosphorus in the paddock. Nutrients in newly-grown pasture and nutrients in carryover pasture are shown separately.	From the management and weight change information, the Calculator builds a herd age structure in each month and works out the weight and weight change of each class of animals. M.E and protein requirements for each class of animals are then estimated as a linear function of weight change, but the slope and intercept of the line are determined by the digestibility of the pasture, the age and weight of the animals and whether they are gaining or losing weight. The animals' requirements for phosphorus are computed as a simple function of weight and weight change. In this context, the *requirement* for a nutrient is the amount needed to sustain the animals at the specified rate of weight change. Once the requirements per head have been computed, they are summed over all animal classes to arrive at the total requirement of the herd in the paddock.

At this point the monthly pasture supply and the monthly animal demand can be expressed in the same units (MJ ha^{-1} $month^{-1}$ for energy, kg ha^{-1} $month^{-1}$ for N and P) and are graphed together. The PSD Calculator shows (diagrammatically, see Plate 5) how the monthly energy supply matches demand. If the monthly demand exceeds 20% of the monthly supply, the demand curve on the screen rises above the supply graphs. The Calculator also shows the months when protein or phosphorus becomes the factor which most limits the nutrition of the stock (see Plate 5).

We emphasise that the various assumptions and approximations in the computations mean that the outputs of the PSD Calculator are approximate. The program highlights *patterns* of supply and demand, not so much the absolute values. Coefficients are read in as needed from a database developed from calculations carried out with an animal production model based on the Australian feeding standard (SCA 1990, Freer *et al*. 1997). The relative scaling of the supply and demand axes can be set to the locally-recommended 'safe' level. Of course, if the annual utilisation rate is (say) 20%, some monthly utilisations will be higher and some will be lower than this value.

The Calculator can be used as a learning and planning tool in the following ways:

- to examine the effects of management changes (eg. altering stocking rate or moving from uncontrolled to controlled mating) on pasture supply and demand;
- to show how month-to-month utilisation rate is likely to shift in years with different rainfall, and the nutritional consequences of this (eg. rainfall values for the 1-in-10 year drought year in an area might be entered and compared with the average year); and
- to estimate future possibilities (eg. anticipated future rainfall can entered as the input and thus the Calculator can be used in combination with seasonal forecasting).

The benefits of the PSD Calculator are that it:

- enables energy supply and demand to be calculated and understood;
- determines when nitrogen and phosphorus become the first limiting factors in cattle nutrition (thus showing when supplementation should be considered); and
- stimulates more accurate measurement of pasture amounts and quality. This will lead to better outputs from the program and permit fine-tuning of management practices.

EVALUATION

The program was evaluated by two groups (25 producers) in Central Queensland within participatory problem solving workshops. Contributions to **k**nowledge, **a**ttitudes, **s**kills, **a**spirations (KASA) and change of practice were assessed with the following results.

Contributions to **knowledge** were assessed through:

- understanding of principles of matching pasture nutrient supply and demand to achieve optimum cattle production on a paddock basis; and
- understanding and utilisation of principles of first limiting factors in nutrition on a paddock basis.

Changes in **attitude** were assessed via questions and answers regarding interest in DSS tools and the principles of good nutrition management. Some results were:

> **Question:** Did you find package useful? Why?
>
> **Answers:** Like the presentation; taught me a lot. I didn't know about pastures and nutrition; easy to use; stimulates thinking.

Results for changes in the **skills** related to managing paddock nutrition for optimum production were:

> **Question:** How will you use this package to improve supplementary feeding in your paddocks?
>
> **Answers:** I'll measure the cattle weights and pasture digestibility and enter these into package. I'll calculate stocking rates and feed first limiting nutrients.
>
> **Question:** How will you use this package to improve matching pasture demand to supply?
>
> **Answer:** I'll enter accurate rainfall figures and see how the computer calculates supply and demand and use this information to aid decisions.

Questions on **aspirations** related to a desire to: learn more about principles of optimum nutrition; measure appropriate inputs; and, monitor performance. For example:

> **Question:** What things has this package given you to start measuring?
>
> **Answer:** I'll measure all the inputs required (rainfall, grass data and cattle data).
>
> **Question:** What improvements would you suggest for the package?
>
> **Answer:** Include other minerals.

Some answers regarding **change in practice** were: *Measure performance*; *Input more accurate data into DSS; Achieve optimum nutrition by managing utilisation levels;* and, *First identify limiting factors in nutrition*.

CONCLUSIONS

The PSD Calculator was developed to meet a need established by the use of the Local Best Practices technique in five producer groups, and was developed to be used with the action-learning process. This process is specifically designed to focus on practices and improving them, thus enabling people to formulate questions which improve the use of knowledge.

Research (Clark 1996) has shown that the lack of understanding of key principles underpinning the management of grazing systems can be the major constraint to appreciating the need to improve practices. By using the powerful learning tool of simulation, the PSD Calculator can enable understanding of key principles of 'first limiting factors' and 'nutrient supply and demand' and can catalyse a change in numerous grazing management practices.

The PSD Calculator enabled people to learn about nutrition by simulating their grazing situation. The simulator prompted the operator to answer insightful questions about their own situation and enabled people to learn in a non-threatening environment. The understanding of key principles of pasture and animal management is enabling because whole herd and whole farm pasture management is based on an understanding of these key principles. The influence of rainfall on pasture quantity and quality was made conspicuous by the PSD Calculator. It enabled people to appreciate the need for early decision-making to prevent over-utilisation of pasture.

This type of tool is valuable if linked to an on-going learning process like Participatory Problem Solving or action learning or in workshops focused on grazing management.

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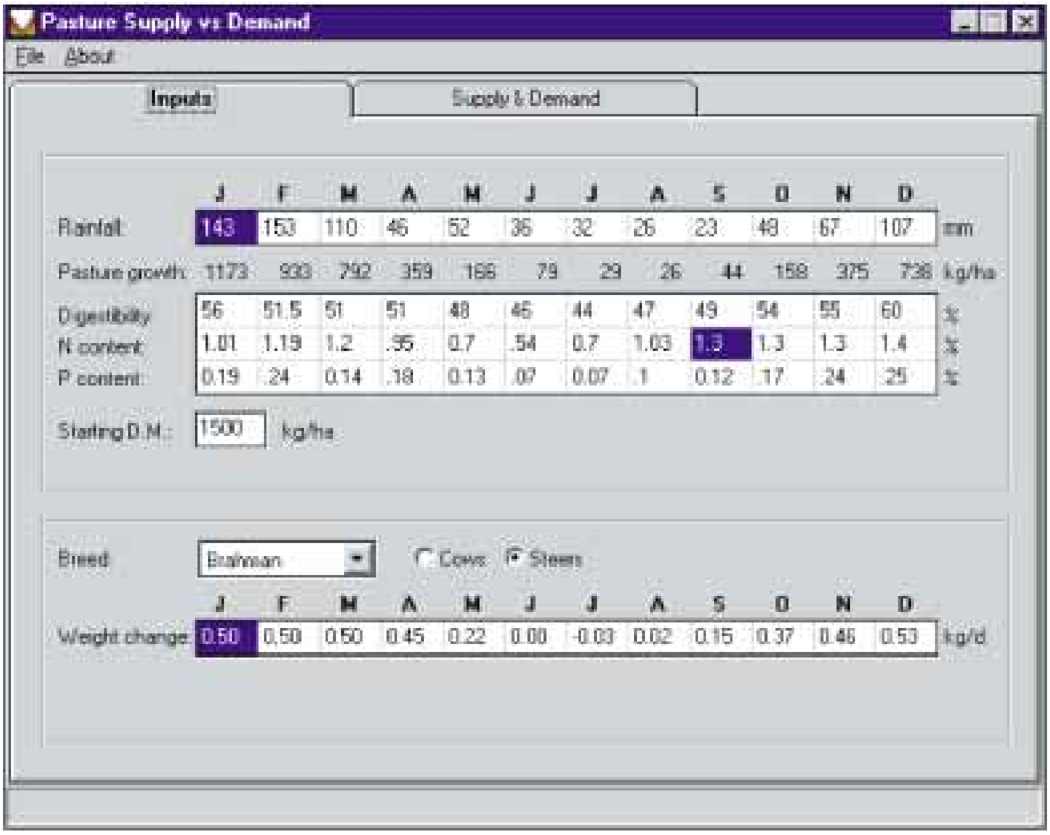
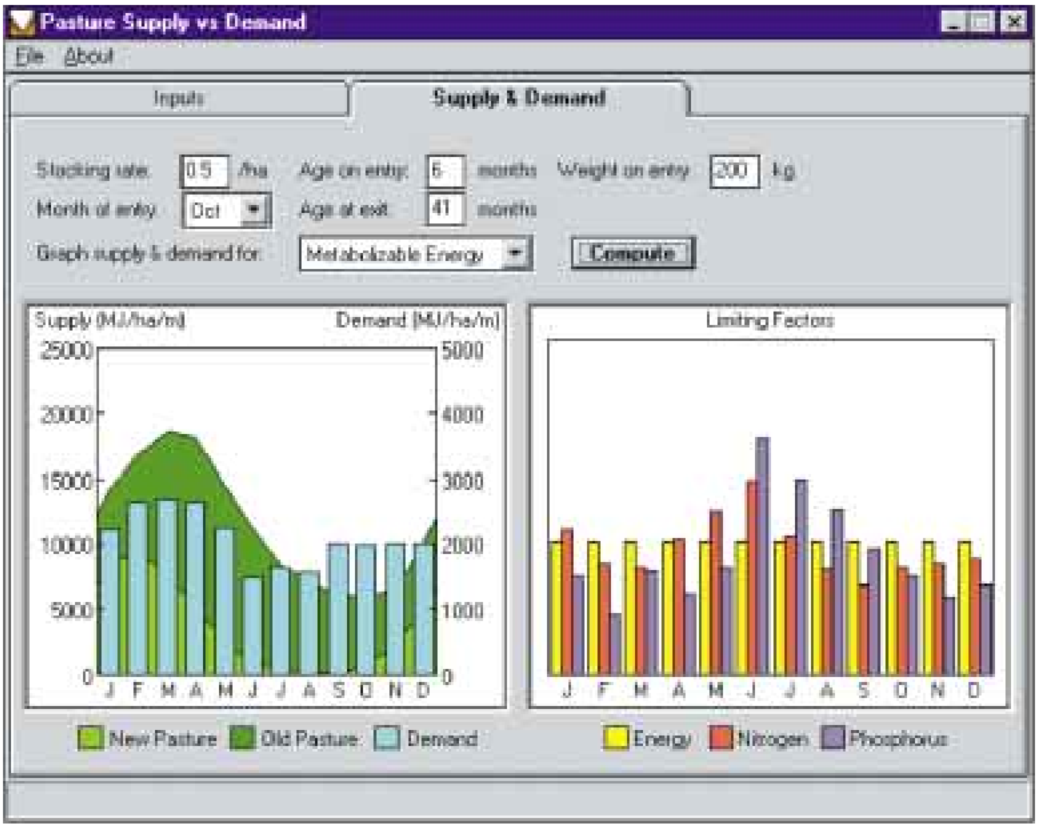
Plate 5
The two main screens from the Pasture Supply and Demand Calculator



- Users enter rainfall, pasture growth and quality, and cattle specifications



- Pasture nutrient supply and cattle nutrient requirements are computed for each month

Appendix 4G: 'Safe' Carrying Capacity Calculator

PETER JOHNSTON, GREG PININGTON, IAN BEALE AND JEFF CLEWETT

OBJECTIVES

- To package a method for the estimation of 'safe' long term carrying capacities based on ecological principles (the 'Safe' Carrying Capacity Calculator).
- To promote the concept of 'safe' long term carrying capacities and the use of the 'Safe' Carrying Capacity Calculator by land managers and land administrators to assist in decision making at the property and paddock level.

SUMMARY

An ecological approach to estimating 'safe' long term carrying capacities for individual paddocks and properties in south-west Queensland was packaged in a variety of forms (computer and paper-based) for use by land managers and land administrators. Components of the 'Safe' Carrying Capacity Calculator include detailed land type maps of the property, surveys of land condition, and a computer software package to estimate long term forage production and 'safe' livestock numbers.

The aim of the 'Safe' Carrying Capacity Calculator was to remove the subjectivity from carrying capacity determinations and enhance the understanding of the capabilities of the grazing resource in the region. It is anticipated that improved land management practices may follow as a result of more informed decision making.

To date 35 properties have been exposed to the Calculator (7% of properties in the Bulloo, Murweh, Paroo, Quilpie and Tambo shires) covering 10,321 km^2 (5% of the above shires) of south-west Queensland. Despite initial scepticism and fear of Government regulation, graziers exposed to the Calculator have found it valuable, enhancing their knowledge of their natural resource base and supporting their stocking decisions. Application and development of the Calculator within south-west Queensland is continuing in a joint NLP and Queensland Government project '*Appraising Safe Carrying Capacities for all Properties in South-West Queensland*'.

This component of DroughtPlan clearly demonstrates how the project has increased the effectiveness of its outcomes by integrating with other projects.

BACKGROUND

Achieving sustainable production from south-west Queensland's rangelands requires an understanding of their productivity, dynamics and long term carrying capacity. Carrying or grazing capacity is defined by Heady and Child (1994) as the average number of animals on a defined management unit that will meet objectives of animal performance without ecosystem deterioration over a long time period.

The vegetation of south-west Queensland is composed of annual grasses and forbs, perennial grasses and shrubs, and trees. Their structure and composition is determined by rainfall, grazing pressure, frequency of fire, soil type and topography. Due to the high degree of rainfall variability (seasonal incidence, amount and reliability), the structure and composition of the vegetation varies from place to place and from year to year (Purdie & McDonald 1990). Managing grazing animals in an environment characterised by such variability is difficult and requires skill.

Prior to European settlement, rangeland ecosystems evolved under a fire regime with light or migratory grazing producing a landscape dominated by grasses and forbs. Settlement brought sheep and cattle, permanent water (from artesian and sub-artesian bores), continuous grazing, utilisation of browse trees (Mulga, *Acacia aneura* F. Muell. ex Benth.), clearing and reduced fire frequency. This has shifted range production from grasses and forbs to woody shrubs and trees.

Despite the changes in range composition and productivity which have occurred over the last 130 years, the region supports a productive grazing industry based on meat and wool. In 1992–93, the gross value of agricultural production for the region was $169m (8% of Queensland's livestock products). However, evidence points to a gradual decline in range productivity (Mills 1989). Thus, improved management of the rangeland resource is necessary to maintain animal production.

Improved management requires sound knowledge of the components of the rangeland grazing system. More importantly, the components need to be considered together to develop an understanding of the whole system. In south-west Queensland, many components of the grazing system have been studied but these components have not been linked in one framework.

The 'Safe' Carrying Capacity Calculator is an attempt to integrate these components based on a systems analysis and computer modelling approach. The links between rainfall, soil moisture, pasture growth, grazing and forage utilisation are described with the objective of calculating sustainable ('safe') carrying capacities. The 'safe' carrying capacity for an individual property is the number of stock that can be safely run in the long term without detriment to the range resource. This can equal the long term average of a flexible stocking policy aimed at matching stock numbers to seasonal conditions. At any point in time the result of flexible stocking is a particular stocking rate for a particular property in a particular season.

The adjustment of stocking rates is the main management option available to producers in south-west Queensland. In the past, graziers have relied on 'gut feeling' and local knowledge to decide on stocking rates. The estimation of 'safe' carrying capacities based on sound ecological principles aims to assist graziers in making these decisions and complements local experience for the sustainable management of rangeland resources.

PROGRESS

The 'Safe' Carrying Capacity Calculator essentially describes in mathematical terms the key biological relationships of a rangeland grazing system. Each relationship has been derived from experiments conducted in western Queensland. The result is an objective and repeatable estimate of a carrying capacity based on ecological principles.

The carrying capacity is based on estimates of the potential average annual forage growth (kg/ha) for each land system on a property. These estimates are the product of average annual rainfall use efficiencies for each land system and the long term average rainfall for that property. Actual forage growth is then estimated after accounting for the negative effect of tree and shrub cover. An estimate of the number of livestock which would utilise the 'safe' portion of the actual forage growth is then calculated. The level of 'safe' utilisation is based on utilisation levels measured in grazing trials conducted in south-west Queensland and on estimated utilisation levels calculated on five benchmark properties. Summing the livestock numbers across the land systems on a property produces an estimate of a 'safe' long term carrying capacity for that property. The term 'safe' implies conservative levels of forage utilisation by domestic livestock and consequent sustainable resource use (based on previous research).

PRODUCT DESCRIPTION

There are a number of methods by which the mathematical relationships can be implemented to calculate a 'safe' carrying capacity for a property. However, the Calculator is only one step in the assessment of a property's carrying capacity. Detailed maps of the property and surveys of land condition a required before the Calculator can be used. As a result, the Calculator is ***not*** a stand-alone product. Access to maps of land types and some knowledge of techniques for conducting land condition surveys are essential. Once this information has been obtained then the Calculator can be used.

The simplest form of the Calculator is a piece of paper and a pocket calculator. This approach was used by two graziers employed as consultants by the Queensland Department of Lands. They estimated 'safe' long term carrying capacities on 20 south-west Queensland properties after receiving training and a manual on how to use the mathematical relationships (Cooney 1995, Crichton 1995).

An alternative is to use computer-based spreadsheets or databases to perform the calculations. The Queensland Department of Primary Industries, the Queensland Department of Lands and a number of graziers have been using a Microsoft Excel™ spreadsheet to perform the mathematical calculations. However, access to a computer and compatible spreadsheet software is required.

During DroughtPlan, a stand-alone Visual Basic™ computer program in a Windows™ environment was designed to handle the mathematical relationships (Plate 6 on page 83). This program simplifies work by using a series of menus to prompt users for the information required to perform the calculations. It also avoids the need to be familiar with spreadsheets or databases. This program is more flexible and can tailor the Calculator to an individual property. The mathematical relationships are documented via the program's help keys.

OUTCOMES

A range of packages has been produced enabling an objective estimation of 'safe' long term carrying capacities for individual properties in south-west Queensland by land managers and land administrators. The packages range from simple paper-based procedures, to spreadsheets, to computer-based software operating in a Windows™ environment. Each package uses the same biological relationships.

The Microsoft Excel™ spreadsheet form of the Calculator is currently being used in the National Landcare Program and Queensland Government funded project '*Appraising Safe Carrying Capacities for all Properties in South-West Queensland*', under the South-West Strategy. To date the Calculator has been used on 35 properties (7% of properties in the Bulloo, Murweh, Paroo, Quilpie and Tambo shires) covering 10,321 km^2 (5% of the above shires) in south-west Queensland.

BENEFITS TO INDUSTRY

- An objective estimate of 'safe' long term carrying capacities for individual paddocks and properties based on ecological principles and previous research.
- Tools for objectively examining grazing resource capability from a financial and physical management perspective (ie. a starting point for property management planning and risk management concepts) which does not rely on many years of local experience.
- Additional support for appreciating grazing resource capability and climatic variability.
- Recognition that each paddock and property has a unique combination of land systems in various conditions producing a unique carrying capacity. This avoids the use of 'district average' carrying capacities with potentially misleading results.

- A repeatable method for estimating 'safe' carrying capacities enabling application to any property or region where appropriate data is available. It may also be applied to the one paddock, property or region over time to examine the impact of changes in resource condition through development or degradation.

EVALUATION OF THE 'SAFE' CARRYING CAPACITY CALCULATOR

The Microsoft Excel™ spreadsheet form of the 'Safe' Carrying Capacity Calculator has been used by land administrators, research officers and a number of graziers for almost 12 months. Those familiar with working with spreadsheets have little trouble operating the Calculator. Queensland Department of Lands staff in south-west Queensland have appreciated the speed and versatility of the spreadsheet form of the Calculator. It enables quick comparisons to be made between property carrying capacities following revisions in areas of land types, etc.

A number of graziers are also using the spreadsheet form of the Calculator. After working through the mapping exercise and examining the productivity of different land types, they feel their knowledge of, and attitude towards, the capability of their resources is improved. One grazier was prepared to change his stocking strategies as a result of working at the paddock scale. Others have found the results of the Calculator valuable in supporting decisions they make regarding livestock numbers.

FUTURE PLANS

Early evaluation of the Visual Basic™ version of the Carrying Capacity Calculator shows that it is significantly more useful than the spreadsheet version. However, this will be more adequately tested during 1996–7 in the South-West Strategy Project '*Appraising Safe Carrying Capacities for all Properties in South-West Queensland*'. Commercialisation of the software will proceed as a component of a property management planning kit for producers and use within land-holder workshops. It is anticipated that this process will take 12 months.

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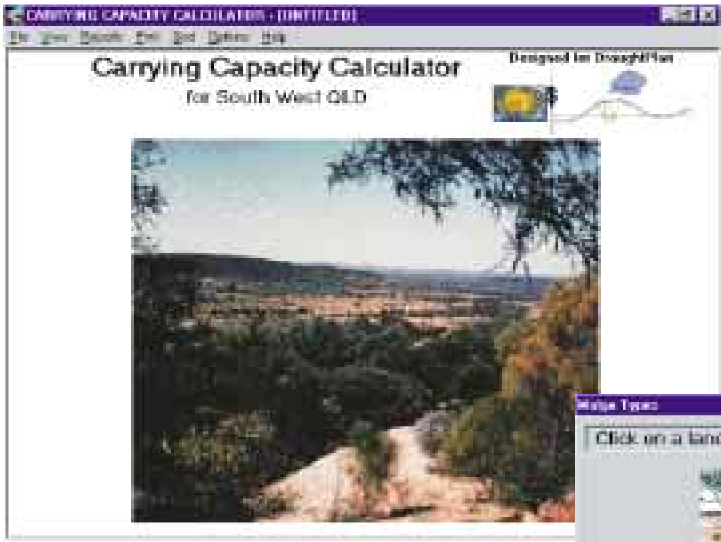
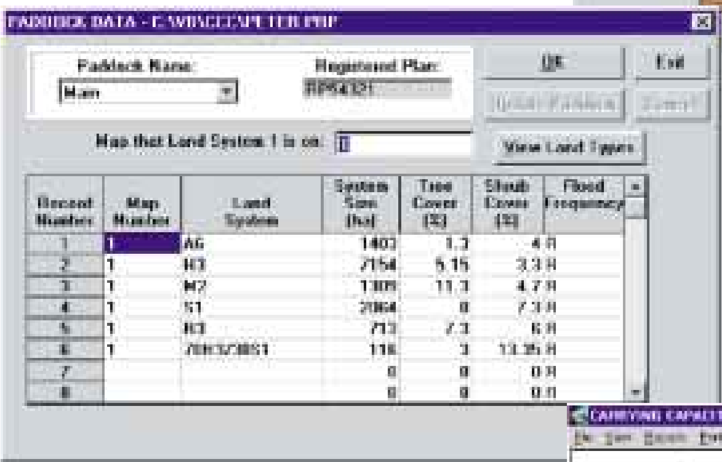
Plate 6

Screens from the 'Safe' Carrying Capacity Calculator

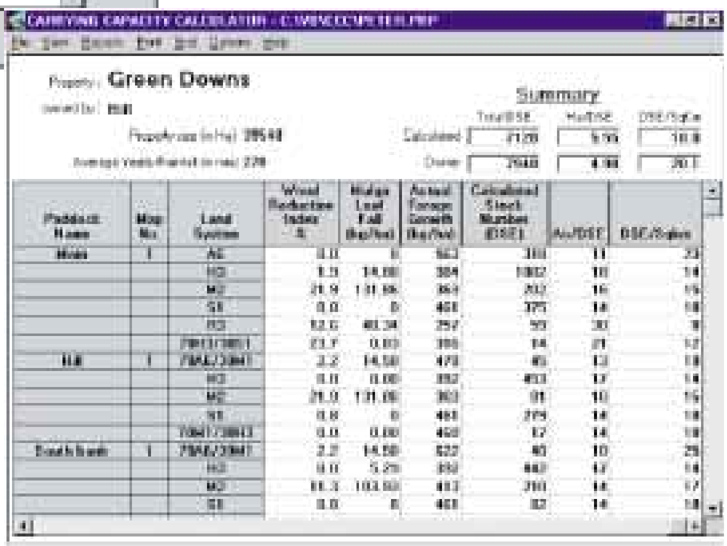


- Long-term 'safe' carrying capacity (for sheep and cattle) based on ecological principles
- Designed for graziers, scientists and agricultural consultants

- View a land system and its description
- Option to attach any photograph of the property to the file



- Identify paddocks
- Simple data entry at paddock level



- Examine effects of land system, existing vegetation and pasture condition on carrying capacity
- Compare current stocking rates to 'safe' carrying capacity

Appendix 4H: Grasp—Pasture Production Calculator

JEFF CLEWETT, GREG MCKEON, NEIL CLIFFE, KEN DAY, DAVID OWENS, GREG PINNINGTON

OBJECTIVE

To improve management of climatic risks and opportunities in the grazing industry by developing software and paper-based tools to examine the characteristics of native pasture production throughout northern Australia.

SUMMARY

Pastoralists, professional agriculturalists and agribusinesses are seeking to improve their skills for managing climatic variability through a better understanding of how climate has affected pasture production in the past. The Grasp: Pasture Production Calculator (Pinington & Clewett 1997) enables users to simulate the last 100 years of pasture growth at any site throughout Northern Australia. The software package has three components: (i) a Windows™-based start up section with facilities to alter inputs such as location, pasture and soil type, (ii) an analysis section that accesses historical climate data and the Grasp simulation model, and (iii) a results section that can display a range of information including estimates of the average, median, probability distribution and historical time series of monthly and seasonal pasture growth and yield, as tables and graphs. In addition the package includes a printed *ready reckoner* for calculating pasture growth from rainfall. These tools enable users to identify the impacts of tree density, stocking rate and climatic phenomena such as El Niño on pastures. The package has been tested with producers, scientists and extension staff. It is expected that the package will be released by the Queensland Department of Primary Industries on CD-ROM in 1998.

BACKGROUND

The impact of seasonal climate variability on pasture production is central to the management of grazing lands in Northern Australia. Thus, the ability to examine seasonal fluctuations in pasture production is valuable to land managers when considering the benefits of alternative stocking rate and pasture management options.

Significant scientific progress has been made in estimating characteristics of pasture production in the rangelands of Northern Australia through development and application of the Grasp model (McKeon *et al.* 1990, Day *et al.* 1996). The Grasp model uses historical climate data as input, and a suite of mathematical equations to simulate changes in pasture growth and yield through time. It has been developed and validated for use in Northern Australia through a suite of research projects over the last twenty years including recently *Threats of Land Degradation* (funded by RIRDC) (Day *et al*. 1997) and the *National Drought Alert Project* (supported by the National Climate Variability R&D Program) (Brook *et al*. 1996).

The development and use of Grasp is also linked to other components of DroughtPlan, including the Carrying Capacity Calculator, GrazeOn, Grasp/Herd-Econ, RISKHerd, and the evaluation of the SOI (Southern Oscillation Index) as a tool for managing climate variability. Since the Grasp model is the foundation of the Calculator, it is useful to briefly describe the model here.

Water use is the main driving variable in Grasp. Hence the water balance components, rainfall, runoff, infiltration, drainage, soil water storage, evaporation and transpiration, are central to the model. Pasture growth is estimated in proportion to daily transpiration:

$$\text{Growth (kg/ha/day)} \propto \text{Transpiration (mm/day)}$$

The proportionality constant or transpiration efficiency (kg/ha/mm) in this equation is influenced by soil fertility and water vapour in the atmosphere. Growth is allocated to dry matter pools of green leaf and green stem which in turn influence the amount of radiation intercepted and hence the potential growth rate. The green dry matter pools decay to dead leaf, dead stem and finally to litter. Losses in biomass occur via litter decomposition, intake by grazing animals and fire. The five key groups of rate and state variables that influence pasture growth and biomass are:

- climate (rainfall, temperature, radiation and vapour pressure deficit);
- soil characteristics (mainly water holding capacity and nitrogen availability);
- pasture characteristics (mainly basal area, biomass of the five dry matter pools, pasture condition, and species composition);
- tree density (through the competitive relationship of trees and pasture); and
- stocking rate (through effects on intake, pasture condition and trampling losses).

APPROACH

The main elements of developing the Pasture Production Calculator were::

- developing 'user friendly' software to run GRASP and display results (tasks included: writing Windows™-based software with Visual Basic™, preparing a data base of historical climate records, and packaging the data base of GRASP parameter values [the parameter files were prepared in parallel projects by John Carter, Ken Day and Greg McKeon]);
- deriving from this a paper-based 'ready reckoner' for estimating pasture growth;
- evaluating these as tools for use in property management planning activities; and
- initiating processes to commercialise the above.

The software and paper-based products were designed for different client groups. The paper-based 'ready reckoner' was to suit mainly the needs of land-holders. In contrast, the software package was to support the activities of professional agriculturalists in either their dealings with land-holders through PMP workshops, or in research activities (eg. analysis of field trials, evaluation of alternative management strategies).

RESULTS

Description of Software

The GRASP Pasture Production Calculator has three main elements:

- a Windows™ program for IBM™-compatible PC computers that provides the 'user friendly' interface, operates the scientific GRASP model in the background, and calls routines derived from AUSTRALIAN RAINMAN to display pasture growth and yield results;
- a data base of parameters (MRX files) needed to operate GRASP for many of the 151 Local Production Units identified by Tothill and Gillies (1992) for the pasture communities in Northern Australia; and
- a data base of historical daily rainfall and historical monthly temperature, evaporation and vapour pressure data for 200 locations in Northern Australia.

The steps in running the program are as follows:

- choose a location (from a list or by clicking on a map of Northern Australia);
- select a pasture community from a list of the common native pastures in the region;
- alter parameter values as needed (the main parameters are shown in Plate 7 on page 89);
- simulate growth through time using the historical climate data; and
- examine results of 20 climate, soil and pasture variables in several ways (eg. as tables, as in Table 4 on page 87; or as graphs; or on screen as in Plate 7 on page 89; or as printed documents).

Table 4
Sample output from the GRASP Pasture Production Calculator showing an analysis of annual growth of open native pasture in North Queensland.

Growth (kg/ha) from May to April		***Average SOI from May to April*** Below –5	–5 to + 5	Above + 5	***All years***
% years, growth at least	800 kg	88	94	100	94
	1,000 kg	74	87	100	87
	1,250 kg	59	78	100	78
	1,500 kg	37	70	100	68
	1,750 kg	25	63	92	60
	2,000 kg	**18**	**57**	**92**	**55**
	2,500 kg	11	45	92	47
	3,000 kg	3	31	56	30
	3,500 kg	0	12	12	9
Number of years in simulation		27	57	25	109
Lowest pasture growth (*kg/ha*)		352	516	1,684	352
Highest pasture growth (*kg/ha*)		3,338	4,348	5,078	5,078
Median pasture growth (*kg/ha*)		1,402	2,373	3,000	2,373
Average pasture growth (*kg/ha*)		**1,462**	**2,302**	**3,091**	**2,275**

All parameters in GRASP may be changed if necessary, but only users with an expert knowledge of the equations in GRASP should consider altering parameters in the detailed list. Most users only need to change simple parameters such as soil depth, tree density and stocking rate to control the model's operation.

Preparation of climate data base

Daily rainfall files for input to GRASP were prepared in the AUSTRALIAN RAINMAN project (Clewett 1995); However, DroughtPlan contributed significantly by preparing long-term historical data files containing monthly data for temperature (maximum, minimum, 9am dry bulb and 9am wet bulb), radiation, pan evaporation, and vapour pressure deficit. Previously these records were only available in computer-compatible format from 1957 onwards. The four tasks required to prepare the monthly climate files (MC5 files) were: (i) obtain TAB elements data files from the Bureau of Meteorology, (ii) extend the length of these records by extracting data from the Australian Archive, (iii) patch missing values using near neighbour regression, and (iv) use temperature data to estimate values for pan evaporation, vapour pressure deficit and radiation.

Description of 'ready reckoner' brochure

The 'ready reckoner' for calculating the growth of native pastures in Northern Australia is in preparation and will be printed as a short brochure that describes a simple approach to approximating pasture growth from seasonal rainfall. The sources of error in this approximation are outlined. The method is based on the relationship:

Pasture Growth (kg/ha) = Rainfall use efficency (kg/ha/mm) x *Seasonal Rainfall (mm)*

The brochure will provide a look-up table of rainfall use efficiencies (derived from GRASP) for the main pasture communities and fertility levels in a local area. The look-up table could be produced locally by land-holders and extension staff in the area as part of the participatory research and extension approach. The table can provide differences in rainfall use efficiency in El Niño and La Niña years as shown by the two examples in Table 5 on page 88.

Table 5
Annual rainfall use efficiency (kg/ha/mm) of native pastures

Location	**Native Pasture Community**	**SOI below –5**	**All Years Average**	**SOI above +5**
Charleville	Mulga	1.5	1.7	1.9
Charters Towers	Open Woodland	3.0	3.5	3.5

EVALUATION

Evaluation of the GRASP Pasture Production Calculator has been limited and thus a more thorough evaluation process is required. The reaction of graziers, extension staff and researchers to prototypes at four workshops (Oakey, Bribie Island, Charters Towers and Gatton) and in consultation with extension staff in central and southern Queensland has been very positive. The main interest has been in examining the influence of El Niño on pasture production and the 100 year time series of pasture growth for drought analysis. Both of these issues concern knowledge acquisition. The GRASP model has been used in many scientific applications but so far the Calculator has been used in preparing analyses for two publications (Clewett *et al*. 1995a [see Section 5], 1995b). A thorough evaluation of the Calculator in combination with other DroughtPlan products in a participatory research setting with landholders assessing alternative management options has yet to occur.

CONCLUSIONS

Development of GRASP as a user-friendly tool to examine pasture production has been a significant step forward. Processes are now needed for adequate evaluation by industry.

Acknowledgments: Many people have contributed to the development of the GRASP Pasture Production Calculator. Within the context of the DroughtPlan project, the following are recognised in particular: Joe Scanlan and Steve Garrard through their MRC-funded project, and Ken Day, John Carter and Greg McKeon.

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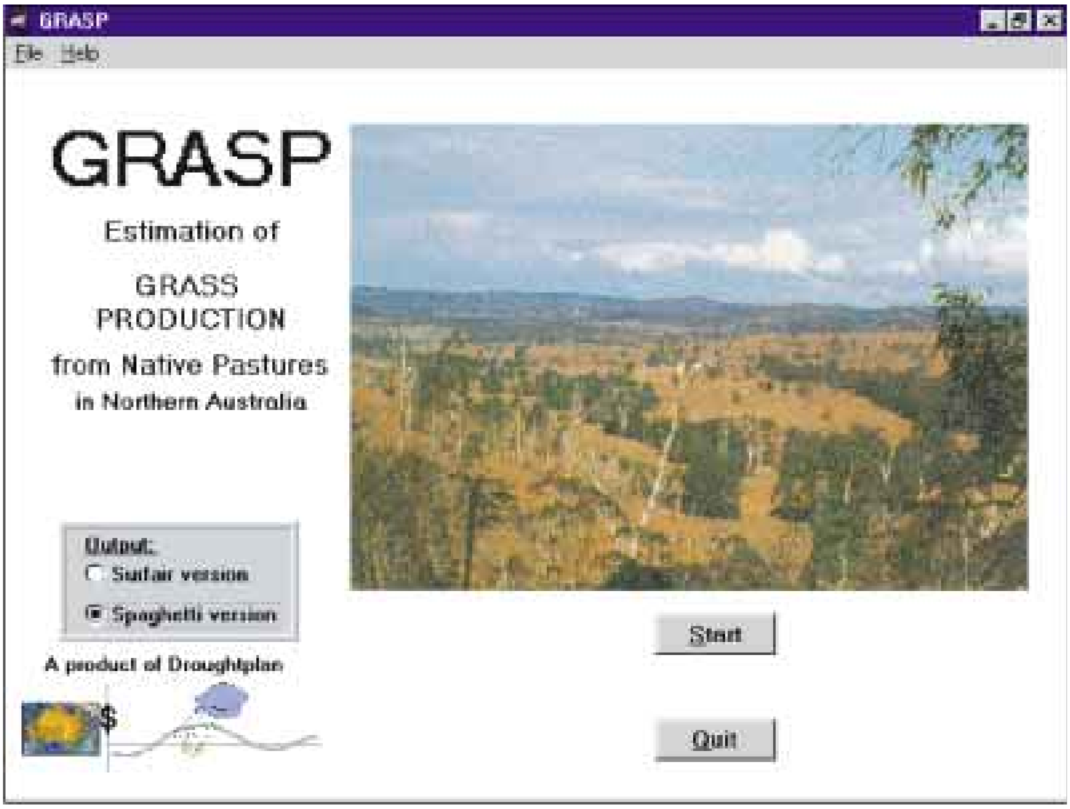
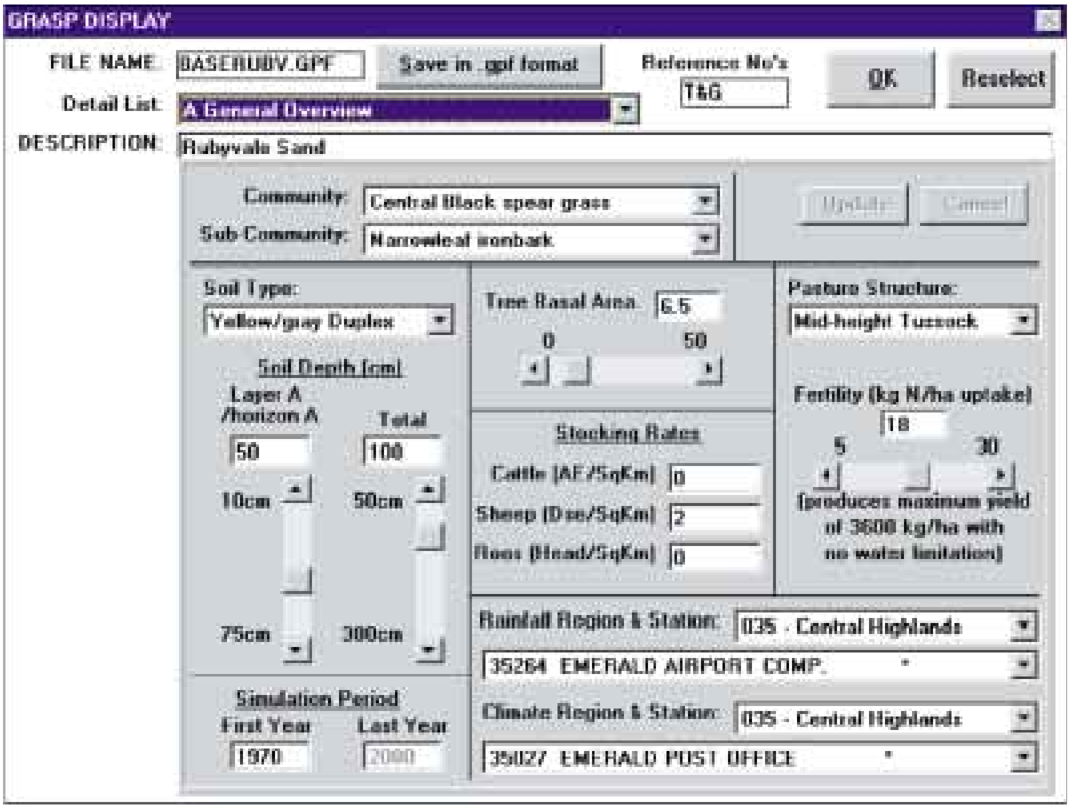
Plate 7
Screens from GRASP Pasture Production Calculator
(a) opening screen and (b) the input selection screen

(a)



(b)



Appendix 4I: GRASP/Herd-Econ link for SOI case study

MARK STAFFORD SMITH, GREG MCKEON, ANDREW ASH, ROSEMARY BUXTON AND JOSEPH BREEN

OBJECTIVE

To link GRASP with RANGEPACK Herd-Econ in a way that would permit an analysis of the utility of seasonal forecasting to stocking rate management strategies for various mixtures of enterprise and geographic regions of Australia.

SUMMARY

To meet the implicit or explicit questions asked about the economics of safe stocking rate strategies by many pastoralists, we need to be able to model the entire production system from rainfall through to cash flow, whilst accounting realistically and flexibly for the alternative management strategies that producers wish to use. This capacity did not exist for the rangelands in a way which could account for climatic variability prior to the DroughtPlan project. This section reports the development of a simulation strategy to link the GRASP and Herd-Econ models, in order, initially, to be able to carry out a case study of the value of using SOI forecasts for managing property stocking rates in the Charters Towers region of northern Queensland.

This section concentrates on the process of linking and validating the models; under Stream 5 are the results of applying the model to seasonal forecasting in the Charters Towers region, where forecasting should be most beneficial. A procedure for linking the models was successfully implemented. Sensitivity studies of the resulting system show that it is particularly sensitive to assumptions about buying and selling decisions, and long term impacts on vegetation condition. The effects of prices are significant but predictable, and errors in the relationships driving herd dynamics may have only modest impacts. The linked model produces results which significantly add to the understanding gained from GRASP alone.

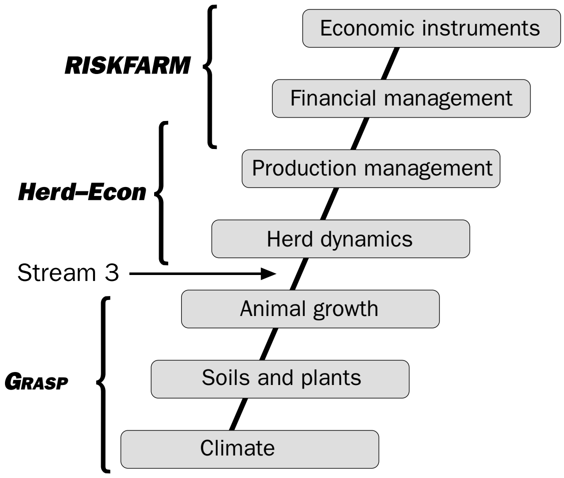
BACKGROUND

For a long time our grazing systems models have failed to incorporate all the components of the system that matter to producers. RANGEPACK Herd-Econ has been in use to assess alternative enterprise strategies for nearly a decade but lacks any basis other than expert opinion for ensuring that strategies that users want to test are in fact biophysically feasible, let alone sustainable. Meanwhile, GRASP has become ever better at simulating subtropical pasture growth under grazing, and providing the implications of different grazing pressures in terms of steer liveweight gain. However, this has left producers asking what such a partial budget really means in the context of the whole self-replacing herd or flock. (Additionally, we have not handled the financial system well: see Appendix 4J on page 96, RISKHerd, for discussion on this.) The weak link between these sectors has been recognised to be the interpretation of animal condition and growth rates into reproduction and mortality rates. DroughtPlan has begun to fill this gap with the Stream 3 work.

Consequently the stage has been set for linking GRASP and Herd-Econ into a genuine system model with at least cash flows as outputs (see Figure 15 on page 92 for the scope of each component). There are many complex factors involved in this effort, so that the goal is not to produce an easily used tool for producers in the near future. Rather, the intention has been to create a research model which could be used to carry out a range of case studies in different systems, and then seek to draw simplified models of the critical factors, in a similar way to that followed by GRASSMAN. DroughtPlan Working Papers 8 (McKeon *et al.* 1997; see also previous section in this publication) and DroughtPlan Working Paper 9 (Stafford Smith *et al.* 1996) describe the details of how the component models and the linked simulation procedure function, as well as describing the first case study fully. In this section we summarise the process of linking and validating the models. A later section under Section 5 outlines the results of applying the models to seasonal forecasting in the Charters Towers region, where forecasting should be most beneficial.

Figure 15

Key components of a whole pastoral management system, showing the coverage of the past models (Grasp, Herd-Econ and RISKFARM) and new data analysis (DroughtPlan Stream 3 work) which have been combined in this case study and in 'RISKHerd'.



Any of the main strategies discussed in this later section can be applied at a variety of target stocking levels, expressed in terms of numbers for the constant strategy, and in terms of utilisation levels for the others. Furthermore, each can be implemented with an indefinite variety of tactical approaches to buying, selling, agisting, feeding and market access. The linked model therefore had to be capable of very flexible implementation, and readily amended to cope with different approaches.

SIMULATION APPROACH

The models used in this study have been described elsewhere; this section concentrates on how they were linked together in practice. The models were Grasp (described fully in DroughtPlan Working Paper 8, McKeon *et al.* 1997; also in the previous section); RANGEPACK Herd-Econ (Stafford Smith and Foran 1992); and, in principle, the relationships between the condition and growth rate of animals and their reproduction and mortality rates researched under Stream 3 of DroughtPlan.

In brief, Grasp is a deterministic, point-based model of soil water, grass growth and animal (sheep and cattle) production, devised and validated on tropical grasslands (McKeon *et al.* 1990). It provides a well-validated framework for estimating animal production levels and short to medium-term pasture sustainability as a result of different sequences of climate and stocking levels. Herd-Econ is a deterministic herd dynamics and property economics model normally intended for use at an enterprise level. Its value to this project is that it provides a flexible and context-independent method for describing the tactical details and dynamics of alternative stock management strategies.

In practice, the growth functions in Grasp at present still operate on annual liveweight gain so that it is not possible to track animal condition during the year, as needed for the Stream 3 relationships. For the development of a simulation approach as described here, therefore, we fell back on results derived from the data of Gillard and Monypenny (1988). These are derived from the study area and probably more reliable for this particular set of simulations, but cannot be generalised in future. However, they allowed the simulation process to be constructed and tested. The relationships are stated in DroughtPlan Working Paper 9 and were subjected to sensitivity analysis.

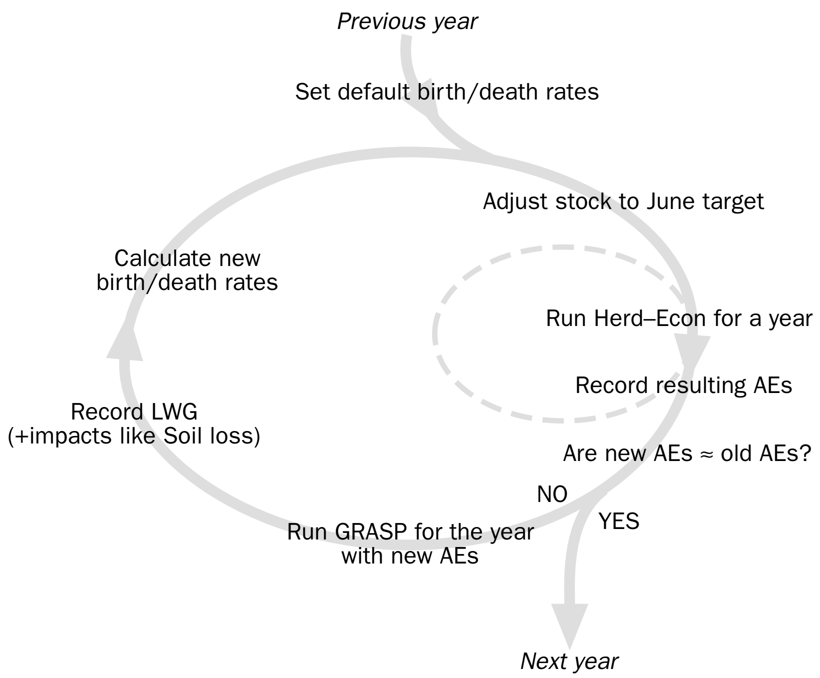
LINKING THE MODELS

To run Herd-Econ, one requires enterprise costs and prices, buying and selling rules, some stocking rate strategy, and monthly growth, reproduction and mortality rates by animal class and age group. We use Grasp to provide the last three biological items via the prediction of an annual liveweight gain. This liveweight gain is derived from Grasp's inputs of daily weather, vegetation growth parameters and stocking rates. The first two of these are externally determined, but the third represents the key feed-back mechanism from Herd-Econ. Due to the different time steps involved, it is not possible to run the two models in tandem. Grasp simulates pasture growth daily but generates an annual liveweight gain which is converted into reproduction and mortality rates via annual relationships; Herd-Econ then runs on a monthly basis, which is necessary to obtain sufficient resolution in decision-making by pastoralists. The models are therefore run discretely, mostly for one year at a time, with an iterative procedure ensuring that they are reflecting the same annual conditions. This has the benefit of minimising the hidden links between the models, and enabling error propagation to be examined explicitly.

The process of linking the simulations is illustrated in Figure 16. In short, each year begins with default biological values and the pasture state and herd numbers left from the previous year. Herd-Econ is run assuming these conditions, and the stocking rate which would result from this is recorded. Grasp is then run with this stocking rate which results in a new assessment of the expected animal production, and hence a new estimate of reproduction and mortality rates. Herd-Econ is re-run for the year with these rates to obtain a new stocking rate, and the process repeated until the stocking rate in two successive Herd-Econ runs differs by less than some tolerance. At this point the end of year state is saved and the next year begun. For some management strategies an additional, internal iterative loop is required to obtain the correct stocking rate over summer as well as the remainder of the year.

Figure 16

Schematic outlining logic flow in connecting Herd-Econ and Grasp iteratively for a year. Each year the full cycle must be completed at least once. The dashed internal cycle illustrates the fact that some strategies require an additional inner iterative cycle to calculate the growth over summer given different stocking rates (details not shown here). For the runs described in DroughtPlan Working Paper 9, new and old animal equivalents (AEs) were regarded as sufficiently close if they matched within ±1%.



In most cases no more than two iterations were required for convergence, but more iterations were sometimes needed at the highest stocking rates, where changes in stocking rate have the maximum impact of the pasture. Also, on rare occasions, the iterations would get into a flip-flop state (usually close to convergence). Hence no more than 10 iterations were permitted per cycle, at which point the failure to converge was recorded and the run continued. These records were inspected afterwards and were usually modest in terms of their effect on the whole run. There were no cases of problems in the near-optimal stocking levels. Some of the highest stocking levels did have problems, leading to an occasional discontinuity in the results, but none of these affect the general conclusions drawn below.

The practical programming mechanism was to link the FORTRAN-based GRASP into the C code of Herd-Econ as a function which could be called with the transfer of key state variables (pasture state, stocking rate, etc), some output variables (liveweight gain, soil loss, total growth and intake, etc) and instructions as to which parameter file to use and which days of weather to run. All the remaining cycles shown in Figure 16 were programmed in the command language of RANGEPACK Herd-Econ (version 3 prototype).

APPLICATION

DroughtPlan Working Paper 8 (and the previous Section) reports on the process of validating the biological processes represented in GRASP. DroughtPlan Working Paper 9 then reports some detailed sensitivity analyses which are not repeated here. However, the key findings of these were:

- amending the representation of management and of biology *can* alter both the optimum target within a strategy and sometimes the relative success of different strategies;
- the effects of changes in purchase and sale prices in drought on long-term cash flow were modest and predictable;
- relatively modest changes in the order of selling animals in dry years (ie. only those years in which stock numbers exceed their target) can have large effects;
- the order and relative profitability of the strategies tested were little affected by changes in biological rates equations, which is encouraging since our knowledge is poor in this area. However, the absolute effects on cash flow are considerable, and the effects might be more significant if the enterprise aims at a younger turn-off age;
- changes in pasture growth parameters related to the level of pasture perenniality have a large impact on cash flow; and
- almost all sensitivity changes had greater effects at higher stocking rates.

This highlights most especially the need for a better understanding of the tactical decision-making of managers, and of long-term vegetation change.

EVALUATION

The linked GRASP/Herd-Econ model was intended to provide the basis for carrying out pertinent case studies, rather than being directly available on-farm. Its major immediate impact is therefore to be expected among researchers.

1. **Verification:** the feasibility of the simulation procedure was successfully demonstrated.
2. **Validation:** the models were individually validated and the process of overall validation begun with sensitivity analyses. Further work is required in this area using historical on-property datasets for long term validation runs (in progress under subsequent projects).

3. **Change in reaction:** the simulations reported under Stream 5 have enabled researchers to see the importance of the Stream 2 and 3 work in providing real answers to producers, and have helped direct the development of GRASP into intra-annual growth patterns and long-term vegetation change to an extent which was not previously perceived as being urgent. This and the remaining elements of evaluation have yet to flow through to industry.

4. **Change in KASA:** as above.

5. **Change in practice:** as above.

CONCLUSIONS

The simulation procedure and protocol was successfully developed and applied to a realistic problem. The later section shows that the linked model produces results which are significantly different to those achieved from using GRASP alone in a partial budgeting mode. Sensitivity analysis demonstrates that there are still limitations in the constituent models, in relation to knowledge of tactical decision making (as addressed in part by Stream 2) and long-term vegetation change in particular. In the long-term there is a need for parameter sets for a much larger range of systems, and the significance of spatial grazing behaviour must be investigated. In the near future, the simulation approach now needs to be applied to a wide range of case studies.

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Appendix 4J: RISKHerd

MARK STAFFORD SMITH, NICK MILHAM, GREG MCKEON, ROSEMARY BUXTON, NICOLA TAPP, BOB DOUGLAS, JOSEPH BREEN, PLUS STREAM 3 TEAM

OBJECTIVES

To develop a linked model to:

- demonstrate the feasibility of a linked GRASP/Stream 3/Herd-Econ/RISKFARM simulation protocol; and
- carry out one reasonable case study (probably north-west NSW) and present at conferences in 1995.

SUMMARY

A repeated concern of producers in Streams 1 and 2 was that policy instruments might not operate as intended to promote sustainable management. In the past this has been hard to test properly, as no model has ever contained realistic biology, sensitivity to alternative detailed management strategies, and a comprehensive handling of taxation provisions for different business structures and policy instruments. The development of 'RISKHerd' took advantage of the opportunity to collaborate with another project under the LWRRDC-managed National Climate Variability R&D Program, and developed a simulation approach to linking the GRASP/Herd-Econ model with RISKFARM from NSW Agriculture and the Centre for Agricultural and Regional Economics.

As a commitment outside the original project contract, it was only possible to develop the protocol and prove that it could work in practice through one case study. This was completed and the results presented at two conferences in November 1995. These preliminary results showed that we could provide information about susceptibility to soil erosion on the same cumulative frequency graph as post-tax cash flow given the use of different taxation instruments. They suggest that some policy instruments such as IEDs and livestock elections have minor impacts on profitability in comparison to modest changes in stocking rate (and therefore are not likely to encourage such changes). Most importantly, the study demonstrated that the approach is feasible and now needs following up with better validation and a bigger range of cases.

BACKGROUND

The intent of government policy is that all instruments should at least be compatible with sustainable resource use, and preferably should actively encourage it. There is thus a real need to be able to analyse the effects of tax and other policy instruments on management decision-making and the resulting impacts on the natural resource base. Some recent analyses of the policy framework have concluded that policy arrangements may even be counter-productive to sustainable management, but have used models which lack a rigorous link to the resource base. Existing models which are reasonably comprehensive in simulating the farm environment do not incorporate taxation and other financial structures in detail, nor handle stochasticity in and interdependencies between financial and environmental conditions. Thus policy-makers must develop new instruments without a full analysis of their implications for sustainability. Industry continues to question the efficacy of taxation policy and instruments such as IEDs and subsidies (eg. frequent comments during Stream 1 and 2), and continues to have limited awareness of the potential effects of different company structures on profitability.

APPROACH

We developed interactive links between the grass and animal growth model (GRASP) and a model of the herd dynamics and cash flow economics of a pastoral property (RANGEPACK Herd-Econ). The resulting biophysical model was then linked to a purpose-built, stochastic dynamic model of the overlying economic and financial system derived from the RISKFARM model. This model, together with the simulation protocols that link it with the composite GRASP/Herd-Econ model, is known as RISKHerd. The three models were linked hierarchically (see Figure 15 on page 92) to enable an appropriate degree of process to be incorporated at each level whilst allowing the information passed between levels to be limited to the minimum necessary.

The final product appearance is a research model structure (Herd-Econ/GRASP model plus links to a simplified RISKHerd Excel™ Spreadsheet, with various ancillary analysis Excel™ macros), plus completed conference papers describing the simulation protocol and a case study (Milham *et al.* 1995, Stafford Smith *et al.* 1995). This product was extra to the original project contract but was strongly urged by producers.

APPLICATION

As a preliminary test of the approach, we examined the interactions between stocking rate strategy, taxation and the use of income equalisation deposits for a pastoral enterprise in mulga country near Bourke in north-west New South Wales (details in Stafford Smith *et al*. 1995). Each stocking option was exposed to the same 100 stochastic 10-year climatic sequences (randomly selected years from observed climate data for the period 1961–1993). GRASP pasture growth parameters were based on mulga ecosystems in southern Queensland. Preliminary reproduction and mortality relationships were drawn from Stream 3, based on wool growth in the current and previous year. Wool growth as predicted by GRASP is in turn affected by pasture availability and hence is susceptible to the effects of overgrazing.

There were two basic stocking rate strategies—one aimed to always keep a constant number of ewes after shearing ('Constant'), while the other was reactive and aimed to adjust the numbers of ewes in such a way as to eat a consistent proportion of the current forage availability, that is, obtain a constant utilisation rate ('Reactor'). We tested the Constant strategy for different levels of target ewe numbers, from a low level of 2,500 (less than the real property), through 5,000, to 7,500 (much more than the real property); these are termed C025, C050 and C075 respectively. As the stocking level increases, reproduction rates drop off in poorer years and deaths rise, thus making the strategy increasingly variable through time. Likewise, we tested more than one level of utilisation rate for the Reactor, 5, 15 and 25% (Queensland DPI recommendations are about 15% for this vegetation type at present); these are termed R05, R15 and R25. In years when the Reactor has too many stock, the Reactor sells wethers and then older ewes; when numbers are low, the Reactor buys in ewe hoggets, although this was not permitted to exceed 2,000 head in any one year (presuming some financial or stock availability constraints).

The 100 sequences of 10-year periods simulated in GRASP/Herd-Econ for each option were then transferred into the RISKHerd spreadsheet, and 600 stochastic simulations carried out for each sequence. For the Reactor options—the only strategy incorporating extensive drought sales and purchases—two sets of simulations were run, representing two different tax-based financial strategies:

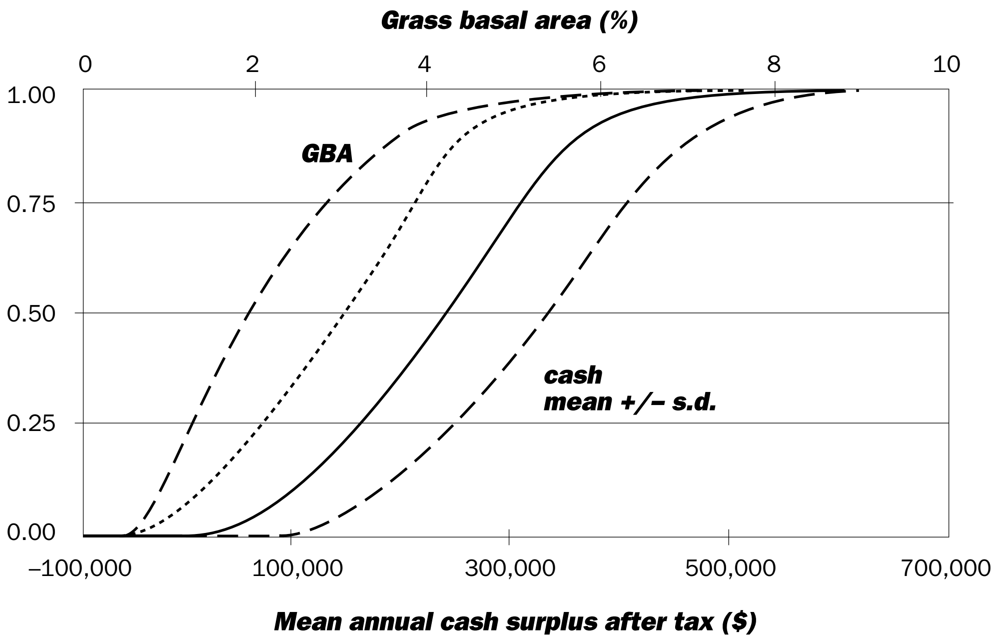
- RxxA—use Income Equalisation Deposits (IEDs) as a financial reserve; and
- RxxB—use special taxation allowances for drought-related sales of stock.

Thus a total of nine options were compared. Assumptions were also made about debt, capital depreciation and probability distributions of various economic factors (cf. Milham *et al.* 1995).

The principal result at this stage was that we were successfully able to run the simulations and to report post-tax cash flow on the same cumulative probability distribution graph as grass basal area, one possible index of sustainability related to the likelihood of soil erosion (Figure 17). Thus the feasibility of the simulation strategy was confirmed. Additionally these preliminary results suggested that the difference between the A and B tax management tactics was minimal in comparison to changes in target utilisation rates, showing that it was possible to draw conclusions relevant to policy instruments. A paper is now in preparation (Stafford Smith, Milham, McKeon *et al.*) which will report the results after re-running the analysis with the up-to-date GRASP/Herd-Econ link.

Figure 17

An example of the cumulative frequency plot of grass basal area (top axis) and mean annual cash surplus (bottom axis) for the Constant management strategy targeting 5,000 ewes. One standard deviation in the annual results for cash surplus (for any given probability) is also shown—the cash surplus range of outcomes becomes flatter and the standard deviation wider as stocking rates increase, indicating an increasing variability in possible outcomes.



EVALUATION

As (at least initially) a research tool rather than an application, RISKHerd is different to some DroughtPlan Stream 4 products. Nonetheless, it must become acceptable and credible to both policy makers and producers. Towards this, the Stream 4 workshop in August 1995 identified the following points [actions shown in brackets]:

- careful verification and validation of model constructions is needed, and should answer the question of whether errors are inappropriately propagated up through the model linkages; [This issue was highlighted in a grant application.]
- future case studies should be chosen to be relevant to producers and to answer questions about taxation, etc, which were of concern in consultations last year; [Communicated to pastoral members on funding agencies; positive response, November–December 1995.]
- policy makers should be consulted to ensure that the results can be produced in a form on which they can act. [An initial forum was proposed in the resulting grant application for further work.]

1. **Verification:** The project has demonstrated that the simulation procedure is feasible in principle, and positive feedback at conference presentations supported its general relevance.
2. **Validation:** Despite the hierarchical structure of the simulation procedure, there are still steps which can interact incorrectly (eg. synchronisation of timing and timesteps in the biology, management and financial sections). Error propagation must be carefully analysed (but the preliminary study shows that the outputs are affected significantly by changes at all levels in the hierarchy, thus justifying the complexity of the model for this purpose). A significant effort is needed to obtain good price and cost probability distributions which are sensitive to co-variance with climate and management factors.
3. **Change in reaction:** Preliminary policy-level response has been good in terms of interest, and some related work was being funded (in May 1996). A few producers who are aware of the idea are showing great interest.
4. **Change in KASA:** None documentable yet.
5. **Change in practice:** None documentable yet. An evident measure will be changes to the taxation system.

CONCLUSIONS

These and other analyses suggest that some existing policy instruments are ineffectual or even counter-productive in their intentions with regard to sustainable land management when properly analysed. The possibility that this is the case is supported by some producer groups. Incorrectly targeted policy instruments have caused enormous damage in the past (eg. closer settlement in SW Queensland and W NSW), and are an inefficient use of public resources. Well-targeted provisions can simultaneously achieve societal objectives whilst saving public funds. Thus the ability to analyse instruments properly has extensive industry and public policy benefits, can improve industry self-reliance in the face of drought, and may reduce future regional adjustment needs. We are now seeking funds to develop a full suite of case studies across the rangelands, and thus identify generalities which might promote changes in policy. Further work cannot occur in the absence of new resources.

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Milham, N., Stafford Smith, M., Douglas, R., Tapp, N., Breen, J., Buxton, R. & McKeon, G. 1995. Farming and the environment: an exercise in eco-economic modelling at the farm level in the NSW rangelands. Invited paper, *Proc.Intl.Congr. on Modelling and Simulation*, Newcastle, Nov 1995. 8pp.

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SECTION FIVE

Stream 5: Evaluating management strategies and identifying new benchmarks for best management practices

JEFF CLEWETT, RICHARD CLARK AND MARK STAFFORD SMITH

Objectives

As a delivery mechanism and in close cooperation with producers, build on project findings to evaluate the following management options, using real production systems information and simulation studies, with both spreadsheet and weather-driven dynamic herd/flock models:

- stocking rate strategies (eg. long-term safe stocking rates compared to reactive seasonal adjustments or pro-active seasonal adjustments) for various mixtures of enterprise and geographic regions of Australia;
- when and what animals to buy/sell/agist in good or poor seasons and during or after drought (including future implications of herd genetics changes);
- risks and benefits of different feeding options (when to start, which animals, for how long); and
- adjustments of the above options in relation to seasonal climate forecasts.

Summary

The original objectives of Stream 5 were to collate a variety of case studies which were valuable to producers. During the course of DroughtPlan, Stream 5 gained an increased emphasis on ensuring that Stream 4 products were useful to industry, and hence the process of evaluation. Both of these issues are covered in this Section.

Case Studies

Many case studies were carried out during the course of DroughtPlan, many of them undertaken in association with work under Streams 2 and 4. Each of the Stream 2 regional reports contains a series of case studies of issues of concern to producers in that region; some of these studies raised issues which were common across the country, as reported in Section 2 and Buxton and Stafford Smith (1996). Under Stream 4, the development of several tools also involved testing them with case studies, in particular 'Decision Trees' (see page 65), RISKHerd (see page 96 and Stafford Smith *et al.* 1995), the GRASP Pasture Production Calculator (see page 85), and the GRASP/Herd-Econ link (see page 91). The latter two case studies were concerned primarily with seasonal forecasting and are reported in a following section. Additionally a study was undertaken of the feasibility of extending the community-owned 'Safe' Carrying Capacity Calculator approach to other regions, with a case study in the Central Burnett. This is also reported in a following section.

Key conclusions from all these case studies were:

- computer-based tools provide a powerful learning process and can effectively catalyse change in grazing management practices;

- industry places considerable value on the computer-based tools developed in this project, and have recommended that tools such as the Carrying Capacity Calculator and GrazeOn should also be developed for other regions;
- a general method was established for combining producer experience and scientific knowledge to establish the long-term carrying capacity of properties;
- continuing research is needed to develop a Carrying Capacity Calculator for North Australia;
- seasonal forecasts based on the SOI were shown to have benefits for resource management during drought in western and northern Queensland;
- continuing research is needed to develop practical tools that utilise seasonal forecast information for tactical adjustment of stocking rate; and
- significant benefits and synergies to the research, development and extension process were derived through using a team approach at a national scale, and hence this team approach should be used in future projects.

Evaluation of Products

A major concern from the start of DroughtPlan was to ensure that whatever the project produced was useful to industry, rather than being research for its own sake. This concern underpinned the design of the whole project, from its initial major consultative phase through the development of the products. During the first year, a project workshop on the research process (Stafford Smith & Clark 1994) brought the issue again into sharp focus, and it was clear that some participants were still stronger on the rhetoric than the practice of true participation with producers. A common process for evaluation was therefore adopted across the whole project (see Appendix 5A on page 104) which forced project members to think about engaging industry in assessment. Complete evenness of process was still not guaranteed, but a much more consistent and open approach to evaluation did thereby evolve.

The sequence of criteria against which evaluation was to be made were:

(i) *Verification*;

(ii) *Validation*;

(iii) Change in *Reaction*;

(iv) Change in '*KASA*'—knowledge, attitudes, skills and aspirations; and

(v) Change in *Practice*.

A more detailed interpretation of each of these criteria is provided in Appendix A (see page 104) which reproduces the document used to ensure a consistent approach across DroughtPlan. Although all products were tested against criteria (i) and (ii), these are a normal part of a traditional research process. The later criteria focus more on assessing behavioural change towards required outcomes, and it is these which are highlighted in this section.

In most cases a significant effort was put into the evaluation process, and each of the reports on the Stream 4 products (Section 4) contains at least a brief section reviewing these formal efforts. For the 'Safe' Carrying Capacity Calculator and GrazeOn, fuller reports are attached as appendices to this Section (O'Sullivan 1996 also provides a fuller report for BB-SAFe). Evaluation was also extensive for the Pasture Supply and Demand Calculator (see page 73). Table 6 on page 102 summarises the extent and response of evaluation for each product.

Thus, with the exception of the research tool, GRASP/Herd-Econ, and the exploratory procedure, RISKHerd, all products passed the validation phase, and several reached at least some level of formal practice assessment. In terms of the long-term objectives of DroughtPlan and the overall National Climate Variability R&D Program, changes in practice need to be specifically towards more sustainable management.

Table 6
Summarised status of formal evaluation for main project products, with their production format ('Evaluation Stage' refers to sequence listed on previous page).

Product	***Evaluation stage reached (mid-96)***	***Stakeholder response***
Assessing Your Livestock Management Options **Workshop** (Workshop program, manual, facilitator's notes, factsheets, worksheets, paddock log book)	Validation	Validation of content and presentation by DPI staff and producers was positive. Awaiting publication of other products.
GrazeOn (Principles, leaflets, work-sheets, computer program, case studies)	KASA (+ formal economic assessment of benefits)	Validation including economic analysis and case study. Positive reaction and documented KASA changes with participating producers.
BB-SAFe (Workshop notes, leaflet, worksheets, spreadsheet program)	Evaluation questions provided; Reaction, some KASA in a limited exercise (not in group process)	Verification and validation completed; reaction positive but showed some areas of complexity. Limited KASA testing positive, with some problems related to evaluation outside workshop context.
Decision Trees (Workshop process, leaflet)	Validation with producers, KASA with agency staff	Useful but complex if formally applied to real problems with producers. Valuable for structuring agency thinking, leading to documented change in KASA and practice for staff.
Pasture Supply and Demand Calculator (Computer Program)	Practice, with groups	Created out of a formal participatory problem solving cycle. Generally positive feedback in respect of Reaction and KASA; documented change in practice.
'Safe' Carrying Capacity Calculator (Work-sheet, spreadsheet, stand-alone program)	KASA to 65 individual properties, some Practice	Positive response overcoming initial scepticism. KASA change documented, beginnings of practice change (ie. in stocking numbers) recorded in industry; methodology adopted by agency. Further formal assessment in progress.
Grasp Pasture Production Calculator (Stand-alone program and databases, paper-based ready-reckoner, workshop materials)	Reaction with producers, KASA with agency staff	Positive reaction, mainly with staff to date, plus strong interest by producers in historical pasture growth patterns (particularly the extent of droughts in 1920s, 1930s).
Grasp/Herd-Econ case studies (Research simulation package; case studies)	Reaction	Verification and validation undertaken: further validation required. Documented change in reaction and practice among researchers, not yet affecting industry.
RISKHerd case studies (Simulation procedure, case studies)	Validation	Procedure verified, further validation still required; key evaluation measure will be whether funding is provided for follow-up (not yet known).
Additional project outputs		
Stream 2 case studies (Individual studies, regional reports, case study sheets)	KASA (some Practice informally)	Some documented change in practice among producers, producer groups and regional agency personnel; widespread positive reaction
Management process (Workshop documentation, this report)	KASA—within project and through assessment by Project Review Committee	Review Committee was generally positive in reaction, but this report is the next stage. Change in KASA among project participants is documented.

The only unequivocal determinant of this would be that some benchmark measures of sustainability improve. Such improvements would be hard to attribute to DroughtPlan or to the National Climate Variability R&D Program in particular, although circumstantial evidence may permit this. However, such measures are beyond the resources and lifetime scope of a single project such as DroughtPlan, so it is necessary for other bodies to provide the long-term view and repeated measurements which might permit such an evaluation. We believe that documentation associated with several of the DroughtPlan products could help with this process.

Further reflection on the evaluation of the project as a whole can be found in Section 6 on page 134, and there are various other outputs of the project (eg. Stream 2 reports and case studies) which have been mentioned earlier in the report.

Evaluation of Stream 5

The evaluation process was also designed to be applied to all other levels of the project, as discussed in Section 6. For Stream 5, the intended outcomes were:

- A written report describing the utility of seasonal forecasting to pasture, beef and sheep management.
- A written report describing detailed case study analysis of alternative risk management strategies that are conducted within a property management planning context and includes:
  - at least two beef enterprises from central Queensland;
  - at least two sheep enterprises from western Queensland;
  - at least two mixed grazing and grain properties from southern Queensland; and
  - an evaluation of the impacts of tax on the adoption of strategies in the property management plan.
- A written report of evaluation of opportunities to improve existing benchmark management strategies with 10 producer groups from the spear grass, brigalow and *Aristida/Bothriocloa* woodlands of Central Queensland regarding:
  - strategic pasture/cattle management issues such as conservative stocking rates and matching herd energy demands with paddock energy supplies; and
  - tactical stock management strategies during drought.
- A written report on the evaluation by producer groups from the mulga and Mitchell grasslands of western Queensland of:
  - the biological and financial consequences of alternative stocking rate strategies to manage climatic variability with emphasis on safe stocking rate strategies; and
  - decision support aids produced by this project.

Some of these outputs were achieved during the course of work under other Streams and have been reported there. The following Sections report on the evaluation of the Carrying Capacity Calculator to regions other than south-west Queensland, and on various approaches to assessing the value of the use of SOI-based forecasts in grazing management. A large number of case studies of risk responses to climatic variability were undertaken during DroughtPlan, to be found in numerous Stream 2 reports, Appendix 4E on 'Decision Trees' (see page 65), and the papers arising from GRASP (see page 85), the GRASP/Herd-Econ link (page 91) and RISKHerd (page 96). Evaluation products are summarised above, and additional investigations have related to the development of the *'Assessing your livestock management options'* workshop (see page 47).

References

O'Sullivan, D. 1996. *BB-SAFe, Review Results*. Memo, February 1996. 4 pp.

Stafford Smith, M. and Clark, R. 1994. *DroughtPlan Decision Support Workshop Report*. DroughtPlan Working Paper No.**3**, CSIRO Alice Springs. 13pp.

Appendix 5A: Evaluation approach

This appendix reproduces the final version of the document used in the DroughtPlan project to ensure a common approach to evaluation.

DROUGHTPLAN: EVALUATION OF PRODUCTS AND SERVICES WHY, WHAT IS IT, WHO BY, WHEN?

Why?

We need to show that we have done something useful

- to ourselves (confirm that the product is right, self-satisfaction, learning)
- to our clients and collaborators (show they have got value for their time
- to our funders (show they have got value for money, identify future priorities)

What is it?

Evaluation has two elements:

- ***during*** the project—an on-going process of assessing and learning whether we are on track with our products, so that we can adjust our course; and
- after the ***end*** of the project—providing information so that we (and others) can assess how successful the approach finally was.

Evaluation can happen at many different levels within the DroughtPlan project:

- individual activities or tools (for team members and customers)
- integrated training approaches (for team members and customers)
- the whole DroughtPlan project (for team members and stakeholders)

The first step in evaluation is making sure that a product or activity does what was intended. Ultimately, though, success is measured by changes in peoples' behaviour. 'Bennett's Hierarchy' defines seven upwards steps:

1. *Inputs*—objectives to allocate people, time and $
2. *Activities*—extension activities—sequenced to ensure interest (motivation), awareness, understanding, dealing with constraints, ensuring decision-making, trial, monitoring, re-evaluation, etc (the problem solving cycle)
3. *People*—target audience
4. *Reactions*—attitudes/perceptions
5. *KASA change*—change in Knowledge, Attitudes, Skills, Aspirations
6. *Practice changes*—change in behaviour
7. *End results*—outcomes of behaviour change

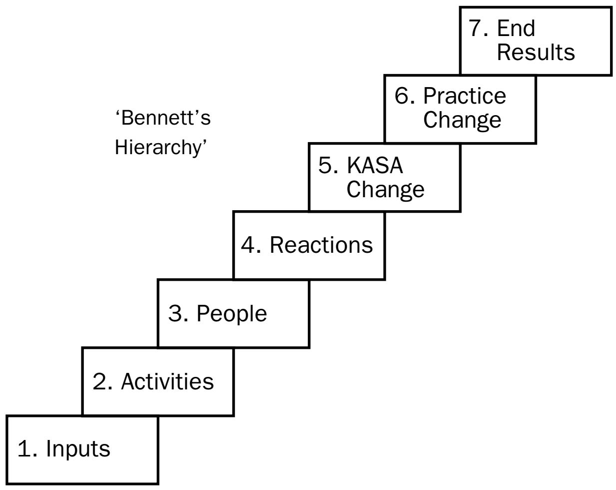


Table 7 on page 105 shows how these ideas could be applied in principle to different components of DroughtPlan.

Table 7
Criteria by which different project components might be judged at different levels of evaluation.

Level\Component	***Decision support tool †***	***Workshop activity***	***DroughtPlan overall***
1. Verification	Addresses problem; language is reasonable, etc.	Materials and process are internally correct (eg. facts correct, covers needs, etc)	Meet milestones as specified in contract
2. Validation	Tests with producers show that it is useable and meets their needs	Test workshop with ‘friendly’ producers meets their approval	Create outputs as specified in contract
3. Change in reaction	Unexposed producers spontaneously find it valuable **Desired:** • Unaware→aware • Easy to use • Easy to understand • Learning device • Useful for...	Unexposed producers wanting this type of training spontaneously appreciate its content **Desired:** • Aware of concepts • Interesting • Enjoyable etc...	Be able to demonstrate through evaluation of components that the outputs have been seen as valuable over wide regions **Desired:** • Useful • Professional etc...
4. Change in KASA	Evidence that producers have internalised knowledge relating to the tool, have gained the skill to use it in their decisions, and have adjusted their expectations relating to the decision it supports **Desired:** • Aware of/understanding (specific) principles • Can see new ways of making decisions • Find it interesting • Are able to use the tool • See value for regular use	Change in knowledge by most of workshop group discernible both immediately after and some later than the workshop, indicated by changes in aspiration and knowledge or skill not previously applied to problem	Be able to demonstrate change in KASA through evaluation of components, with significant geographic spread **Desired:** • Project team can document change in KASA
5. Change in practice	Evidence that management has actually changed as a result of the tool **Desired:** • Regular use as part of decision-making • Improvements in targeted management practices • Benchmarks improve • ‘Critical Success Measures’ improve	Evidence that the practices learned at the workshop are applied on-property by many individuals without external input (as appropriate)	Be able to show significant changes in industry-wide behaviour related to project outputs* **Desired:** • project personnel have changed their practices as a result of learning • Benchmarks of best practice have improved

† NB a decision support tool might be software, but it also might be a process like the ‘Decision Tree’ structuring of a problem—thus a user might take on a package or a set of principles.

* This one at least will be impossible during the time-frame of the project, but by having measures in place for the components it may be possible to infer on review some years later.

For us to apply Bennett's Hierarchy, we need to develop explicit questions about different products. The whole project level is up to the Management Committee! The other areas need to be considered by each product development team. If we accept this, then we need to ask customers the following types of example questions, adjusted for each product. As you read, jot down questions ***you*** might ask for the product you are involved with....

1 & 2: Verification/Validation

This is where most of our evaluation has been so far, confirming that the products do what we were asked to make them do in a general sense. We still need to document this.

- Do the products work in 'field tests' with producers?

3: Change in Reaction

- What do you think people know about the product?
- What do you think of the product?
- What stood out when you heard/took part in....?

4a: Change in Knowledge

- What did you learn? What do you understand about....(eg. the water cycle)?
- What are your alternative drought management activities?
- What is the effect of different re-stocking strategies on your property?
- What methods could you use to compare the cost of different management options?

4b: Change in Attitudes

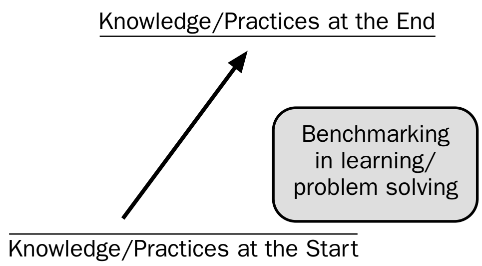
- How has your attitude towards climate prediction changed?
- How has your attitude towards using spreadsheets changed?

4c: Change in Skills

- How do you lay out a 'Decision Tree' about your next 12 months' management options?
- How can you calculate metabolic stocking rates?
- How do you 'assess your options' against each other?
- How do you run a spreadsheet?

4d: Change in Aspirations

- What do you plan to do differently about....?
- How can this product be integrated into your management?



5: Change in Practice

This will be hard to establish for most products during the life of the project, but we should be developing measures which could be looked at again in a few years if someone wants to in order to see whether there has really been an effect on industry. In this context it is vital to think about establishing benchmarks (see Figure above) at the *outset* of evaluation.

CIRCULATED IN JULY 1995.

Appendix 5B: Evaluation of the 'Safe' Carrying Capacity Calculator in SW Queensland

BY PETER JOHNSTON, STEVE GARRAD AND JULIE FROUSHEGER

This section reports work by the authors in the period July 1995 to June 1996 assessing the carrying capacity of properties in south-west Queensland and shows the application of the 'Safe' Carrying Capacity Calculator developed as part of DroughtPlan Stream 4. The Calculator developed in DroughtPlan is based on the spreadsheet we used to assess carrying capacity on properties as part of the project *'Appraising Safe Carrying Capacities for all Properties in south-west Queensland'*. This project and DroughtPlan have operated in a synergistic manner.

To date 62 properties have participated in carrying capacity assessments (12% of properties in the Bulloo, Murweh, Paroo, Quilpie and Tambo shires) covering 25,467 km^2 (11% of the area of the above shires) of south-west Queensland. An additional 20 properties are waiting to participate in assessments. Results show that application of the 'Safe' Carrying Capacity Calculator gives estimates similar to the current view of owners but appreciably less than the pre-1989 estimates of carrying capacity by the Queensland Department of Lands (see Table 8).

Table 8
Carrying capacity estimates—dry sheep equivalents (DSE) of 62 properties in SW Queensland

	DNR Estimate [1] DSE/100 ha	Owner Estimate [2] DSE/100 ha	Estimate with Carrying Capacity Calculator [3] DSE/100 ha	Change from DNR
Mean [4]	31	25	24	–30 %
Heaviest	77	88	88	12 %
Lightest	18	17	17	–6 %

1 Queensland Dept. Natural Resources estimate based on pre-1989 estimate by Queensland Dept. of Lands

2 May not represent actual livestock carried on property

3 Spreadsheet version of 'Safe' Carrying Capacity Calculator

4 Mean of 62 properties (mean area = 41,076 ha, largest = 667,432 ha, smallest = 5,368 ha)

Whether land management has changed as a result of the project's activities will be formally gauged in a project review being conducted in November 1996. The review will target four groups across south-west Queensland: (a) participating graziers, (b) randomly selected non-participating graziers, (c) government agencies and financial institutions working in south-west Queensland and (d) formal grazing industry representatives. Preliminary observations at two of these levels (participating graziers, land administration and financiers) are discussed below.

PARTICIPATING GRAZIERS

Despite some initial scepticism and a natural fear of Government regulation (eg. the draft tree clearing guidelines) the majority of participating graziers have found the exercise valuable in enhancing their knowledge of their properties and in questioning their stocking decisions. Johnson *et al.* have found that most participating graziers have an in depth knowledge of the land types found in the paddocks on their properties. In mapping and measuring the areas of land systems at the paddock scale, the carrying capacity project complements this knowledge. An improved understanding of the relative proportions of different land types and the long term forage productivity expected from them has in several cases lead to a re-evaluation of the livestock numbers allocated to specific paddocks (R. Rennick and M. Lyons *pers. comm.*) (ie. a change in land management following application and evaluation of a model).

Throughout the project it has been essential to work at the paddock scale. This is the scale most relevant to graziers as it is here that livestock stocking decisions are made and implemented. While working at the paddock scale is more time consuming than the whole property scale we believe it is the level necessary to have an impact on land management decisions.

LAND ADMINISTRATORS

The Queensland Department of Natural Resources has been concerned for several years that its traditional rated carrying capacities generally represented an over-estimation of the ability of land types in the mulga region to sustainably carry stock in the long term (Tannock, *pers. comm.*). The majority of these capacities were based on subjective judgments from early settlement up to the 1940s and 1950s and were no longer considered appropriate by local land managers and administrators. In 1989 the Queensland Department of Lands reviewed the carrying capacities on a number of properties in the Paroo and Bulloo shires of south-west Queensland based on the condition of 'benchmark' properties and the land system mapping for those properties. For the Murweh and Quilpie shires an across-the-board reduction was made (Tannock *pers. comm.*). While these reviews generally reduced grazing capacities, the process remained a subjective one.

As carrying capacities largely determine the value of land bought and sold, a review of these capacities directly affects the livelihood of individuals and the economy of the region. Any review of carrying capacities was therefore a sensitive issue. An objective assessment of carrying capacity for individual properties in south-west Queensland was therefore considered important by the grazing community (Warrego Graziers Association 1988, pp. ii), the Queensland Department of Primary Industries (Mills *et al.* 1989, pp.44; Miles 1989, pp.2,4) and the Queensland Department of Lands (Anon. 1993, pp.1,8,16).

Following an evaluation by two grazier consultants (Crichton 1995, Cooney 1995), Queensland Department of Natural Resources staff are now using the QDPI-developed methodology when reviews of individual properties are required. These staff are located at the Charleville and Cunnamulla offices and cover the Murweh, Quilpie, Paroo and Bulloo shires of south-west Queensland.

FINANCIERS

In April 1996 a seminar was presented to financiers from south-west Queensland. At the seminar the methodology, results and implications of the project were presented and discussed. While the major local banks and financial institutions (Westpac, Commonwealth, National Australia Bank and the Queensland Industry Development Corporation) were well-represented, there was poor attendance from the local pastoral houses and agents (Elders, Primac, Dalgety's and McCurran's).

There was strong interest from each of the banks in the methodology. They were attracted to the objective nature of the estimate of carrying capacity and its relevance to individual properties. They felt the information could complement other material used in making financial decisions.

During the seminar, questions regarding accessibility to the methodology and use of the ‘Safe’ Carrying Capacity Calculator were discussed. Current access to the methodology is limited to assessments by the Queensland Department of Primary Industries and the Queensland Department of Natural Resources. However, publication of the ‘Safe’ Carrying Capacity Calculator as a robust, stand-alone product through the DroughtPlan project will enable a wide range of users (graziers, consultants, financiers and other agencies) to have access to the methodology.

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Appendix 5C: Evaluation of GrazeOn as a tool to adjust stocking rates

BY DAVID COBON

BACKGROUND

GrazeOn has been produced to assist pastoralists make responsible decisions about the capability of paddocks to run grazing animals. GrazeOn incorporates a process of resource monitoring with objective measurements of the amount of pasture available for consumption by grazing animals. The demand for pasture by animals to produce meat or fibre is compared with the amount of available pasture in the paddock. Thus GrazeOn calculates grazing rates that balance the feed requirements of the animals that make up the total grazing pressure (sheep, cattle, kangaroos, horses) with feed availability. Since grazing rates are calculated by linking proven resource monitoring and newly researched pasture budgeting techniques, their implementation is likely to prevent overgrazing and degradation. Continued use of these grazing rates is likely to either maintain or improve sustainability of the land.

GrazeOn allows users to be progressive, and champion the use of technology such as climate and pasture growth forecasting, and incorporate the outcomes into feed budgeting. This approach opens windows of opportunity in the areas of drought preparedness and risk reduction.

VALIDATION

GrazeOn was tested on seven commercial properties and two research stations in central and north-west Queensland in 1995 and 1996. Stocking rates calculated by GrazeOn have compared favourably with estimates made by the managers in paddocks with average biomass, however GrazeOn stocking rates tended to be lower when biomass was limiting. Comparisons during good seasons have yet to be made but discussions with managers indicate that GrazeOn stocking rates could be higher when pasture is plentiful. These findings suggest a reduced likelihood of overgrazing during dry seasons but an opportunity for greater production during good seasons.

The economic performance of four of these properties was compared to a situation in which the properties were stocked at the beginning of each season according to GrazeOn's calculations. The exercise was completed using Herd-Econ which provides a means of comparing the economic performance of grazing strategies over long periods of time. A forty year period using rainfall variability from the nearest available meteorological station (with the necessary records) was used for each property. At the end of the forty years each property produced greater income (62–93%) by implementing the GrazeOn strategy compared to their current management and most of the benefit was gained by taking advantage of the pasture available during good seasons.

CHANGE IN KNOWLEDGE, ATTITUDES, SKILLS AND ASPIRATIONS

Observations and comments of people using GrazeOn show change in the following areas:

Knowledge

- Using photographs to estimate pasture biomass has been successful with pastoralists. Initially, the extent of their knowledge of objective biomass assessment is limiting however they find the photographs easy to compare with the pasture in the paddock and quickly get good at estimating biomass, in many cases without the need of photographs.

- The method of estimating pasture condition requires identification of species. Previously, pastoralists have only known the common names of major grasses and forbs. They gain a much better knowledge of the common and scientific names, growth patterns and survival mechanisms of different species, palatability of different species and their use as indicators of under or over-grazing, soil types, run-on or run-off areas, eroded or exposed areas, etc.

Attitudes

- Pastoralists are taking an objective rather than subjective outlook to management and are recognising the advantages.
- Pastoralists are recognising the importance of total grazing pressure and are now considering kangaroos and horses in management decisions.
- Pastoralists are now considering the area of paddocks that produces little pasture and reassessing carrying capacity as a result.

Skills

- Pasture plant identification.
- Pasture, soil and woody weed monitoring.
- Recognising indicators.
- Record keeping.

Aspirations

- Seen as a tool to assist pastoralists prevent further decline in the landscape.
- Can be used to show the community that the land is being managed responsibly.
- Offers an opportunity for pastoralists to responsibly make a profit from pastoralism, particularly during good seasons.
- Enables pastoralists to highlight possible feed deficits in the future providing an opportunity to prepare for drought rather than react to it.

FEEDBACK FROM PASTORALISTS

Comments from pastoralists who have seen or used GrazeOn include:

- exactly what is needed
- impressive
- crying out for use
- support development for other pasture communities
- gives good base-line data
- provides basis for a regional or larger monitoring program
- we need this for all of western Queensland
- pleased to see a looming tool
- readily adaptable to other pasture types
- has long-term benefits for the land
- good variety of functions
- practical tool for management
- progresses the industry into the next era of grazing management technology

Appendix 5D: Further development of methods to estimate carrying capacity

BY KENNETH A DAY, WALTER J SCATTINI AND JASON C OSBORN

OBJECTIVE

The aim of this study was to determine what changes are required to the 'Safe' Carrying Capacity Calculator developed by Johnston *et al. (*1996) in order to extend its use to other regions in Northern Australia. There were likely to be three key difficulties in extending the Calculator to other regions: (a) uncertainty as to whether safe levels of utilisation for south-west Queensland were applicable to other regions;
(b) lack of a suitable scheme to calculate pasture growth, and (c) lack of appropriately scaled land system mapping in other regions. The Central Burnett region of Queensland was used as a focused case study for assessing these issues.

SUMMARY

As a result of this study we have established that:

- safe carrying capacity as estimated by graziers was highly correlated with independent estimates of pasture growth;
- annual safe levels of utilisation of pasture growth differ between south-west Queensland and the Central Burnett;
- 20% utilisation of average pasture growth during the growing season is considered by graziers to be a safe level of utilisation for much of Queensland;
- land system mapping agrees closely with grazier perceptions of land types in the Central Burnett and, as such, can be used as a basis for calculating carrying capacity on a property basis; and
- a more general scheme for calculating pasture growth on a land type basis is needed and a prototype has been developed using the GRASP model for the Central Burnett.

INTRODUCTION

A number of recent studies (Scanlan *et al.* 1994, McKeon *et al.* 1994, Johnston *et al.* 1996) have shown how the concept of a safe level of utilisation of pasture growth can be used to calculate safe carrying capacity for grazing properties in Queensland. For properties in the Dalrymple shire, Scanlan *et al. (*1994) applied a rule for safe utilisation gained from interpreting research studies to examine safe carrying capacities nominated by graziers as well as the Queensland Department of Lands ratings. McKeon *et al.* (1994) proposed a conceptually-different approach. Recognising some of the limitations of research studies (eg. limited range of years, locations and land types studied), they proposed that rules of safe utilisation could be derived directly from (i) grazier knowledge and experience of safe carrying capacity, and (ii) calculation of pasture growth for a given land type, tree density and pasture condition. Johnston *et al.* (1996) have used this approach to calculate safe utilisation levels for properties in south-west Queensland (cf. 'Safe' Carrying Capacity Calculator on page 79).

In this study we have examined safe carrying capacity for the Central Burnett region of south-east Queensland applying the general steps employed by Johnston *et al. (*1996). In particular we have examined some of the likely difficulties in applying the 'Safe' Carrying Capacity Calculator described by Johnston *et al. (*1996) beyond south-west Queensland. We expected these difficulties to be as follows:

Safe Utilisation

The key concern in extending the Carrying Calculator beyond south-west Queensland was that safe utilisation levels of forage for south-west Queensland may be inappropriate for other areas. Differences in safe utilisation between regions might be expected for a number of reasons, including differences in average rainfall, rainfall variability, fertility, and grazing tolerance of grasses. Johnston *et al.* (1996) evaluated safe utilisation for a limited range of average annual pasture production (80–920 kg ha^{-1}). The range of average annual pasture production for native pastures in Queensland is much wider (*ca.* 0–6,000 kg ha^{-1}: cf. Day *et al.* 1997), so safe utilisation needs to be evaluated for more productive pastures if we are to derive more general rules for calculating safe carrying capacity.

Pasture growth

A second concern was the calculation of forage production. Johnston *et al.* (1996) developed a calculation of pasture growth which was based on location, land type and pasture condition (tree and shrub density), factors which were specific to south-west Queensland climate and the WARLUS land system mapping. To extend these calculations to other regions requires either extending the procedure developed by Johnston *et al.* (1996) based on 'rainfall-use-efficiency' or the development of an alternative procedure. Rainfall-use-efficiency is likely not to be the most appropriate basis to calculate pasture growth for other regions in Queensland. Pasture growth studies across Queensland (Day *et al.* 1997) suggest that other factors, such as temperature and nitrogen limitations to growth, significantly affect annual pasture production. These factors are less important in south-west Queensland where rainfall is the main limitation to growth, and growth is aseasonal with potential for winter growth by C3 grasses and forbs.

Land system mapping

A third anticipated difficulty in extending the Carrying Capacity Calculator beyond south-west Queensland, especially to areas with small paddocks/properties and high spatial variability in soil types (eg. southern speargrass), is the lack of sufficiently detailed land system mapping on which to base carrying capacity calculations. For the purpose presented here, the criteria for usefulness of land system mapping is that the mapping delineates and describes land types which are meaningful to the grazier in terms of production.

METHODS

We evaluated the above aspects of calculating carrying capacity in a study of benchmark properties in the Central Burnett region of south-east Queensland. Properties in this region are used to breed, grow and fatten cattle. The region is generally more fertile and has a higher annual rainfall than south-west Queensland. Temperature, soil water, frost and plant phenology are all likely to limit growth over the winter (June–August) period. As such this region provides a considerable contrast to south-west Queensland in terms of climate, soils, species, tree type and enterprise. The study of Scanlan *et al.* (1994) for the Dalrymple Shire provides further information on safe utilisation levels for the seasonally-dry tropical areas of Queensland.

In this Central Burnett study, we have followed the methodology and calculations employed by Johnston *et al.* (1996) closely. In particular we have used the same procedure of determining safe carrying capacities for benchmark properties. After consultation with a local property management and planning officer (J. Osborn), four graziers were selected who were considered able to provide experienced views as to the safe carrying capacity of their properties and land types.

Determining land types

To evaluate the appropriateness of land system mapping we asked graziers to define and map the land types on their properties for later comparison with land system maps. The graziers' maps formed the basis of the calculations presented for the Central Burnett properties. Land type maps were made as an 'overlay' to a recent air photo of the property. Land types were defined as units of land which the grazier believed were distinct in terms of potential productivity. Land types could be cleared, wooded or contain a mixture of timbered and cleared country. The land units thus defined were then matched against land system maps to provide an assessment of the appropriateness of land system mapping to identify meaningful land types on a property basis. 'Land type sheets', as used by extension officers for describing regional land types, were evaluated alongside land system mapping as (i) a basis for calculating pasture growth (below), and (ii) a means of extrapolating findings to other properties in the region.

Determining tree density

Tree and regrowth density was estimated for each land type on the property. This was achieved by first assisting the grazier to provide a map of areas of differing tree density over the property. The property was mapped into three or four subjectively chosen tree density classes (eg. cleared, scattered trees, thinned trees, dense trees). The tree density for each class was measured in the field using a Bitterlich gauge by selecting at least one representative area on the property for each class. On this basis a tree density (m^2 ha^{-1}) was assigned to each tree density class.

Determining safe carrying capacity

Graziers were asked to provide an estimate of long term safe carrying capacity both for their property as a whole and for each mapped land type. For land types with both wooded and cleared areas graziers could provide a carrying capacity either for the whole area or independently for wooded and cleared areas.

We believed that graziers would provide a better estimate of carrying capacity at a whole property scale rather than at a land type scale but would also be able to provide reliable *relative* estimates of individual land types. Hence the carrying capacities provided at a land type scale were multiplied by a weighting factor for each property:

$$\text{weighting factor} = \frac{\text{safe stock numbers (head ha}^{-1}\text{, property estimate)}}{\text{safe stock numbers (head ha}^{-1}\text{, sum land types)}}$$

Calculating safe utilisation

For the four properties and their component land types, safe utilisation was calculated as follows:

$$\text{safe utilisation(\%)} = \frac{\text{safe annual intake (kg ha}^{-1}\text{)}}{\text{annual pasture growth (kg ha}^{-1}\text{)}} * 100\ \%$$

Safe intake (kg ha^{-1} y^{-1}) is calculated as the product of (i) grazier-nominated safe carrying capacity (AE ha^{-1}) and (ii) an estimated annual intake of 2,800kg/year for an adult equivalent (AE). An intake of 2,800 kg AE^{-1} y^{-1} was calculated to be consistent with Johnston *et al.* (1996) as 400 kg DSE^{-1} y^{-1} * 7 DSE AE^{-1} (DSE=dry sheep equivalent). Annual pasture growth (kg ha^{-1} y^{-1}) is that estimated for an ungrazed pasture in good condition.

Calculating pasture growth

There is no simple system of determining pasture growth for different land types in south-east Queensland. However numerous pasture growth studies have been conducted and the pasture growth model GRASP has been parameterised for these study sites (Day *et al.* 1997). For the purposes of this study and to bring together the findings from the pasture growth studies, a simple expert system was derived to provide parameters for each land type in the Central Burnett as identified either in land system maps or graziers' 'land type' sheets.

This involved linking key Grasp parameters with relevant land types for the Central Burnett. Ten general soil groups were defined based on a gradient of soil texture and structure (see Table 9 below). Thirty-five pasture study sites from southern Queensland were classified as belonging to one of these groups. Pasture growth and soil parameters for Grasp (eg. for water holding capacity, transpiration efficiency, potential nitrogen uptake, potential regrowth rate and sward structure) were averaged for the sites in each group. Potential nitrogen uptake appeared to be too high for two groups (because the study sites were more fertile than average) and this was subjectively reduced. Two other parameters (rooting depth and nitrogen uptake) were subjectively modified within each group according to landscape position as indicated by tree community (see Table 9 below). These modifications were independent of the graziers' estimates of relative productivity.

The soil groups derived for this study were linked to local land system map units, local land type sheets and more general soil classifications (eg. Northcote 1979). Pasture growth study sites used to construct this scheme are from subtropical Queensland (east of the mulga lands to the coast). Thus the scheme could potentially be used throughout this zone.

Table 9
Land type basis for grouping Grasp parameters in sub-tropical Queensland.

Parameter Group	*Land Type Description*
1	Softwood scrub on light, non-cracking clay
2	Silver-leaved ironbark on light, non-cracking clay
3	Self mulching cracking clay (black earth) with: (a) silver leaf ironbark, and (b) blue gum
4	Grey and brown clays (flats) with (a) brigalow, and (b) box
5	Duplex (solodic) soils with box
6	Yellow or grey duplex soils (upland sediments) with narrow leaved ironbark and (a) wattles, and (b) spotted gum
7	Yellow or grey duplex (granite hills) with (a) blue gums, and (b) silver-leaved ironbark, or (c) red duplex (granite hills) with narrow-leaved iron-bark
8	Lithosols (shallow sandy soil on ranges) with (a) narrow-leaved iron-bark and wattle, and (b) narrow-leaved iron-bark and spotted gum
9	Deep sandy red earth (red tablelands) with: (a) narrow leaved ironbark and wattles, and (b) narrow leaved ironbark and spotted gum
10	Siliceous sandy alluvium (creek and river flats) with blue gums

User inputs

Each land type on each property must be classified into the correct soil and tree community group. This was easily achieved either by matching the grazier's descriptions of soils and trees of each land type with Table 9, or by matching the grazier's mapped land types with land systems map units. Tree basal area (as measured) was the only further input.

RESULTS

When combined with the study of Johnston *et al.* (1996), the evaluation of the Central Burnett properties and land types extends the range of average annual growth for which safe utilisation levels have been calculated to 100–6,200 kg ha^{-1}, which encompasses those expected for most non-fertilised pastures in Queensland. Together, these studies found that safe carrying capacity as estimated by graziers was highly correlated (R^2=0.79) with pasture production as independently estimated by pasture measurement and simulation (see Figure 18 on page 116).

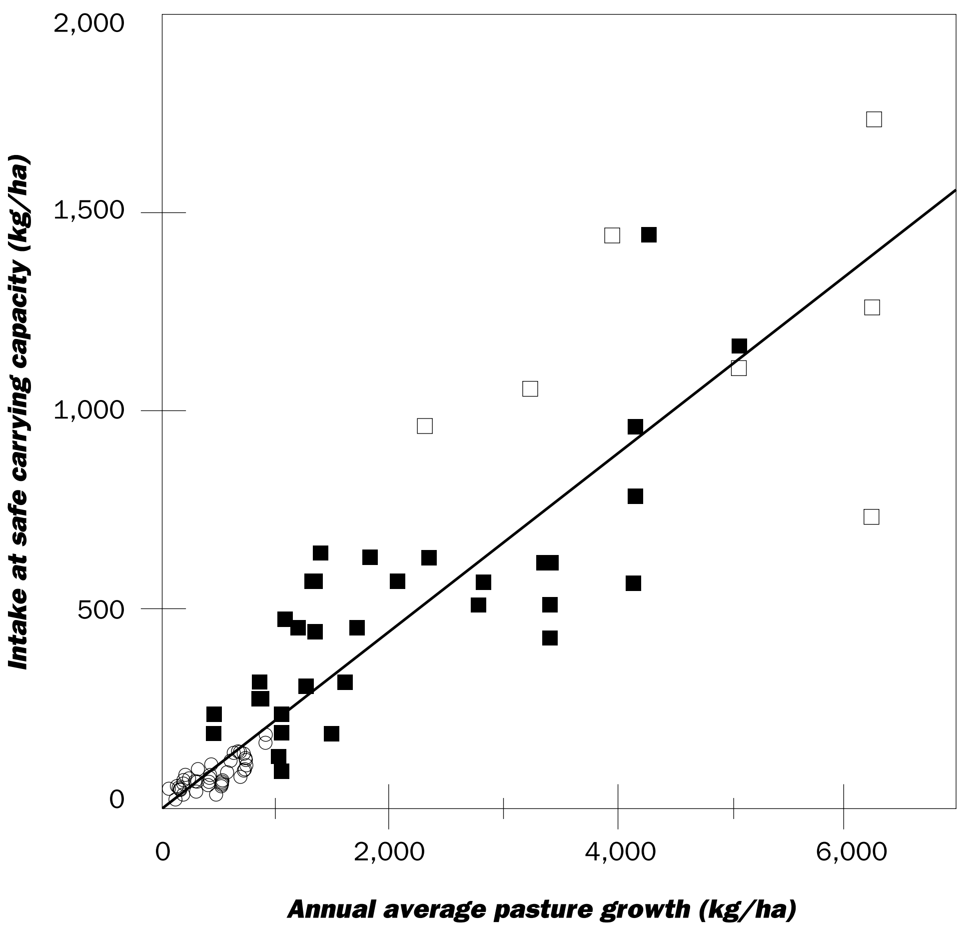
For 40 land units on four benchmark properties in the Central Burnett this study indicates a mean safe annual utilisation level of 27.3% (range 9.0 – 52.5%). The average utilisation calculated for individual properties was 26.9% (n=4, range 23.4 – 29.0%). The results were little affected by using the weighting factor (26.4% by land type and 27.4% by property).

The annual utilisation level of 27.3% for the Central Burnett land types was significantly higher ($p<0.05$) than the 21.3% (range 8.4 – 61.9%) calculated on the same basis for 38 land types on three benchmark properties in south-west Queensland (Johnston *et al.* 1996). However the result is similar to that for north Queensland (30%) as recalculated from Scanlan *et al.* (1994). This result suggests that safe annual utilisation of pasture production does vary from region to region.

Utilisation calculated over the growing season, as proposed by McKeon *et al.* (1994), was 22.8% for September to May in the Central Burnett, 21% for the whole year in south-west Queensland (Johnston *et al.* 1996) and 18% for November to April in the Dalrymple shire (Scanlan *et al.* 1994). These results suggest that about 20% utilisation over the growing season is a safe average level of utilisation over much of Queensland and over a variety of land types.

Figure 18

General relationship between animal intake (kg ha^{-1}) at a safe carrying capacity and annual average pasture growth (kg ha^{-1}) for two study areas: south-west Queensland and the Central Burnett. The points represent individual land types on benchmark properties. The slope of the line shown (0.227) represents safe utilisation (eaten/grown).



Land type descriptions

The land system study of the Central Burnett (D. Kent & P. Sorby unpublished) was found to agree closely with graziers' perceptions of the spatial distribution of land types on three properties in the Gayndah and Munduberra shires. A fourth property adjoined the western boundary of the study area of Kent and Sorby and is contained within the region currently being described by T. Donnollan (unpublished), which was unavailable at the time of preparing this report. On the basis of these findings we conclude that current land system mapping is appropriate for property scale land type descriptions. However we emphasise that, although the scale of land system mapping is the same for the Central Burnett as for south-west Queensland, the effective outcome is not because the scale of management is different. Land system mapping provides descriptions appropriate for the paddock scale in south-west Queensland but only for the property scale in the Central Burnett.

DISCUSSION

A general rule of safe utilisation?

The results of this study show that safe carrying capacity as estimated by graziers is highly correlated with pasture growth over wide range in annual average pasture growth (see Figure 18 on page 116). The analyses of grazier-nominated safe carrying capacity in three regions, the Central Burnett (this study), south-west Queensland (Johnston *et al.* 1996) and the Dalrymple Shire (Scanlan *et al.* 1994), suggest that average annual utilisation is lower in south-west Queensland than in the other two regions. However, when utilisation is calculated over the growing season (which differs in length between regions) the safe utilisation levels for each region are in close agreement at about 20%. The proposal that utilisation should be calculated during the growing season has been discussed by McKeon *et al.* (1994), and is based on the assumption that pastures are insensitive to grazing when dormant. This assumption is supported by results from a long term grazing trial in the Central Burnett where pasture condition deteriorated under heavy utilisation in summer but remained stable with heavy grazing only during winter (D. Cooksley, unpublished data). The variation in growing season from region to region warrants further investigation if carrying capacity calculations are to be made more widely on this basis.

What is still missing?

There are circumstances and regions where 20% utilisation of growth over the growing season is likely to be too high or too conservative. Lower utilisation levels may be appropriate where a grazier wishes to run constant stock numbers in regions with high variation in pasture growth from year to year, such as north-west Queensland. In south-west Queensland such variation may be buffered if stock have access to browse. Utilisation may also be expected to be lower in situations of poor animal nutrition (eg. long dormant season, phosphorus limitations), where there is a high proportion of unpalatable species, or where there are poisonous species. Plant species vary in their tolerance to grazing, so that higher utilisations may be feasible on sown species which have been selected for a higher grazing tolerance than native species.

Pasture condition, differential grazing across the landscape, and feral animals are all important components of calculating safe carrying capacity which are not explicit in the studies considered here. Johnston *et al.* (1996) and Scanlan *et al.* (1994) have discussed the importance of these factors. By using property benchmarks, it is possible that graziers have implicitly accounted for these factors in their estimates of safe carrying capacity. However, the fact that these factors are not explicit in the calculation is a deficiency of the methodology which will limit its application.

The wide range of safe utilisation levels for individual land types (see Figure 18 on page 116) could be used as a basis for arguing that there is no 'safe' level of utilisation but only a trade-off in terms of economics, management input (lifestyle), animal production and resource protection. It would be ideal if we could quantify different perceptions of risk, either between graziers or, for individual graziers, between one period in life and another. As this is probably not possible, the 'ultimate' Calculator would aim to calculate both financial and environmental risk of carrying more or fewer animals. These concepts have been explored by Day *et al.* (1997) and, more thoroughly, in *Working Paper 8* of DroughtPlan (McKeon *et al.* 1997).

Extrapolation of results

For the reasons presented above, and because we have not fully investigated the reasoning behind the graziers' estimates of safe carrying capacity, the extrapolation of these results to other regions and properties should proceed cautiously. In particular, benchmark properties should be studied in any region in which carrying capacity calculations are to be made. Such studies provide a reasonably robust basis for a carrying capacity calculation, and also develops 'ownership' of the calculation by graziers. Graziers can play a further role by providing the reasoning behind the choice of carrying capacity.

Land types

We believe that allowing graziers to define the land types on their property is a vital step in providing ownership of the calculations and builds on established practice in 'self-help' property management and planning (PMP). However, grazier-defined land types must be matched with a general scheme of land type description (eg. land type sheets used in PMP, or land system maps) to provide a general framework for pasture growth calculation and extrapolation of findings to other properties. This would appear to be less of a problem than at first anticipated, at least for the land system study examined in this publication.

Pasture growth

As part of this study we have developed an alternative scheme for calculating pasture growth from that used for south-west Queensland. We believe this scheme will be more readily applied across other areas of Queensland. It uses the pasture model GRASP and, at this stage, is developed for land types within the southern and central speargrass zones. General parameter sets for broad land types in this region have been developed which can be subjectively matched with various land type classifications. These general parameter sets provide most inputs for GRASP. However, as with the methodology of Johnston *et al.* (1996), tree basal area must be measured on site. Climate input can be directly linked to existing databases such as the rainfall data in AUSTRALIAN RAINMAN (Clewett *et al.* 1994).

Further development of the scheme presented here could be linked to the development of the user friendly version of GRASP (cf. page 85). The benefit of using GRASP is that it provides graziers with a tool to examine year-to-year, seasonal and daily variation in pasture production. Linking these developments will provide a better framework for parameterising GRASP for a property. However, a disadvantage of this approach is that a complex model such as GRASP is not as transparent to users as the simple relationship between rainfall and growth used in south-west Queensland.

CONCLUSION AND RECOMMENDATIONS

The calculation of safe carrying capacity for properties should be conducted more widely through Queensland and northern Australia. The methodology tested in this report provides a basis to integrate diverse and independent types of information—local experience and knowledge, land system mapping, pasture growth studies, grazing trial studies and modelling. This integration of knowledge represents a partnership between graziers and researchers to address carrying capacity and grazing management—a sensitive but key issue in the sustainable use of grazing lands. The work should not occur in isolation. It will be more likely to deliver changes to management if incorporated into a framework which is aimed at communicating key principles of strategic and tactical grazing management, as currently proposed by M. Quirk (*pers. comm.*).

The methodology promotes 'ownership' of the calculation by graziers. Not only is the product specific to the grazier's own property, but results are calculated for land types described in the grazier's own terms. Most importantly the calculation used is derived from grazier experience yet backed with findings from research.

The methodology presented here will also provide a quantitative basis for regional planning as it (i) links land types as perceived by graziers with technical 'land system' mapping, and (ii) links this descriptive base with key indices of sustainable and profitable production.

ACKNOWLEDGMENTS

The contributions by the graziers who participated in this study are gratefully acknowledged. We hope that your contribution to this study will benefit your property and district. We are also grateful to Greg McKeon, Joe Scanlan and Peter Johnston for laying the foundations to this work. We thank Greg McKeon for his valued insight in the preparation and critique of this document. The study would not have happened nor the report been as far reaching without Jeff Clewett's drive, enthusiasm and desire to kick goals.

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Appendix 5E: Evaluation of Seasonal Climate Forecasts in Grazing Management

OVERVIEW: MARK STAFFORD SMITH

OBJECTIVE

To assess and describe the utility of seasonal forecasting to pasture, beef and sheep management.

INTRODUCTION

A number of studies of the value of seasonal forecasting were carried out during DroughtPlan. Industry is increasingly acquiring knowledge of seasonal forecasts based on ENSO (El Niño Southern Oscillation) and considering ways to incorporate the knowledge into management. Many producers are now aware of the SOI (Southern Oscillation Index) and its potential use as a tool to help manage pastures and adjust stock numbers. No survey results are available on the adoption of SOI as a risk management tool, but some DroughtPlan staff have encountered the use of the SOI by many producers. Assessments in the past have been valued according to the impact of different year classifications on pasture growth, which, together with the experience in cropping areas, suggests a considerable potential for the use of the SOI for forecasting. A key purpose of the studies under DroughtPlan studies was to take this assessment on to animal production and the economic implications in a whole enterprise context.

OVERVIEW OF RESULTS

This section summarises the results of the three case studies on pages (No. 1 on page 123; No. 2 on page 128; and No. 3 on page 130). Study 1 relates pasture growth and SOI in sheep country in south-west Queensland (Clewett and Drosdowsky); Study 2 examines the effects on animal production around Charters Towers in north-east Queensland (McKeon *et al.*). Study 3 takes this through to whole enterprise economic implications in the same region (Stafford Smith *et al.*). Each of these studies is described in the following sections. The common threads which may be drawn out of them are as follows:

- Study 1 shows that years with very negative and very positive SOIs at a useful time for forecasting are clearly distinguishable from others in terms of the mean rainfall and consequent pasture growth. This result is for Charleville, but is likely to be true for much of rangeland Queensland.
- However, Study 2 shows for Dalrymple that, even if it is assumed that growing steers are available in appropriate numbers in any season to meet the desired stocking levels, a simple forecast strategy based on spring SOI in fact performs more poorly than a reactive strategy based on current knowledge in June, though both are notably better than the best constant stocking rate strategy.
- Once more realistic processes of reproduction and mortalities are added to affect the herd dynamics, as well as market prices to affect buying and selling of stock, Study 3 suggests that neither reactive nor forecast strategies (which are subject to market risk) significantly outperform constant strategies when there is only one decision point per year (in June for reactor, November for Forecast). The precise relativities are very dependent on prices for sales in drier years or purchases in wetter years and are affected by the liveweight gain model used, so this finding needs better quantification.
- Study 3 also found that a second decision point, such that both Forecast and Reactive strategies make an assessment in June and November with the forecast only using the SOI in November, improved the financial outcomes considerably. However, there are questions about simulation details in relation to this finding which need further elucidation.

- In both Studies 2 and 3, various measures of resource management are benefited by forecasting. In Study 2, opportunities to burn were more frequent and soil loss was less likely under the forecast strategy for a given level of animal production. Similarly, Study 3 showed that reactor and forecast strategies usually had a lower soil loss risk for given levels of (reasonable) economic returns than the constant strategies, and forecast out-performed reactor in some circumstances.
- In both Studies 2 and 3, perfect knowledge simulations considerably out-perform the reactive strategies, indicating that there is a real scope for new management approaches if forecasts can be improved even at the time when the SOI is currently available. In both cases some more speculative simulations based on possible future skills with climate models also looked at forecasts up to a year ahead. Again, perfect versions of these hold out considerable hope for improved economic performance as well as resource protection.
- In both Studies 2 and 3, it is apparent that modest changes in achieved utilisation rates can have substantial impacts on animal or economic production (far greater than those achievable through the use of forecasting). This finding reinforces the essential importance of getting stocking rates right, using whatever pattern (from constant to fully reactive) that managers may prefer over time.
- Finally, the assessments based on pasture growth, simple animal production and full enterprise economics provide somewhat differing outcomes because either (i) most real enterprises are unable to adjust stock numbers naturally to track the climate patterns to full advantage, or (ii) tracking by buying and selling stock introduces additional risks which mean the returns are unreliable, and (iii) incorrect forecasts and missed opportunities have greater downside risk implications in the more integrated models.

From these points I conclude:

1. Forecasting with the current skill and currently-suggested tactics based on SOI values has modest long-term *economic* benefits for grazing enterprises at present, at least in the Dalrymple Shire;
2. Forecasting with the current skill and tactics based on SOI values can already provide some benefits in terms of long-term resource protection;
3. Forecasting with possible future skill based on new climate modelling approaches has considerable potential for economic and environmental benefits in the future, and there may also be better tactics for using the current SOI skill; and
4. Important as the future of seasonal forecasting may be, a focus on getting the utilisation rates and associated stocking rate strategies right will have more immediate and bigger economic and environmental benefits.

There are some important caveats noted in the full reports of these studies; in particular:

- It is likely that neither Studies 2 (page 128) nor 3 (page 130) capture all the benefits that could be derived in a fully flexible fashion from forecasting, because of (i) the model formulation, (ii) the use of a conservative response function for forecast summer pasture growth and (iii) of the options of devising ever more sophisticated tactics, some of which are very region-specific. These factors understate the potential value of the forecast strategy. Conversely, Studies 2 and 3 use an annual liveweight gain model which does not correctly apportion intra-annual variability in liveweight. This may contribute to the overstatement of liveweight at the end of the dry season, exaggerating the value of stock sales in November for Study 3. This effect would tend to overstate the value of the forecast strategy as simulated.
- All three studies use the full period of weather data available for their regions (about 108 years). However, it is known that climatic teleconnections, at least as measured by the SOI, broke down for about three decades around 1930. Including this period in the simulations therefore gives a correct long-term evaluation but may under-estimate the current value of using forecasting. (Contrarily, the prospect of climatic change also means that the past century may not be a good guide for the future.)

- The economic benefits identified in Studies 2 and 3 certainly do not include the long-term feedbacks from the environmental opportunities—better use of fire to control woody composition and the eventual impacts on productivity of soil loss, especially on a spatial diverse landscape. However, these benefits *are* long-term, so even a tiny discount rate would minimise their additional economic value.
- The studies have identified some limitations in the simulation of (i) long-term vegetation change and (ii) liveweight gain. The latter flows through to effects on (iii) reproduction and mortality rates and (iv) the accuracy with which marketing of animals by weight is carried out. Additionally (v) outcomes are very sensitive to marketing tactics which are only moderately well understood. These limitations need correction.

In summary, there is value in getting utilisation rates correct. Once such changes have been made either on individual properties or through industry at large, there will be additional value in forecasting, especially as new techniques become available. This applies at the individual property level, where leading managers could already use the information, and in the industry at large, but here there are probably larger immediate gains to be made by concentrating on the management aspects. However, in a continent such as Australia which experiences such extreme climatic variability, any opportunity to help environmental management through forecasting must be taken seriously.

CASE STUDY 1:
USE OF THE SOUTHERN OSCILLATION INDEX (SOI) AS A DROUGHT MANAGEMENT TOOL

J.F. CLEWETT AND L. DROSDOWSKY

Introduction

Climatic variability and drought is a major risk of agricultural industries in Australia. Knowledge of the El Niño/Southern Oscillation (ENSO) effect, and its impacts on rainfall, crops and pasture growth can help pastoralists to reduce risks in their decision making (Nichols 1985, Hammer *et al.* 1991, Willcocks *et al.* 1991, McKeon & Howden 1992, Partridge 1994). Many pastoralists in the sub-tropical pastoral zone of eastern Australia adjust their stock numbers in autumn for the year ahead. Decisions are based upon the amount of standing feed and expected rainfall. This case study (see also Clewett and Drosdowsky 1995) examines the use of the Southern Oscillation Index (SOI) for management decision making in this zone by considering relationships of SOI with rainfall and pasture growth at Charleville in south-west Queensland.

Methods

Australian Rainman (Clewett *et al.* 1994) was used to evaluate the influence of ENSO on rainfall. The Grasp model (version dated 4 May 1995, but in principle similar to that described on pages 85–89) was used to examine the influence of ENSO on pasture production, by simulating pasture growth over a 108-year period (January 1887–December 1994) for a typical Mulga lands pasture on a red earth soil at Charleville in south-west Queensland. Charleville was chosen because it is located centrally in the sheep pastoral zone of eastern Australia and is thus a good indicator site to assess the impacts of El Niño. The area is also one of high risk for wool production compared to southern areas of Australia (Scoccimarro *et al.* 1994), and a considerable amount of pasture research that has been conducted in the region since the late 1960s. The site has a carrying capacity of 3 ha DSE^{-1} (DSE = dry sheep equivalent).

Input weather variables were daily rainfall, and monthly means (for each month) of maximum temperature, minimum temperature, vapour pressure deficit, radiation and pan evaporation. Key site parameters were pasture rooting depth (90 cm), available soil moisture storage in pasture root zone (43 mm), rooting depth of trees (150 cm), soil nitrogen availability (22 kg ha^{-1} yr^{-1}), tree basal area (0.5 m^2 ha^{-1}), transpiration efficiency of pasture (11 kg ha^{-1} mm^{-1}).

Two simulations are reported, one ungrazed and the other grazed at 31 sheep per 100 ha, which is equivalent to 15% utilisation of the average annual pasture growth (783 kg ha^{-1}) (15% represents the community's views of a long-term safe stocking rate). In the ungrazed simulation the mean grass basal area (GBA) was 310 m^2 ha^{-1}; in the grazed case, GBA was reduced to 250 m^2 ha^{-1} to account for the impact of grazing on the plant community. So that years were independent in evaluating relationships with the SOI, values of soil moisture and plant yield were reset to their long-term means on 1st May each year. The impacts of non-domestic grazers are not simulated.

The results were then analysed in Australian Rainman. The relationships between ENSO and other variables are described in terms of changes in means, medians, probability distributions and correlation coefficients. In addition, *% Effect of ENSO* is defined as:

$$\%\ Effect\ of\ ENSO = (P-N)\ /\ 2\ /\ M\ *\ 100$$

where *P* = Mean value of the attribute in years when the SOI is >+5
N = Mean value of the attribute in years when the SOI is <–5
M = Mean value of the attribute over all years

For example, for the average rainfall given in Table 12 on page 125 the calculation is:

% Effect of ENSO = (574—400)/2/489 *100 = 18 %

Table 10
Long-term monthly means and medians of observed rainfall and temperature, estimated pan evaporation and simulated growth of ungrazed native pasture at Charleville.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)													
Mean (mm)	67	68	60	33	32	28	28	21	21	35	41	57	*490*
Median (mm)	45	50	30	18	22	20	16	10	8	23	25	45	*464*
Max Temp (C)	35	34	32	28	23	20	19	21	25	29	33	35	*28*
Min Temp (C)	22	21	19	14	9	5	4	6	9	14	18	20	*13*
Pan Evap (mm d^{-1})	12	9.9	8.3	6	4.2	3.4	3.7	4.7	6.5	8.7	11.4	12.8	*7.6*
Pasture Growth													
Mean (kg ha^{-1})	80	91	109	86	54	77	47	58	66	65	53	69	*855*
Median (kg ha^{-1})	46	58	43	32	32	33	22	36	36	20	14	40	*721*

Results and discussion

Both rainfall and pasture growth at Charleville are slightly summer dominant (Table 10 above). Low temperatures and rainfall reduce pasture growth in winter, but summer is often hot and dry.

Average values of the SOI from late summer to mid autumn (January to March) are not useful indicators of future rainfall or pasture growth (Table 11 below). Australian Rainman shows this to be true for rainfall in most parts of Australia, as recognised by the Bureau of Meteorology in their Seasonal Climate Outlook service. Thus, the SOI is not a useful indicator of future seasonal conditions for primary producers who develop critical plans in autumn.

By contrast, winter (May to July) values of the SOI *are* useful as indicators of future rainfall and pasture growth up to the end of following autumn (Table 11), thus providing a nine-month outlook. The SOI could be used as a managerial tool in reviewing stocking decisions made in the previous autumn or as an early warning for adjustments that will be required next autumn.

Table 11
Seasonal relationships at Charleville of SOI with rainfall and simulated estimates of pasture growth for various periods up to a year. (% effect of ENSO is defined in text.)

		Rainfall (mm)			Pasture Growth (kg ha^{-1})		
SOI Forecast season	Rainfall/Growth period	Mean	Correlation coeff.	% Effect of ENSO	Mean	Correlation coeff.	% Effect of ENSO
Jan to Mar	Apr to Jun	93	0.13	5	207	0.02	5
Feb to Apr	May to Jul	88	–0.05	–1	169	0.10	12
Mar to May	June to Aug	77	0.12	14	169	0.11	16
Apr to Jun	Jul to Sep	70	0.23	15	155	0.18	18
May to Jul	Aug to Oct	76	0.29	26	174	0.26	36
Aug to Oct	Nov to Jan	165	0.24	19	184	0.29	52
Nov to Jan	Feb to Apr	158	0.19	26	257	0.28	46
May to Jul	May to Jul	88	0.36	38	169	0.33	44
May to Jul	Aug to Oct	76	0.28	26	174	0.26	36
May to Jul	Nov to Jan	165	0.16	7	184	0.27	39
May to Jul	Feb to Apr	158	0.1	16	257	0.15	14
May to Jul	May to Apr	488	0.31	19	788	0.37	29

Table 12
Relationship of average SOI (May–July) to annual values (May–April) of climate and soil water balance variables, estimated by GRASP. (% effect of ENSO is defined in text).

Variable	*Average SOI (May–Jul)* Below –5	Above + 5	*All Years*	*% Effect of ENSO*
Mean maximum temperature (C)	28.6	27.9	28.3	1%
Mean minimum temperature (C)	13.2	13.5	13.4	1%
Mean vapour pressure deficit (hPa)	23.5	21.1	22.3	5%
Mean pan evaporation (mm d^{-1})	7.5	6.8	7.1	5%
Soil evaporation (mm $year^{-1}$)	220	275	256	11%
Soil evaporation (as % of rainfall)	56%	48%	53%	
Transpiration (mm $year^{-1}$)	56	124	93	38%
Transpiration (as % of rainfall)	14%	22%	19%	
Run-off (mm $year^{-1}$)	56	59	57	1%
Run-off (as % of rainfall)	14%	10%	12%	

SOI is related more strongly to pasture growth than rainfall (see Table 11 on page 124 and Table 12 above). A compounding effect on pasture growth results from the effect on climatic variables other than rainfall. When the SOI is negative, rainfall is less, pan evaporation and vapour pressure deficit are greater, and a higher proportion of rainfall is evaporated from the soil or runs off (Table 12).

Grazing increased the effect of ENSO on pasture growth. Comparing the mean, median and probability distributions of years when SOI<–5 in winter (May–July) to years when SOI>+5 in winter (see Table 13 on page 126), *% Effects of ENSO* are:

Rainfall 18 % based on the mean, 20 % based on the median

Ungrazed pasture growth: 30 % based on the mean, 37 % based on the median

Grazed pasture growth: 32 % based on the mean, 42 % based on the median

Grazing reduces plant cover which increases soil evaporation and hence reduces transpiration and growth. GBA is reset each year in the simulations reported here, but grazing can also reduce the density of tussock plants in dry years. The resulting downward spiral may be reversed through pasture regeneration in wet years.

In the grazed simulation, five years out of 24 (21%) had pasture growth <200 kg ha^{-1} when winter SOI<–5 (see Table 13, column 1 on page 126). This would not be sufficient growth to sustain grazing unless plenty of feed was carried forward from the previous year, so that a reduction in stock numbers or feeding would be necessary to avoid land degradation. In contrast, pasture growth of <200 kg ha^{-1} did not occur in any of the 30 years where winter SOI>+5.

Conclusions

Winter SOI values could be useful to assist pastoral decision making. The probability distribution of annual pasture growth in years when winter SOI<–5 is substantially less than in all years. Thus, the risks of lost animal production, over-grazing, land degradation and increased animal feeding costs are higher in these years. The reverse occurs when winter SOI>+5.

However, many primary producers make important management decisions during autumn when climate forecasting has low skill. Future climate research needs to target this ‘predictability gap’.

Table 13
Relationship of average SOI (May to July) with annual (May to July) rainfall and pasture growth simulated with GRASP.

		Years when average SOI (May–Jul) was:			All Years
		Below—5	—5 to + 5	Above + 5	
Annual Rainfall					
% years with rain at least	200 mm	88	98	100	96
	300 mm	64	87	83	81
	400 mm	44	62	74	61
	500 mm	28	35	54	39
	600 mm	16	21	41	25
	800 mm	4	7	12	8
Number of years in historical record		25	56	31	112
Lowest rainfall on record (mm)		135	194	229	135
Highest rainfall on record (mm)		846	1,160	1,315	1,315
Median rainfall (mm)		357	448	541	457
Average rainfall (mm)		400	483	574	489
Annual Pasture Growth (Ungrazed)					
% years with growth at least	200 kg ha^{-1}	79	98	100	94
	400 kg ha^{-1}	58	81	93	79
	600 kg ha^{-1}	33	56	80	57
	800 kg ha^{-1}	25	45	66	46
	1,000 kg ha^{-1}	16	28	53	32
	1,250 kg ha^{-1}	12	18	33	21
Number of years		24	53	30	107
Lowest pasture growth (kg ha^{-1})		89	153	360	89
Highest pasture growth (kg ha^{-1})		1,584	2,170	2,387	2,387
Median pasture growth (kg ha^{-1})		501	713	1,034	713
Average pasture growth (kg ha^{-1})		585	845	1,085	854
Annual Pasture Growth (Grazed at 31 DSE per 100 ha)					
% years with growth at least	200 kg ha^{-1}	79	98	100	94
	400 kg ha^{-1}	54	75	90	74
	600 kg ha^{-1}	29	54	66	52
	800 kg ha^{-1}	20	33	60	38
	1,000 kg ha^{-1}	12	22	43	26
	1,250 kg ha^{-1}	8	16	26	17
Number of years		24	53	30	107
Lowest pasture growth (kg ha^{-1})		75	125	304	75
Highest pasture growth (kg ha^{-1})		1,505	2,143	2,367	2,367
Median pasture growth (kg ha^{-1})		425	613	938	613
Average pasture growth (kg ha^{-1})		519	773	1,013	783

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CASE STUDY 2:
UTILITY OF SEASONAL CLIMATE FORECASTING TO BEEF PRODUCTION

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Introduction

This study evaluates the utility of the Southern Oscillation Index (SOI) as a tool for managing beef production from open woodlands in north-east Queensland via manipulation of stocking rates. The results reported here are presented more fully in DroughtPlan Working Paper 8 (McKeon *et al.* 1997).

Methods

The GRASP model (see page 85) was used to simulate the following stocking rate strategies:

1. constant stocking rate;
2. stocking rate changed in June each year to eat a constant proportion of the standing dry matter in June (reactive strategy);
3. stocking rate changed in November each year to eat a constant proportion of forecast growth based on August–October SOI (SOI forecast strategy);
4. stocking rate changed in June each year (as in point 2 above) but modified by a perfect forecast of August–October SOI (reactive + forecast strategy); and
5. stocking rate changed each year in June to consume a constant proportion of the future year's growth (perfect knowledge strategy).

Simulations were carried out for the whole range of possible stocking rates and proportions using 110 years of daily climate for Charter Towers (1887–1996). Strategies were compared in terms of steer liveweight gain (LWG) per hectare, steer LWG per head, risk of weight loss, pasture availability, frequency of burning and soil loss.

Results

Some key results are shown in Table 14 on page 129. For liveweight gain per ha, the % advantages of the best flexible strategies 2–5 over the best constant stocking rate were 20, 10, 24, 44% respectively. For the constant strategy maximum LWG/ha was achieved at 30% utilisation of average annual growth. The strategies based on SOI-forecast growth in November were not superior in terms of LWG/ha to strategies based on known June standing dry matter. However the SOI-strategy increased LWG/head and frequency of pasture burning.

These simulation studies indicate that varying stocking rate in June by modifying the strategy based on standing dry matter **with a perfect forecast August–October SOI** would increase LWG/ha by 9% (25.2/23.1), reduce the risk of liveweight loss by 57% (from –3.9 to –1.7kg/hd), reduce risk of low pasture yield, but would increase the risk of soil loss (4%). Alternative strategies could also be developed which could reduce soil loss by 7% (955/1,022) without reducing production (LWG/ha). Future work will concentrate modelling feedbacks of changes in resource condition on cattle production.

References

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Table 14
Key results of simulation of grazing strategies with GRASP (see Table 1 in DroughtPlan Working Paper 8 for more details)

Treatment	Stocking rate (hd km^{-2}) Mean	%CV	Utilisation %	LWG kg ha^{-1}	LWG kg hd^{-1}	Years <100 kg hd^{-1} %	Years fire possible %	Soil loss kg ha^{-1} y^{-1}
June change in stocking rate								
Perfect 40%	27.8	36	38	29.2	99	48	9	1,333
Perfect 30%	21.0	36	29	24.7	112	33	31	1,064
Reactive 60%	31.2	47	42	24.3	79	57	1	1,349
Reactive 40%	24.3	41	33	23.1	96	43	12	1,022
Reactive 30%	19.3	40	27	20.7	107	33	36	975
Constant 40%	26.7	0	35	20.3	76	47	18	1,270
Constant 30%	20.0	0	27	20.2	101	36	44	1,091
Constant 20%	13.4	0	18	15.6	117	28	60	908
Reactive&SOI–50%	21.4	49	30	23.0	105	32	22	955
Reactive&SOI+50%	26.5	46	36	25.0	93	46	6	1,128
Reactive&SOI±50%	23.9	58	33	25.2	102	37	16	1,062
November change in stocking rate								
Perfect 35%	25.1	33	37	27.3	102	45	6	1199
Perfect 30%	21.6	33	32	24.8	109	36	14	1,009
Constant 40%	26.9	0	37	19.9	74	50	8	1,320
Constant 30%	20.2	0	29	19.9	99	33	33	1,112
Constant 20%	13.4	0	20	15.6	116	22	55	920
SOI Forecast –50%	16.9	28	25	18.7	110	26	39	992
SOI Forecast +50%	23.0	20	33	22.4	95	39	27	1,236
SOI Forecast ±50%	19.7	40	29	21.3	106	32	29	1,096

Perfect 40%: stocking rate changed to eat 40% of known future pasture growth over the next year

Reactive 60%: stocking rate changed to eat 60% of June standing dry matter over the next year

Constant 40%: stocking rate held constant to eat 40% of long-term average growth

Reactive & SOI –50% or SOI forecast –50%: stocking rate reduced by 50% in El Niño years (SOI<–5) below base treatment

Reactive & SOI +50% or SOI forecast +50%: stocking rate increased by 50% in La Niña years (SOI>+5) above base treatment

Reactive & SOI ±50% or SOI forecast ±50%: stocking rate reduced by 50% in El Niño years and increased 50% in La Niña years compared to base treatment.

For June the base treatment was stocking rate changed to eat 40% of pasture standing dry matter and multiplied by 0.5 in El Niño years and 1.5 in La Niña years.

For November the base treatment was stocking rate set to eat 30% of long-term average pasture growth and multiplied by 0.5 in El Niño years and 1.5 in La Niña years.

CASE STUDY 3: WHOLE ENTERPRISE IMPLICATIONS OF USING SEASONAL FORECASTING

MARK STAFFORD SMITH, GREG MCKEON, ANDREW ASH, ROSEMARY BUXTON AND JOSEPH BREEN

Summary

This section reports the results of a study of the value of using SOI forecasts for the management of property stocking rates in the Charters Towers region of northern Queensland. The study was carried out as a simulation case study using the linked **GRASP/Herd-Econ** model (see page 91). The study involved linking the two models together; establishing an appropriate parameter set for the pasture and animal growth model; adding a realistic vegetation change sub-model; defining the suite of strategies which pastoralists in the region might use; identifying appropriate marketing and management strategies; defining costs and prices associated with these, and then running the simulations. This was the first full case study using the new model. Studies show that the model is sensitive to assumptions about buying and selling decisions, and long term impacts on vegetation condition. The effects of prices are significant but predictable, and errors in the relationships driving herd dynamics may have only modest impacts. Simulations showed that financially-optimal stocking targets could be defined for different stocking rate management strategies, and the interaction between these targets and their riskiness could be readily assessed on various measures.

Forecasting strategies appear to have limited benefit for grazing enterprises in the region given today's skills with the SOI, but improved skill has considerable potential both to improve economic returns and to help protect the resource.

Background

DroughtPlan Working Paper 8 (McKeon *et al.* 1997) describes the details of how GRASP has been developed and validated against a range of pasture types, and concludes with an analysis of the value of the SOI to beef fattening alone. DroughtPlan Working Paper 9 (Stafford Smith *et al*. 1996) summarises the implications of carrying this understanding through to the whole enterprise level.

Table 15 on page 131 illustrates the idealistic management strategies that could be adopted by producers (Stafford Smith 1992, McKeon *et al.* 1993) with their implications for two general regions and types of enterprise. As it shows, the framework that we apply here to cattle in the Charters Towers region could be applied elsewhere in the country. Each of the main strategies shown can be applied at a variety of target stocking levels, expressed in terms of numbers for the constant strategy, and in terms of utilisation levels for the others. Furthermore, each can be implemented with an indefinite variety of tactical approaches to buying, selling, agisting, feeding and market access. For this study, we have defined what seem to be typical approaches for the region, derived from those in Table 15 but much more precisely defined (details in DroughtPlan Working Paper 9).

There are several limitations to the model as it stands, discussed in detail in DroughtPlan Working Paper 9. Two important ones here are that (i) liveweight gains are simulated on an annual basis so that liveweight differentials between the two main marketing times may not be correct (November sales may be overvalued) and (ii) the relationships supplied for forecast pasture growth under different SOI conditions were conservative (and even with today's skill, there may be other SOI tactics which work better than those tested). Both issues are now being examined.

Results

For all strategies, the variability of cash flow increases as target stocking levels increase. Strategies based on buying and selling generally show higher levels of cash flow variability, but in some cases are able to operate at higher long-term utilisation levels without damaging pasture productivity or obtain their optimum financial performance at lower long-term utilisation rates than constant stocking rate strategies. From about the stocking level targets which appear to give the best long-term financial performance, significant pasture collapses eventually happen after a series of extreme seasons in all strategies.

A forecasting strategy based on one decision point per year outperforms constant or reactive (single decision point) strategies. Strategies with two decision points per year seem to outperform all of these substantially (see Table 16 on page 132), but this may be confounded by the growth rates issue mentioned above. A reactive strategy with two decision points marginally outperforms the equivalent forecast strategy. A ‘proactive’ strategy, using a perfect wet season forecast for a single decision point in May, considerably outperforms a November forecast. However, the detailed management responses that could be made with such a long term forecast have not been explored fully with producers. There are probably considerable additional benefits to this information which are not captured by the simplistic implementation here.

Table 15
Outline of example production systems

Strategy	***Principal goals***	***Cattle in north***	***Sheep in south***
	[NB there are non-pasture strategies too—eg. respond to market only, animal condition only—see Stafford Smith 1992]	eg. Brian Pastures: 700 mm rain: turn-off steers April–May at end of growing season; calving Oct, wean April–May; nutritional stress July–August; main deaths October–December; pasture burning in October	eg. Port Augusta region: 300 mm rain: two main times for shearing—after summer or after winter, associated with lambing; main reliable rain in winter
Constant	Constant target	**May:** adjust to normal target numbers (do not capitalise on good looking years) *In extremis: maybe feed (if pre-wet) or lighten off anytime* (deaths a key simulation criterion)	**February shearing**—adjust to normal numbers in March *[Winter failure—maybe sell in October]* September/October shearing—adjust to normal numbers in October
Reactor	Respond to current pasture amount only +/- ‘normal’ season ahead	**May:** assess pasture yield; calculate S/R for next year (+/– assuming wet will come); make buy/sell decision for year *[If spring rain, maybe buy in] Wet season failure: maybe feed, maybe sell early (February/March)*	**February shearing**—adjust to number based on current yield and typical winter September/October shearing—adjust to actual forage post-winter (ignore possible summer rains)
Forecast	Respond to current pasture condition + SOI-corrected growth expectation for season	**May:** sales like reactive *[alternatively assume the forecast now and sell anything at risk such as cows likely to drop in October–December]* **Oct:** 2nd muster, 2nd weaning, etc; assess quality and timing of wet; adjust numbers for best bet S/R for target utilisation given SOI level; if bad, sell/feed/agist those at risk	...is there skill?
Perfect Knowledge	As forecast but using known ‘future’ data (simulation baseline)	As forecast, but uses known pasture growth in October based on actual summer rain	Can still try this by adjusting to actual coming year.

(normal text is basic strategy; *italics show possible complications*)

There are a wide range of alternative measures available from the simulations for the strategies, including variability of cash flow, animal numbers, animal biological performance, ground cover, pasture condition, potential soil loss, and post-tax analyses of the cash flow outputs. These provide a picture of the risk response of each strategy in terms of financial variability and potential environmental damage. These are discussed more fully in DroughtPlan Working Paper 9.

Table 16
Key outputs for the target stocking level for each strategy which is simulated to achieve the highest mean annual cash flow (DroughtPlan Working Paper 9 contains a full listing).

Strategy/Target	Utilisation achieved (%)	Annual cash flow ($) Mean	SD	'Gain' ** (%)	AEs in January (450 kg steer equivalents) Mean	SD
Constant						
1,750 cows	32.7	* 65,673	158,221	0	3,712	667
Reactor (June)						
20%	33.7	* 70,033	492,804	6	3,802	1,295
Reactor (June+grwth)						
10%	32.9	* 75,616	425,449	14	3,727	784
Forecast (November only)						
20%	30.7	* 95,047	444,684	43	3,415	768
Perfect (November only)						
20%	34.0	* 134,758	550,354	100	3,724	1,262
Reactor (June & November)						
20%	28.7	132,828	175,727	74	2,896	182
Forecast (June & November)						
17.5%	28.4	128,531	408,469	70	3,003	768
Perfect (June & November)						
22.5%	37.2	155,889	618,701	100	4,122	1,444
Proactor						
10%	39.1	* 120,082	464,843	—	4,333	1,053

* these strategies are comparable in the sense that they all involve a single stocking decision per year, whereas the remainder (shaded) involve two.

** gain in cash flow over the constant strategy relative to the appropriate perfect knowledge strategy (ie. single decision point strategies are compared with the single decision point Perfect Knowledge, etc)—calculated as (Mean cash flow—constant cash flow)/(Perfect cash flow—constant cash flow) * 100%

The analysis of alternative strategies for the northern speargrass zone highlights three points.

1. Across many different ways of managing stock numbers, ***optimal financial returns seem to be obtained at a broadly similar level of achieved utilisation***—30–35% in this particular vegetation type (NB: we would expect this value to vary depending on the short and long-term resilience of the pasture type). This level seems to relate whether a crash in pasture composition occurs at some stage during the century; this has two implications:
   - ***it is important that changes in pasture composition are simulated correctly***; if extreme events are actually dis-proportionately more important than simulated, then increased damage is likely to occur under a strategy which results in greater year-to-year variability at a given mean utilisation (the converse would also be true); and
   - the significance of this to the predicted optimal stocking rate depends on the particular climatic sequences simulated—if a catastrophic drought occurs early on, then optimal stocking levels are lower because more of the simulation is likely to be in a degraded state. This effect was highlighted by the analysis of net present values from different times during the run, but would have been much more extreme if the actual climatic sequence had been similarly modified. ***Simulations using only short climatic sequences can therefore be very misleading***.

2. However, the actual mean ***cash flow achieved at this utilisation differs considerably between strategies***, so that a given financial return can have very different implications for resource protection in terms of soil loss risk and change in pasture composition.
3. Simulating beef production per ha only (ie. DroughtPlan Working Paper 8) provides a reasonable indication of the likely trends in terms of comparing strategies, and is far quicker than carrying out these full simulations. However, the relativities between stocking levels and between strategies are significantly different, and clearly dependent on external pricing patterns as well as secondary productivity. Thus ***the full simulation is needed to make sense of whether the beef production changes are actually significant to producers in the context of their whole enterprise***.

Implications for forecasting

The simulations of DroughtPlan Working Papers 8 and 9 show very modest gains for grazing enterprises from using Forecasting based on the current levels of skill with the SOI. This is despite the Charters Towers region being the area of Australia where the information is most useful. The present simulations include the 1920–1950s period when the SOI/rainfall relationship broke down, and, as indicated earlier, used a conservative assessment of forecast summer pasture growth. These factors may have under-represented the value of SOI forecasts a little, if we can be confident that the relationships will hold in the near future. However, the gains for economics are sufficiently marginal that it is not surprising that industry is hesitant to take up the idea. The gains may be more important in terms of resource protection.

However, both sets of simulations indicate that there **is** a considerable margin to be gained from a better ability to predict future seasonal conditions, so this work should certainly continue. The development of case studies such as these allows researchers to test the value of different forms and timings of new indices before investing in marketing them to industry. Additionally, it allows industry to begin to explore how it might be able to use new information before it is actually available, in turn helping to set priorities for the research.

In the immediate term gains could be made by close attention to buying and selling tactics in dry years. A more sophisticated risk analysis of these is needed.

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SECTION SIX

Reflections on research, management and evaluation processes in DroughtPlan

MARK STAFFORD SMITH

Objective

To apply action learning principles at all levels in the project, including the evaluation of the project itself.

Summary

This section summarises the principal investigator's reflections on DroughtPlan and what it has contributed in a sphere that is broader than the immediate research outputs. The project strongly endorsed the principles of action learning and continuous improvement in management and research, and sought also to apply them in research management. However, we sought to identify when people of different skills, backgrounds and interests should be involved in the various elements of an action learning cycle. It is clear that not everyone should be involved all the time, and that it is possible to say when involvement is appropriate. These thoughts lead to discussion about the nature of decision support, and vital need to unify so-called soft and hard systems into a single seamless approach to improved decision-making. Examples can be found within the DroughtPlan to support all of these points, notably arising from a comparison of the many different individual products and their relative successes. The section closes with a candid assessment of how effectively the process was implemented in this project.

It is vital that the DroughtPlan products are followed up and that their evaluation is completed, and that continued support is given to those participatory processes that have raised community expectations so far. Many of the individual products also warrant further support. This is generally outlined in the relevant earlier sections.

Background

DroughtPlan was focused on using action learning principles to engage people in the process of applying knowledge to changing management. It is only fitting that the same principles should be applied to the project itself. A particularly important part of learning is reflection on the experiences of having taken certain courses of action. To a considerable degree, what follows is therefore a personal statement by the project principal investigator, but it is based on many conversations over the course of the project.

The LWRRDC-managed National Climate Variability R&D Program originally derived from the drive towards self-reliance in drought management for the agricultural industries from government and the National Drought Policy in 1992. Given this context, the need for work like that of DroughtPlan arose in many discussions and projects with producers. The first detailed proposal for the project was a response to a commissioning request from the National Climate Variability R&D Program. This commission suggested that a group of researchers and extension personnel who were well known to each other should develop a project capable of integrating and delivering information on management relating to climatic variability to the grazing industries. The group included strong Queensland players, but the commission carried with it the reasonable demand that their work should be integrated with other key groups and be relevant across the nation.

Fortunately, the emphasis on 'delivery' and the involvement of people already taking the rhetoric of participation into action meant that the proposal delivered to LWRRDC, the Meat Research Corporation and the International Wool Secretariat contained a heavy emphasis on producer involvement. Streams 1, 4 and 5 were to be an interactive version of the participatory problem solving cycle (Clark and Filet 1994), where Stream 1 engaged producers in groups to identify their information needs; Stream 4 developed these; and Stream 5 was the iterative process of ensuring that they were really met. Meanwhile, Stream 2 also engaged producer participation in another form to ensure that the products were likely to be relevant across the nation. The original vision for this process was limited, and there were short-comings in its implementation, as discussed below. However, it was genuinely the case that the needs of producers were identified in the first year and responded to in the second year. Indeed, the funding agencies must be congratulated and thanked for having sufficient confidence in the legitimacy of a process in which the contractual outputs of the project were not to be defined until halfway through the study.

Research and the research management process

DroughtPlan was a large project in terms of coordination across many people and a huge geographic range. About 50 agency personnel were associated with the project, with commitments varying from that of being core contributors down to just a few days interaction. At least 200 producers were formally involved in the project in one capacity or another, and many more touched by it in passing. We faced the problem of establishing genuine participatory processes and responding to them in under two years, yet ensuring that these responses had relevance to half the continent. The significance of these issues led us to convene an early workshop which focused on the project's research methods and research management, rather than its *outputs*. The detailed results are reported in Stafford Smith and Clark (1994), but its two key findings were that:

- action learning concepts should be applied to the research methods and management, just as much as being encouraged in participatory research with industry; and
- evaluation, as a critical component of action learning, needed to be formalised in the course of the project itself, both as part of its own assessment and to ensure that its products were really providing value to the industry in the long-term.

The workshop report, many subsequent discussions, and this section are all part of fulfilling the first finding. Identifying and applying a consistent approach to evaluation across the project (see Appendix 5A on page 104, and the later parts of this section) responded explicitly to the latter. There were many other findings, however, which are discussed in the next few pages.

Figure 19
The basic problem solving cycle (after Clark & Filet 1994)

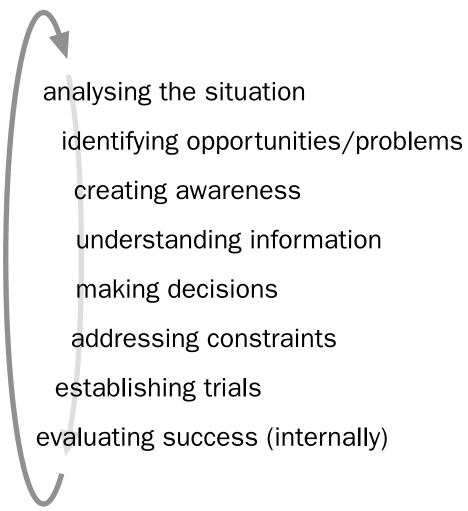
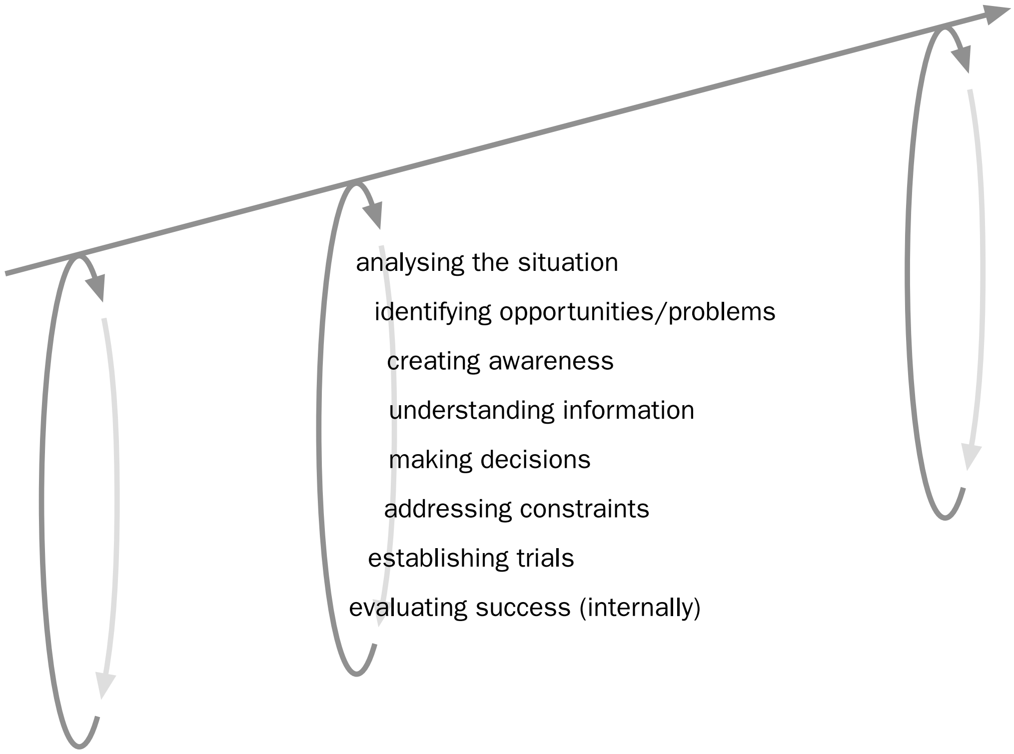


Figure 20
The basic problem solving cycle, showing that each cycle should lead on to another in the process of action learning development for continuous improvement



Considering its invitees, it was perhaps not surprising that the workshop endorsed participatory research methodologies, but this was certainly in line with the times. There was strong agreement that some form of action learning cycle should be central to the project, and we adopted the particular formulation then being used by Richard Clark as a 'participatory problem solving' cycle (see Figure 16 on page 93 and Figure 17 on page 98; Clark 1996). This was promoted to the rest of the project team at subsequent workshops, and adopted in principle where-ever it was relevant in the project, if not always in practice. Although the formal use of such a cycle is not necessarily that much more time-consuming than traditional extension (especially if it succeeds where the latter fails), it does have two important characteristics:

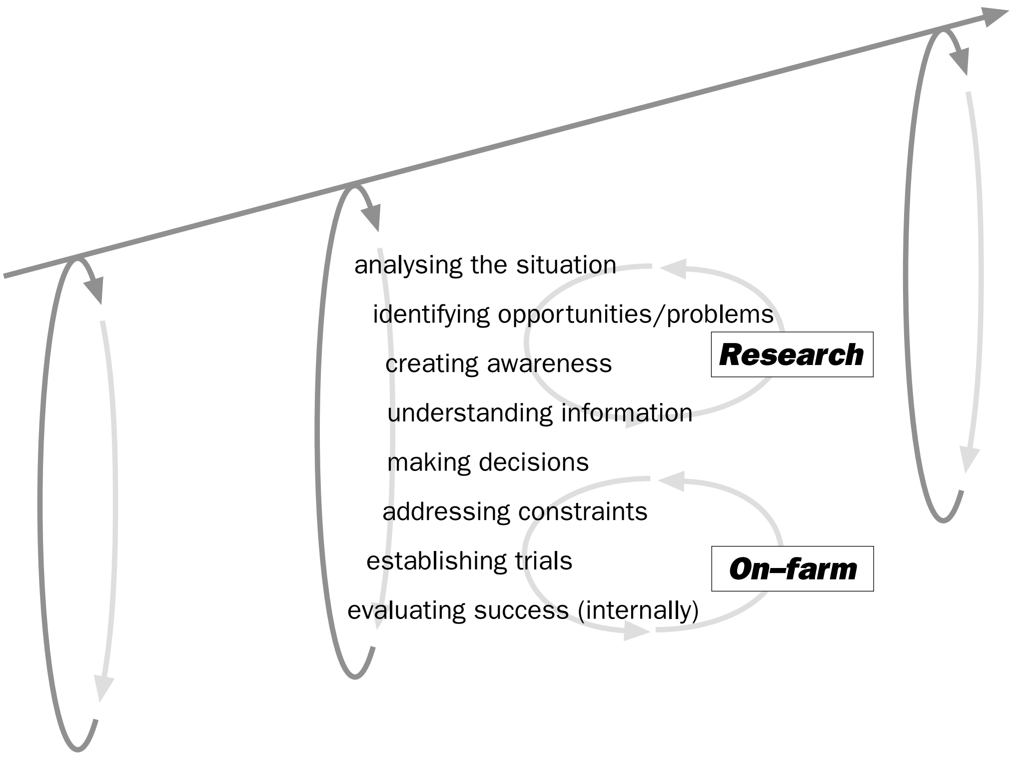
- if it successfully engages producers in the research process, it also then raises considerable expectations about follow-up—failing to meet these can be very damaging, so it is essential that participation be entered into with genuine commitment; and
- a genuine conversation about problems and solutions must mean that all participants must be prepared to see the points of view of others and allow their positions to evolve in response (however, since the purpose in this case is to assist industry, its point of view must have some primacy in this negotiation of meaning, and agencies must be prepared to relinquish their views after a reasonable level of debate).

These issues and others led to an on-going discussion about participatory learning during the rest of the project. In particular it led us to debate *when* participation was most appropriate and whether everyone needed to be involved in the whole cycle. It also led to debate on the question of 'wants' as opposed to 'needs' and who can best judge these. Who has the expertise to best consider these and identify what is 'researchable'? Finally, at a more esoteric level, how does all this intersect with the general R&D promotion process in Australia? Let us look at these issues.

The first question that arose was whether we were being consistent in regard to participation across the project. Stream 1 included some central Queensland processes which undoubtedly met this goal. Features here included groups, plenty of opportunity for problem identification, benchmarking, monitoring, challenging, and taking time to learn how to learn (see Clark 1996). The context of the DroughtPlan project meant that some groups were encouraged to work through these processes specifically in relation to coping with climatic variability, but of necessity all sorts of other issues had to be acknowledged in the integrated system that is a property.

Could such a process be repeated across the rest of the continent within the resources of the project? Even allowing for the fact that not everyone wants to be involved in group processes, the answer was undoubtedly no. That could only arise out of local extension commitment to similar processes. This is evolving in many regions, but DroughtPlan did not possess the resources to significantly speed up such developments. We faced the problem first in Stream 2. Here it was resolved by developing a different form of participation which was just as intensive but on a one-to-one basis. The problem of expectations and follow-up was addressed head on by explaining very explicitly to participants what we were hoping to get out of the interaction and what we thought they might gain before any work was carried out on a property. While we were obtaining information from them, in all cases we provided them with an immediate (within a week or so) study on a problem of interest to their property. The regional reports developed from their collective information went back to the participants with a clear statement that they and their peers owned this information even if we had engaged in some interpretation. Finally, wherever possible, we or the pastoralists themselves engaged local extension personnel into the process so that it has continued in some areas. The participation was not usually based on groups nor guaranteed long-term intensive follow-up (except in the broadest sense of national DroughtPlan products) but these issues were addressed openly and there seems to have been no disappointment or dashed expectations among collaborators.

Figure 21
The problem solving cycle incorporating specialised research and on-farm testing roles—these may be larger or smaller depending on the cycle and state of the problem, and may intersect with various parts of the main cycle



All these considerations led to debate about *when* it is appropriate for intensive participatory engagement and when it is not. We certainly do not have all the answers on this, but some issues do arise out of the project. As a general observation, participatory approaches will be particularly valuable in two circumstances:

- when the principal need is to go beyond awareness of the problem towards learning skills, then a participatory process, especially involving groups, can be essential to engage people's commitment. This is often particularly true for resource management problems which do not have easily-optimised solutions and possess ill-defined boundaries; and
- when it is necessary to significantly re-define a problem, as may occur if research has become inward looking or divorced from industry, then close participation may be needed to challenge both parties to come to new views.

This led us to perceive that the simple action learning cycle (see Figure 19 on page 135) can really be made more sophisticated, at least by adding research and implementation loops (see Figure 21 on page 137). These are intended to identify times when people trained formally as researchers do not necessarily need to be involved in the day-to-day process of implementation and fine-tuning on the ground; and correspondingly times when a sufficiently well-defined problem exists that it is efficient for formal researchers to get on with analysing it by themselves, when most producers would in fact be bored by having to be closely involved. However, there are two vital differences between the traditional linear research-extension-management process and these interlinked cycles:

- here the interlinked cycles clearly imply joint ownership of problem definition, and an iterative approach to its solution which involves all categories of participant (it just recognises that not all individuals need to be involved at all times); and
- here all people recognise and accept the role of the other participants in their parts of the cycle, rather than perceiving some aspects (their own!) to be more important than others.

No doubt additional elements could be added to Figure 21, but DroughtPlan semi-consciously sought to meet this model. Stream 1 (and 2) established the overall cycle; Streams 3 and 4 carried through the development of product solutions; and Stream 5 aimed to obtain testing on the ground as at least one iteration of the feedback mechanism. As discussed below this was not fulfilled for all products, and the time frame of the project funding fundamentally limited the extent to which this is possible within the context of the DroughtPlan itself.

A key issue in this integrated R&D process is *who* defines the problem and consequently formulates its solution. This has been described as discriminating between 'wants' and 'needs'. In retrospect, this turned out to be a poorly debated aspect of the project, and the workshop which made these decisions did not, in my opinion, carry through an ideal process even though it almost certainly came to a generally reasonable outcome. Our consultative process identified a wide range of issues that producers found to be important. At some stage this had to be converted into achievable goals—who should do this? Researchers are the people who have been trained to explore problems formally and who are aware of what is feasible in research delivery. However, it is very easy for researchers who have spent their lives working in a particular area to perceive that all problems can be solved by more work in their own area when in fact quite different constraints are limiting industry. Comparably, the paradigm of the moment is that producers themselves are the only ones who can identify their own problems; yet producers can hold short-sighted enthusiasms just as easily as researchers.

If an appropriate form of the problem solving cycle is in place, it can genuinely assist with solving the dilemma of who is appropriately involved in priority setting. It provides a forum in which all parties can negotiate the relative significance and form of different solutions at the local level. DroughtPlan followed this process in a partial way. The problem is how to replicate this form of dialogue at a national level, in order to determine which of many local problems justify national effort and investment. Presumably this requires participants with a recognised national perspective to carry out the dialogue. The choice of these is not easy and, in the event, the DroughtPlan workshop which made the translation from *perceived wants* to *perceived needs that were answerable by the project* did not carry through the process perfectly. It did not have producer participants present and too much weighting therefore fell (mostly with the best of intentions) on researcher interpretation of what producers had said, even though DroughtPlan had evolved a reasonable national overview. This is a lesson for the future (which was actually recognised but inadequately acted upon at the time).

Debating this type of issue explicitly leads one to see that Figure 21 (see page 137) can really be applied either at the level of the individual problem or at any other level all the way up to the whole national innovation and problem solving process. The full range of R&D motivators in Australia include not only the Research and Development Corporations, such as LWRRDC, with their funding but also the research providers (state agencies, CSIRO, universities, etc), and policy makers at state and national levels. It would help if the role of different players and different research process approaches was more explicitly recognised in some framework comparable to a more complex, multi-layered and hierarchical version of Figure 21. This would clarify when particular levels of participation are needed, when it is appropriate for research to go on in splendid isolation, when interaction with any or all of industry is needed, and so on. This remains to be developed.

Principles for developing decision support

Both the actions of carrying out DroughtPlan, and the internal discussions about the process, led to a development in the thinking of the participants about decision support. Decision Support Systems (DSS) in the literature initially captured a very computer-oriented approach, sadly tagged with the title 'Hard Systems'. These were supposed to be set up against the 'Soft Systems' products of purportedly woolly social scientists. Although this dichotomy continues to be promulgated in the literature, in fact many practitioners have long since moved away from such a daft split. In 1991 a major DSS workshop concluded that both approaches depended on each other—the 'hard systems' would often have no-one asking the questions which they could solve if 'soft systems' did not get clients into the frame of mind to ask the question. Conversely, when 'soft systems' were successful in promoting action learning, eventually questions would arise which needed 'hard systems' approaches for answers, and expectations would be dashed if these were not available (Stuth & Stafford Smith 1993).

The solution that seems obvious, and which DroughtPlan has attempted to implement, is that the concept of a DSS must be seen much more broadly to include the processes which provide a context for decision-making as well as the activities involved in assessing and solving problems, and accessing the information which may assist in this. We thus came to favour a concept of 'decision support tools' which encompassed all the product types, whether motivational materials, worksheets, workshop processes, training approaches or actual computer programs. Given such a broader concept, the idea of decision support then becomes the provision both of the decision-promoting environment and the training, information, and tools which can, as appropriate, support the consequent decisions.

The traditional failing of computer-based DSS has been uptake, especially if it is only sought after system development is nearly complete. In this broader picture, computer packages simply become one of a range of decision support tools which are integrated in the whole participatory process which leads to decision making. Likewise, the ‘traditional’ criticism of ‘soft systems’—that they concentrate on process to the complete exclusion of providing information content, and hence eventually alienate action-oriented farmers—becomes irrelevant. The participatory problem solving approach as described by Clark and Filet (1994) with its development of benchmarks and community based measures for monitoring the attainment of best practice explicitly seeks to weld these processes together. Producer groups identify their own current best practices but both the further development of these and the validation of their selected measures are open to challenge in discussion with extension professionals, who in turn are challenged to provide better information to support changes in practice. This potentially creates a whirlpool of participatory interactions.

In my opinion, it is unfortunate that there are still lonely prophets of doom crying the failings of DSS. Still (usually different) people complain of the failings of participatory approaches to research. It seems to me the world has actually passed by many of these concerns. DSS *has* had a poor history of uptake, but it has not all been negative especially when presented in the appropriate context. Participatory approaches *are* time consuming and are not appropriate for all circumstances, but there are some excellent examples of success where past failed approaches have been much more wasteful of resources. Today, the focus should be on *when the different approaches are most appropriate* (in relation to types of people, types of problems) and *how they should then be carried out*, rather than on setting them up as straw men to determine whether they are universally essential or worthless.

The evolution of DroughtPlan has some ideas to offer to this more useful debate. Out of its many discussions, DroughtPlan has sought to inform its work with these key points:

- There *is* a widespread need for real participatory problem solving based on action learning principles and focused on real management decisions. However, as discussed in the previous section, this approach like any other is not a panacea for all things. It is not appropriate to all parts of the research and management cycle. Furthermore, not all people are comfortable with the ‘traditional’ group-based approaches to participation. There are many other forms of communication which can permit similar experiential learning (including, sometimes, even more ‘traditional’ extension methods, although this fact should not be used as an excuse for avoiding participatory approaches!).
- The concept of DSS must be interpreted more widely than traditionally, as the whole amalgam of motivation, tools, and training, using many types of tools including paper-based worksheets, learning activities, simple spreadsheets, and the occasional complex computer program.
- There is a vast diversity of people with different skills, attitudes, interests and circumstances who are involved in management. Just as a single ‘optimised’ management strategy will not suit all, nor will one communications and training method. Some will come to workshops; others will work at home; some will read newspapers; others will talk with their neighbours; some will use pencil and paper, while others will use computers. DroughtPlan has sought to recognise this by producing multiple solutions (both in terms of information form and communications method) to the major problems posed by producers.
- In relation to management of drought (and other climate variability) in particular, the critical risky events occur rarely, so we must find ways of making the decisions about these events regularly. For example, deciding to de-stock in drought is a major, anxiety-provoking decision. However, if stock numbers are assessed and adjusted every year, then the drought year response is just one end of a continuum of regular decisions. One route into this behavioural change is that of monitoring performance benchmarks; others are several Stream 4 products.

Richard Clark has developed the beginnings of a framework for identifying when group processes are likely to be appropriate in the context of problems related to grazing management (see Table 17 below). He relates the appropriate techniques to the stage of the producer 'client' and the complexity of the problem. If the producer is unaware that there even could be a certain type of problem that the remainder of industry may have identified, then techniques like motivational advertising are needed to rise awareness.

Once aware of the problem, but unaware of how to go about tackling it, experiential learning can begin and for complex issues in particular groups processes may be most rewarding. For highly motivated and knowledgeable producers who are simply seeking solutions to well-defined problems, groups may be an inefficient way of supporting decision-making. A more linear source of information (whether human, paper or computerised) is often best in this case. We sorely need further development of such a guidance system in the agricultural context, which could also be extended to consider other types of 'client groups' (eg. for regional problems, communities, policy makers, etc).

Some of these findings are supported by the differential successes of the diversity of products from Stream 4 (see Table 6 on page 102) in different contexts. For example, the 'Decision Trees' approach was most effective as a motivational awareness tool, giving people an enthusiastic introduction to the idea that there can be a systematic approach to options. The *'Assessing your livestock management options'* workshop is then a more formal framework for this. BB-SAFe, in its various formats, is a specific implementation tool given that people have accepted the importance of the underlying problem. The combination of the workshop framework, the 'Safe' Carrying Capacity Calculator and Grasp is a parallel set of tools more appropriate to the strategic stocking rate side.

Table 17

Framework for judging the appropriate approaches to people in different states of mind with respect to management issues, simplified from a note by Richard Clark and Gavin Graham. They argue that to develop a community of self-directed learners, the majority of people need to move from the bottom to the top of the table. Note that (a) they seek to establish a sustainable environment of continuous improvement at the personal level, (b) they always specify a variety of technologies or media to meet each level, (c) they recognise that simple and complex problems may be approached in different ways for the best efficiency.

Status	***Issue***	***Approaches***
Aware and understanding ("know what they want to know")	Simple	*Self-directed* (direct access through pamphlets, newsletters, fax, phone, internet, etc) [Face to face generally not essential]
Need to identify what is important, identify new opportunities and new questions	Complex	*Self-directed* (direct access through newsletters, newspapers, videos, books, databases, phone, internet, DSS, models, group processes, etc; plus face-to-face for education and training about the learning approaches themselves)
Aware ("know they don't know enough") Need to identify what makes a difference, and formulate questions	Simple or complex	*Facilitated learning* (needs analysis, education, action learning, systems analysis, TQM, benchmarking through models, DSS, group processes)
Unaware ("don't know what they don't know") Need to become aware of existing opportunities	Simple or complex	*Promotion/marketing* (field days, demonstrations, mass media, pamplets) *Facilitated learning* [especially through association with other issues where people are already aware] (education, action learning, modest use of groups)

A parallel requirement is that of identifying what portfolio of decision support tools are most useful for different types of problems and different people. One explicit effort in DroughtPlan was to provide graduated forms of a product, such that an unskilled person could begin with general concepts, try out an idea on paper, and only then perhaps move on to a computerised version (which itself might start off simple and gradually offer more complex options). The same considerations can be applied to people in different stages of life, financial commitment, education, and even intensity of involvement.

Evaluation and reflection

DroughtPlan was committed to participatory approaches to research; but these had to be applied across 70% of Australia. As well, the project design required Stream 4 products to be defined on the basis of consultations in the first year. The project thus had to ensure that its participatory approaches were correct and that a conscientious process was applied to identify critical needs. The Executive Summary (see page 1) summarises a formal review of the overall project against the same evaluation criteria as were applied to the individual products. This section aims to go past the general self-justification to a deeper assessment of what was done well and what could have been improved about the project.

Figure 22 (see page 143) is an effort to be candid about the processes involved in DroughtPlan. Indeed, the first point is that, although the diagram represents my view of the overall pattern of development, in truth there *was* no single process. Figure 22 starts with the gathering of information through time in Streams 1 and 2 (as well as other sources) that led to a list of 'wants' being delivered to the project. Meanwhile the internal workshop debating process had helped to inform us how to handle this flood of information. The main Stream 4 planning workshop at the end of the first year acted like a lens to turn the wide range of stated 'wants' into a narrower suite of apparent 'needs', and a still-narrower suite of needs that the project could act upon. The process of this workshop was imperfect, as mentioned earlier. In particular, my perception is that a few products were driven more by researcher priorities rather than by demonstrated producer demand.

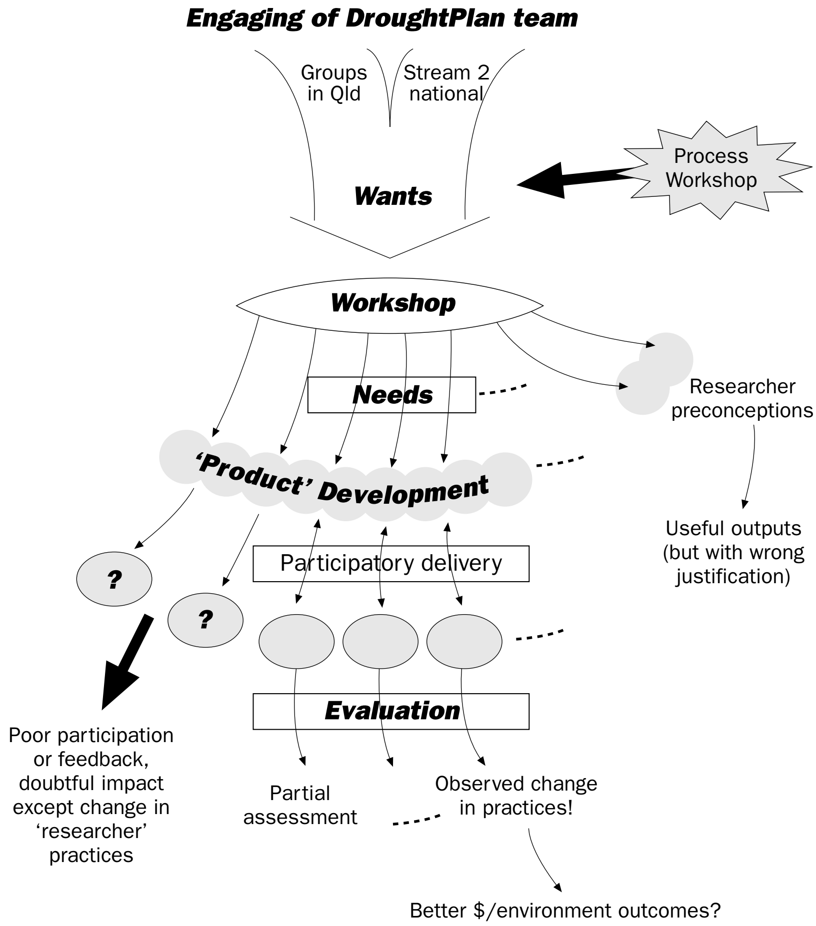
From the product definition, a series of product developments evolved. Some of these were carried out with good iterative participatory feedback, others more poorly. Partly as a result of this, the evaluation phase failed to work well or gave poor feedback to some products. Where the process was poor, the product often had its greatest impact through changing researcher KASA and perhaps Practice, rather than reaching industry directly. Since this represented a minority of products, this is not a wasted outcome. Among those products that were developed well, there was still a diversity in the extent to which we were able to evaluate them fully within the time-frame of the project. Only in a very few cases were we able to begin to document change in practice, and it will take a significant re-evaluation in a few years time for the National Climate Variability R&D Program to identify whether these have really contributed to raising the benchmarks of industry to the point of having an impact on sustainable productivity.

To return to the failings, as a good action learning reflection should, I make four observations:

1. Few of the failures in process were actually complete failures. They may have been less efficient in resource use than the successes, but all had some outcomes. Thanks to its diversity of approaches, DroughtPlan did not have all its eggs in one basket.

2. Researchers and agency personnel are human too. Developing a process of change in their approaches to participation is not an instantaneous action, much as this would be nice. Such change has to be nurtured in all players, including the researchers (although, since this is their job, there may be a stronger case for demanding change here than elsewhere). It is often the organisational structures rather than the individuals which are slowest to change. There were certainly constraints during DroughtPlan which resulted from organisations being unable to come to terms with the commitment needed for a true participatory process, whatever the organisational rhetoric.

Figure 22
A personal (Mark Stafford Smith) schematic view on the successes and failures of the research management process in DroughtPlan



It was also very noticeable that across the project there were some people well-versed in the ideas of participation; others who rapidly caught on (to varying extents by the end of the project depending on their exposure to the ideas and opportunities to act on these); and others who could use the rhetoric but really did not appreciate how to go about it in practice.

Many of the last category were still good extension officers or researchers in the appropriate role. In some cases it would be more useful to leave these people in those roles in the appropriate part of the overall research cycle (see Figure 21 on page 137) rather than forcing them into a new world which does not suit their aptitudes.

3. Some of the failures in process (notably a few cases where researcher preconceptions got their own way at the main planning workshop) still developed good products. In my opinion, these were, in most cases, correct projects to be working on, which raises the issue of 'who knows best?'. The answer, of course, is that no-one does. There is strength in diversity providing no-one has the hubris to believe that only their way is right. In the case of DroughtPlan, the balance between tool and process development turned out reasonably but it was not designed as consciously as we can now recognise that it could have been. The single simple action which would have assisted this would have been a better balance of participation in the priority setting workshop.

4. One of the greatest strengths of DroughtPlan *was* that there were many products being developed broadly under the one roof. Consequently (and really *only* because of this), it is possible to draw Figure 22 (see page 143) and Table 6 (see page 102) and compare with some confidence the outcomes for different products and their associated processes. Without such comparative studies, it is impossible to identify when alternative approaches are likely to work best. Naturally, in a large suite of products there are likely to be some poorer results. These are in fact a fine best source for insights. The concerns of those who critique decision support or participatory processes are often based on a singular bad experience where a whole project fails because the approach does not work. DroughtPlan had the crucial luxury of being able to incorporate such failures into the overall learning process, because it has encompassed much more than a single product or approach.

Finally, we have already noted the importance of a consistent and well applied evaluation process. The DroughtPlan evaluation approach should itself be subjected to evaluation. In the event, this was developed and agreed upon a little too late in DroughtPlan, so that it had less of a chance to be systemically in place from the start of Stream 4 than would have been ideal. The commitment of different participants to taking the common approach was also therefore somewhat variable. Indeed the evaluation process itself was an important part of altering people's views on participation, since it was impossible to obtain the evaluation without actively seeking producer feedback during the development of the product. Where there was a mind-set against this—a develop-then-present-to-industry mentality—the evaluation process inevitably fell short, but often only after raising awareness of the issue. At the final major DroughtPlan workshop, everyone participated in discussing the types of questions and feedback that each product needed for evaluation. It was clear that the views of many evolved rapidly through this activity and we should have carried the exercise out earlier in the project. In short, the evaluation process was a successful approach, though not always successfully implemented, which contributed to change in KASA and practice among project participants.

Conclusions

The DroughtPlan project is part of an on-going process, which eventually aims to contribute to developing an industry in which continuous improvement of personal skill and management practices is a normal part of life. Notwithstanding the rhetoric of grant proposals, it would be ludicrous to imagine that DroughtPlan could have completed such a task across the continent in a mere two years for a modest sum of money. Most of the products described in this report, as well as some of the on-going research processes, will come to true fruition early in the next century, perhaps having their most important impact then. We hope that LWRRDC and other RDCs will continue to assess the significance of these as those products as the years pass by, and to resource those products that prove their success. However, it is my belief that, in its short time-frame, DroughtPlan has contributed crucially to the process of continuous improvement in research outputs and in research management approaches, as well as in industry benefits.

It is vital that the DroughtPlan products are followed up and that their evaluation is completed, and that continued support is given to those participatory processes that have raised community expectations so far. Many of the individual products warrant further support also, but this is generally outlined in the relevant earlier sections.

We commend the results to industry and hope that the support provided to us by individual producers has been repaid.

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APPENDIX 1

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