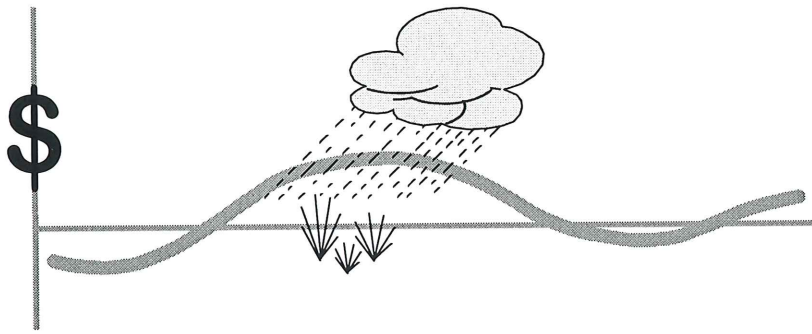


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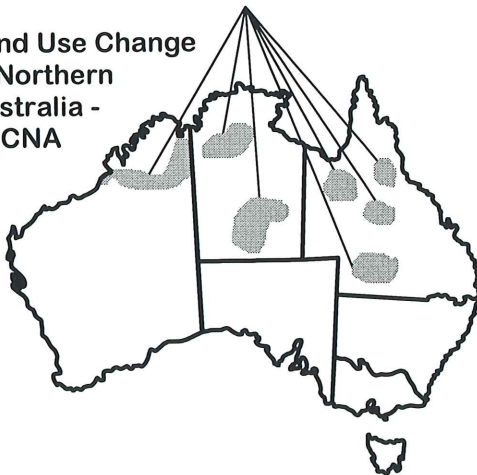


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## Evaluating the use of SOI forecasts in north Queensland using the Herd-Econ/GRASP linked model

Mark Stafford Smith, Greg McKeon, Andrew Ash, Rosemary Buxton and Joseph Breen

Land Use Change  
in Northern  
Australia -  
LUCNA



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## EVALUATING THE USE OF SOI FORECASTS IN NORTH QUEENSLAND USING THE HERD-ECON/GRASP LINKED MODEL

### Summary

This document 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, hereafter referred to as **HERDGRASP**. 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, so that this report is preliminary in the sense of a complete assessment of the value of the linked model; further simulations are being performed as the basis for a fully refereed journal paper.

A procedure for linking the models was successfully established and 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. Given this preliminary verification of the operation of the model, simulations then showed that financially-optimal stocking targets could be defined for different stocking rate management strategies, and the interaction between these targets and their riskiness readily assessed on various measures. Forecasting strategies appear to have little benefit given today's skills with the SOI, but improved skill has considerable potential both to improve economic returns and to help protect the resource. An immediate message of value is that additional decision points in the year can significantly improve economic returns. Some additional analyses examine the effects of taxation and net present values, and compare the results from this approach with those of Working Paper No.8, using GRASP alone.

An important finding is that the full enterprise simulations produce qualitatively different results than those obtained by simulating secondary productivity only. Key research needs are now for a better understanding of (i) within-year liveweight changes, (ii) reproductive and mortality rate relationships, (iii) tactical decision-making by producers, and (iv) long-term environmental feedbacks. The models also require further thorough verification and, as much as possible, validation.



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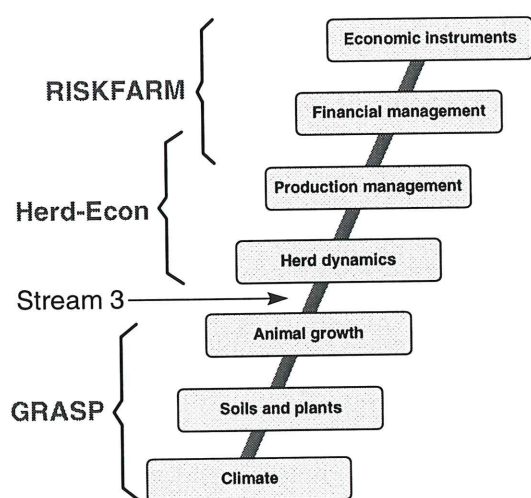
**Acknowledgments:** The research described in this Working Paper was undertaken mainly under the DroughtPlan project (supported by LWRRDC, MRC and IWS), but extended through the involvement of CSIRO's Climate Variability Multi-Divisional Program (precipitating examination of the 'Proactor' strategy) and the LUCNA project (supported by RIRDC, under which the sensitivity analyses and initial examination of tax and NPV effects were made). Our thanks to the funding bodies and many colleagues for their assistance in this endeavour. We are also grateful for the comments of various readers, including Brian Walker and Andrew Moore. After some of the issues raised in this preliminary work are resolved, this Working Paper will be written up as formal research papers.





## 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 and tropical pasture growth under grazing, and providing the implications of different grazing pressures in terms of steer liveweight gain; but 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; DroughtPlan has addressed this in a preliminary way with RISKHerd, see Stafford Smith *et al.* 1995.) 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 (Moore *et al.* 1995, Pepper *et al.* 1996).



**Fig.1:** 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'.

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 Fig.1). There are many complex factors involved in this effort, so that the goal is not to produce a tool which is easily used by 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 Paper 8 (McKeon *et al.* 1996) 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. This Working paper summarises the methodology and implications of carrying this understanding through to the whole enterprise level, as well as beginning some analyses which are needed under the LUCNA project.

Table 1 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. The study reported here concentrates on cattle in northern Queensland, in the Charters Towers region, where forecasting is currently most feasible. As Table 1 shows, however, the same framework could be applied elsewhere in the country.

In addition to the main strategies shown, each 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. Here we have defined what seem to be typical approaches for each in the region, as outlined in following sections.

**Table 1: Outline of example production systems**

| Strategy                 | Principal goals                                                                                                         | Cattle in sub-tropics                                                                                                                                                                                                                                                                                                                             | 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 Apr-May at end of growing season; calving Oct, wean Apr-May; nutritional stress Jul-Aug; main deaths Oct-Dec; pasture burning in Oct                                                                                                                                                             | eg. Port Augusta region: 300 mm rain: 2 main timings for shearing - after summer or after winter, associated with lambing times; main reliable rain in winter                    |
| <b>Constant</b>          | Constant target                                                                                                         | <u>May</u> : adjust to normal target numbers (don't capitalise on good looking years)<br><i>In extremis: maybe feed (if pre-wet) or lighten off anytime</i> (hence deaths a key simulation criterion)                                                                                                                                             | <u>Feb shearing</u> - adjust to normal numbers in Mar.<br><i>[Winter failure - maybe sell in Oct]</i><br><u>Sep/Oct shearing</u> - adjust to normal numbers in Oct.              |
| <b>Reactor</b>           | Respond to current pasture <b>amount</b> only +/- 'normal' season ahead                                                 | <u>May</u> : assess pasture yield; calculate S/R for next year (+/- assuming wet will come); make buy/sell decision for year<br><i>[If spring rain, maybe buy in]</i><br><i>Wet season failure: maybe feed, maybe sell early (Feb/Mar)</i>                                                                                                        | <u>Feb shearing</u> - adjust to number based on current yield and typical winter<br><u>Sep/Oct shearing</u> - adjust to actual forage post-winter (ignore possible summer rains) |
| <b>Forecast</b>          | Respond to current pasture condition + SOI-corrected growth expectation for season                                      | <u>May</u> : sales like Reactive<br><i>[alternatively assume the forecast now and sell anything at risk such as cows likely to drop in Oct-Dec]</i><br><u>Oct</u> : 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?                                                                                                                                                               |
| <b>Perfect Knowledge</b> | As Forecast but using known 'future' data (simulation baseline)                                                         | As Forecast, but uses known pasture growth in Oct based on actual summer rain                                                                                                                                                                                                                                                                     | Can still try this by adjusting to actual coming year.                                                                                                                           |

[normal text is basic strategy; *italics show possible complications*]

### The models and simulation approach

This section outlines the models used in this study, and how they were linked together in practice. The following section describes the particular environment, enterprises and strategies that were simulated.

#### GRASP

The current development of GRASP is described fully in Working Paper 8 (McKeon *et al.* 1996). 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). The model has been calibrated for 40 pasture communities in



Queensland. From daily inputs of rainfall, temperature, humidity, pan evaporation and solar radiation, soil water is simulated for given soil attributes (texture and depth). Plant growth is calculated from transpiration, but includes the effects of vapour pressure deficit, temperature, radiation interception, nitrogen availability and grass basal cover. The effect of variable tree density is simulated through the effects of trees on water use and nitrogen uptake. Animal production responses are captured through empirical equations for live weight change and wool growth as a function of utilisation and length of growing season, developed from grazing trials.

The feedbacks of increased grazing pressure on plant production are simulated through effects on run-off, perennial grass basal cover, sensitivity to soil water deficit and nitrogen uptake. Additionally changes in grass basal area gradually cause a shift in parameter values between those appropriate for perennial-dominated pastures and those dominated by annuals. As yet, no feedback of soil loss on nutrient availability or infiltration characteristics has been modelled. Effectively, GRASP allows the simulation of the risks of production losses but not the long-term consequences of taking those risks. The latter effect are the subject of continuing work.

GRASP thus 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.

## RANGEPACK Herd-Econ

The other component of this linked simulation approach is RANGEPACK Herd-Econ, a deterministic herd dynamics and property economics model normally intended for use at an enterprise level (Stafford Smith and Foran 1992). It allows users to define a grazing enterprise of any number of animal classes by age groups, each of which has given biological (mortality, growth and reproduction) rates. The model then tracks animal numbers on a monthly time-step, subject to different buying and selling strategies and transfers between animal classes. The economics module uses animal numbers to adjust variable costs, and combines trading results with other expense and receipt items to generate a cash flow. Although loans and taxation can be investigated, these are dealt with in a very simplistic fashion.

The value of Herd-Econ 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.

## Reproduction and mortality relationships

To link Herd-Econ to the outputs of GRASP (see Fig.1), relationships are also needed between the condition and growth rate of animals and their reproduction and mortality rates. These relationships have been researched under the DroughtPlan Project (Moore *et al.* 1995, Pepper *et al.* 1996), and ideally these results would be used here. However, 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: since rates are affected by the minimum body condition during the dry seasons, among other factors, a considerable effort was put into developing a reasonable monthly liveweight gain model but this was not yet judged adequate for the simulations. Hence the simulations described here fall 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 less generalisable in future. The rates were calculated from the predicted annual liveweight (LWG) using relationships fitted to Gillard and Monypenny (1988, Table 1) as follows:

$$\text{Reproduction} = (-9.67 + 0.655 * \text{LWG})$$

$$\text{Reproduction} = \text{MIN}(80, \text{MAX}(0, \text{Reproduction}))$$

$$\text{LWG} = \text{MAX}(-10, \text{LWG}) \quad (\text{this limits the maximum deaths in the following})$$

$$\text{Mortality}_{\text{cows}} = 6 + 94 * \exp((\text{LWG} + 50) * -0.0273048)$$

$$\text{Mortality}_{\text{drys}} = 2 + 88 * \exp((\text{LWG} + 50) * -0.0340950)$$

Thus the reproduction rates were constrained to fall between 0 and 80%: this is 10% higher than observed by Gillard and Monypenny (but with the same functional form) who found rates appeared to asymptote at about 70% because these higher rates are now feasible in supplemented herds. The death rate function is constrained to a maximum at





LWG=-10 kg/yr: Gillard and Monypenny never in fact observed more than 37.5% whole herd mortality, to which this roughly equates.

These relationships are an important part of the simulation, since they determine, *inter alia*, how sensitive a herd is to deaths from overstocking and how rapidly a herd can recover drought. Sensitivity analysis was therefore performed on these relationships. These are also still the subject of on-going research.

### 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. Here 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. Because of 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; this 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 Fig.2. 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.

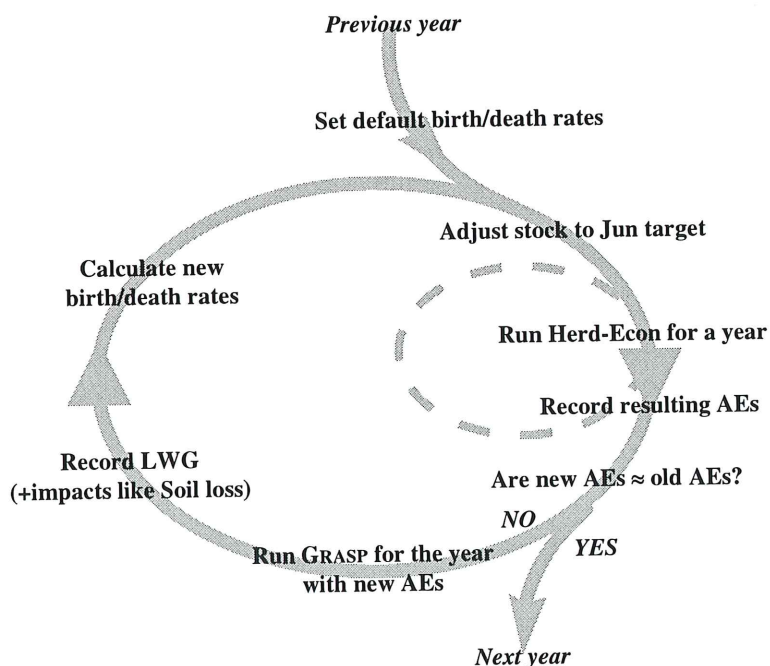


Fig.2: Schematic outlining logic flow in connecting Herd-Econ and GRASP iteratively for a year. Each year the full cycle must be completed at least once. The dashed included cycle illustrates the fact that some strategies require an





additional inner iterative cycle to calculate the growth over summer given different stocking rates (details not shown here). For the runs described in this Working Paper, new and old AEs were regarded as sufficiently close if they matched within  $\pm 1\%$ .

In most cases no more than 2 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 on 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 for linking the models was the command language of the RANGEPACK Herd-Econ (version 3 prototype) program. The FORTRAN-based GRASP was linked 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 Fig.2 were programmed in the RANGEPACK command language.

### Enterprise description and management strategies

This section outlines the assumptions regarding the Herd-Econ property model for each of the strategies to be tested. The case study region is the cattle industry in the northern speargrass community around Charters Towers in north Queensland. In this region the SOI provides one of the highest predictive abilities for the season ahead of anywhere in Australia (Clewett and Drosdowsky 1995), although this level of forecasting 'skill' is still modest.

#### General enterprise description.

The Charters Towers region still has a predominance of fattening steers for the Japanese market (here based on 580 kg liveweight by age 3.5y). Although the live export trade is increasing in importance, for the initial study we assume sales are either fat steers, or store steers and heifers to local markets or aged cull cows. Likewise, agistment to Gulf and northern Mitchell grasslands is increasingly common, but initially we assume changes in stock numbers are achieved only by buying and selling. An exception to this is that a core cow herd (ages 3-5y) will never be sold. Future studies should examine buying agistment or feed to maintain the core cow herd *in extremis*, and alternative approaches to tactical supplementation.

The modelled property is envisaged as 20000 ha, in a region where average stocking rates are about 1 beast (450 kg steer) to 8 ha (GRASP uses stocking rates in terms of 200 kg weaners, a conversion factor of 1.8 times 450 kg animal equivalents [AEs]). AEs in the property description are assumed to increase with age group from .56, .78, 1.0, to 1.3 for steers (and heifers before they are joined); cows are assumed to settle at 1.3 if with calf, so that, assuming about a 2/3rd branding, this is discounted to 1.2 for the mature cows. Bulls are assumed to be 1.3 AEs.

The branding and mortality rates will eventually follow the Stream 3 relationships but are initially implemented using Gillard/Monypenny relationships converted to be based on liveweight gain and with adjusted caps, as described earlier. Calving is year round but with 60% of the calf drop in Oct-Dec, so the Herd-Econ biological year is set to begin in Oct. Birth distributions through the year are based on the Katherine patterns (Foran *et al.* 1990) and are not currently corrected for factors such as late wet seasons; mortalities are assumed even over the year (given the long-term runs, the unvarying patterns should only create small biases, though calf mortality might be underestimated). A weaning round is presumed to occur in May and again in Nov, and calves are 'born' at their weaning weight of 170kg. Liveweight gain is applied directly to steers and heifers but not accounted accurately for cows; hence the latter are sold per head, the remainder per kg liveweight.





In all strategies, bulls are purchased to maintain a 4% ratio with breeders, at \$5000/hd. Most steers are sold in May for \$1.30/kg; remaining steers and surplus heifers are sold for \$1.10 to local markets whenever sales are made (a future study should assess what percentage would achieve the premiums of the Jap-Ox market as opposed to local sales, according to a weight distribution; the live export cattle market is also being considered under LUCNA). Cull cows are sold at \$1.00/kg and surplus younger cows when over-stocked at \$1.10/kg, which presumes that a market can be found (this should possibly be increased for Forecast sales of cows in calf).

All costs and prices are presumed to be in ca.1992 \$Aus. The variable direct cost of running cattle is taken to be \$17.60/adult hd/y, with an additional total selling costs of \$5.80/head sold (based on Hinton 1993, p.73). For the average herds of 2000 AEs and 25% turnoff discussed by Hinton (1993), this represents ca. \$38,000/y; other major direct cash costs were loan interest (\$19,000), livestock purchases (\$17,000), labour (\$21,000) and materials and repairs and maintenance (\$70,000), leaving about \$22,000 in other cash costs from the total cash payments of \$187,000/y. Here we assume the latter items represent \$92,000 of fixed overheads, with a further fixed interest bill of \$19,000/y. Labour is made variable per head of breeders (ca. 47% of herd: 25% turnoff plus 5% deaths requires ca. 600 births/y, which at 64% branding means 940 breeders) to capture the effects of major changes in numbers, at \$22/hd/y; this combines some assumptions for economies of size with some realistic change in costs with increasing animal numbers. Finally, regional estimates show depreciation at about \$48,000/yr and that family work receives about \$24,000 (Hinton 1993, p.68), so these amounts are entered as capital replacement and personal expenses respectively to represent some additional outgoings. No provision for cost deferment is made since we assume the intention is to stay in business for a long time; hence the temporal distribution of expenses is less significant than in short-term investments. (With these average figures and the herd stabilised at 1000 cows, average annual cash surplus was around \$6,000 in a total turnover of ca. \$300,000, comparing favourably with Hinton's estimate of \$7,000.)

When de-stocking is needed, all strategies first ensure normal sales are complete. The herd has a fairly high replacement rate, so sales then concentrate on reducing cows somewhat before selling additional steers (initial attempts to sell these first resulted in there rarely being any fully grown steers and hence very poor profits). The sequence is therefore to sell any cows 6 years old and older (from the oldest; ages 7+ sell for \$540/hd, age 6 for \$550/hd), then cull up to 25% of all the remaining age groups of cows (\$550/hd); if more than 30% of the herd is cows (the long-term proportion of cows in the stabilised herd), all remaining 5 year old cows are then sold. If the stocking rate is still too high, any purchased trading steers are sold next; then up to 30% of all home-bred steers are sold from all age groups, before selling all remaining steers from the oldest downwards (again, selling from the oldest initially caused considerable losses in income relative to this modified strategy). Finally all the heifers are sold, but the core 3 and 4 year old cows are retained regardless. All animals other than cows are sold at \$1.20/kg on their current weights. The strategy sounds complex, but simplistic approaches had drastic implications for sales; for example, the change from selling from the oldest to selling across age groups increased average annual cash flows by an astonishing \$20,000/y - further investigation of these types of modifications is urgently needed.

[Originally, we intended all strategies to respond also to severe years, even if they normally have high target numbers; if the total standing dry matter (TSDM) on the ground in May is such that there would be less than 750 kg ha<sup>-1</sup> left 6 months later (in November) for current stock numbers, then stock were to be sold until this was no longer the case (not selling the core breeding herd - this could provide the trigger for optional extra feeding or agistment costs in future analyses). 750 kg ha<sup>-1</sup> was intended to provide a minimum soil erosion protection and some buffer against a bad summer seasons from the point of view of forage in years which are clearly very poor. However, this provision proved too strong and was relaxed: it should be investigated at some stage, perhaps using 375-500 kg ha<sup>-1</sup> instead.]

To meet a re-stocking target with too few animals, stock will be bought with the following constraints. If the breeder numbers are below a long-term typical breeding herd size (assessed on whether more than 60% of the herd is cows - if so, no more females are bought), then heifers (at 250kg liveweight for \$300/hd) will be bought up to the lesser of 200 in one year or a number which takes the cows to 70% of the herd. If breeders already exceed 60% of the herd, or if more animals are still needed after buying the maximum heifers, then store steers will be bought (at the same price and weight as heifers) into a fattening class which has the same growth and mortality characteristics as the home-bred steers; these are sold as stores or fats in the normal course of steer selling strategies in the following years, depending



on their weight gain and the season; steer purchases are limited to a maximum of 1000 in one year. The purchasing limits are intended to mimic cash flow and availability constraints.

### The strategies

Various forms of 5 approaches to management were tested, leading to a total of 9 sets of simulations (Table 2).

#### Constant

The Constant strategy targets a constant number of cows in May each year. Other than ordinary sales of steers and old cows to maintain these numbers, no further buying or selling is carried out; fluctuations in mortalities and branding rates are accepted as they come. We ran 12 levels of target cows - C0250, C0500, C0750, C1000, C1250, C1500, C1750, C2000, C2250, C2500, C2750, C3000.

#### Reactor

The Reactor strategy adjusts stock numbers in May to attempt to meet a given utilisation level of the pasture *then* on offer; that is, the AEs targeted are ( $utilisation * TSDM / intake\ per\ head\ per\ year$ ). To meet this target with too many animals, the Reactor will sell as many animals as necessary according to the selling strategy; if it is understocked, it will buy (up to the caps) according to the buying strategy. We ran 12 levels of target utilisation level from 2.5% to 30% - R025, R050, R075, R100, R125, R150, R175, R200, R225, R250, R275, R300.

Initial runs suggested that much of the benefit of the Forecast and Perfect Knowledge strategies might come from the second stocking decision regardless of the information then available, so an additional Reactor run was carried out where it too was permitted a second decision in November but always based on the middle forecast of expected growth (*ie.* the  $-5 < SOI < +5$  forecast was used in all years). Finally, it is possible that ignoring future growth even in June is unrealistic (although many producers do seem to). Further runs were carried out where the decision in June was based on current TSDM plus the middle forecast of expected summer growth (*ie.* the two decision points of the previous option were telescoped into one). Both of these options were repeated for the same target utilisations as the main Reactor run.

The three Reactor strategies were thus: *Reactor (Jun)* for a June only decision point on current TSDM, *Reactor (Jun&Nov)* for two decision points, and *Reactor (Jun+growth)* for a June only decision point including prospective summer growth.





Table 2: The key decision-making differences between the strategies simulated

| Name                          | Timing of adjustments | Basis for adjustment                                                                       |
|-------------------------------|-----------------------|--------------------------------------------------------------------------------------------|
| <i>Constant</i>               | None                  | (Normal sales target a set number of cows)                                                 |
| <i>Reactor (Jun)</i>          | June                  | Use of current standing dry matter                                                         |
| <i>Reactor (Jun+grwth)</i>    | June                  | Use of current standing dry matter plus median expected summer growth                      |
| <i>Reactor (Jun&amp;Nov)</i>  | June<br>November      | Use of current standing dry matter<br>Use of median expected summer growth                 |
| <i>Forecast (Jun&amp;Nov)</i> | June<br>November      | Use of current standing dry matter<br>Use of SOI-adjusted expected growth for summer ahead |
| <i>Forecast (Nov only)</i>    | November              | Use of SOI-adjusted expected growth for summer ahead                                       |
| <i>Perfect (Jun&amp;Nov)</i>  | June<br>November      | Use of current standing dry matter<br>Use of actual growth for summer ahead                |
| <i>Perfect (Nov only)</i>     | November              | Use of actual growth for summer ahead                                                      |
| <i>Proactor</i>               | June                  | Use of actual growth for year ahead                                                        |

## Forecast

The Forecaster makes the same decisions in May as does *Reactor (Jun)*. Further stock adjustment decisions are made in November, when purchases or sales are made according to the same strategy as *Reactor*, except that the target AE number is for utilisation of the expected growth over the summer season, where this expectation is adjusted by the SOI for that year (residual standing dry matter is assumed irrelevant). The expectation is provided by regression relationships against the perennial status of the pasture (p, % perennials: see Working Paper 8) for the three categories of SOI years as follows:

$$\begin{array}{ll}
 \text{SOI} < -5 & ) \\
 -5 < \text{SOI} < +5 & ) \text{ Expected growth} = \\
 \text{SOI} > +5 & ) \quad (\text{kg/ha})
 \end{array}
 \begin{array}{l}
 ( 191.8 + 4.872 * p + 0.07051 * p^2 \\
 ( 201.9 + 5.215 * p + 0.06422 * p^2 \\
 ( 457.1 + 10.63 * p + 0.06921 * p^2
 \end{array}$$

[Additional adjustments could be made to sell cows-in-calf due to drop late and therefore at high risk in years forecast to have a late wet. Other Forecast responses could also be tried, eg. reduce stock 50% if SOI<-7, and increase 30% if SOI>+7.] We ran 12 levels of target utilisation from 2.5% to 30% - F025, F050, F075, F100, F125, F150, F175, F200, F225, F250, F275, F300.

In order to compare with Working Paper 8 and to clarify the value of a second decision point, additional runs were carried out where only the normal sales decisions were made in May, then all stock adjustments related to expected growth were made in Nov only. This strategy was repeated for all target utilisations. Thus the base Forecast strategy was *Forecast (Jun&Nov)* and the simplified strategy was *Forecast (Nov only)*.



### Perfect Knowledge

Perfect Knowledge operates exactly as Forecast except that the growth over summer is calculated by GRASP (initially using the stocking rate in Nov, but iterating this with the number proposed by GRASP until there is convergence) and the actual prospective growth is then used to determine the target stock numbers. We ran 12 levels of target utilisation from 2.5% to 30% - P025, P050, P075, P100, P125, P150, P175, P200, P225, P250, P275, P300.

As with Forecast, additional runs were carried out where only the normal sales decisions were made in May, then all stock adjustments related to the known summer growth were made in Nov only. This strategy was repeated for all target utilisations. Thus the base Perfect Knowledge strategy was *Perfect (Jun&Nov)* and the simplified strategy was *Perfect (Nov only)*.

### Other runs

Additionally, we tested how valuable a full year's forecast might be in a simplistic way by carrying out a 'Proactor' perfect knowledge strategy; this behaved like the original Reactor strategy in making a decision once a year in May, but ran GRASP a year ahead with no stock to assess the potential growth in the forthcoming year, then set stock numbers according to this instead of the existing standing pasture. Thus it is really a Perfect Knowledge strategy for one year ahead. The same target utilisations were tested, although these result in higher achieved utilisations, so only the lower target results are shown.

### Outputs.

A very wide range of outputs can be obtained from the linked models, but here we focus on the following items: year, total rainfall (June-May), pasture growth and pasture eaten (hence actual utilisation achieved), grass basal area, perennial index, soil loss, AEs in June, AEs in January (*ie.* over summer), cow numbers in June (after extra sales; *ie.* approximately the number that will calve in the main calving time in early summer), annual LWG, births, deaths, annual cash surplus, sales, purchases, and 'forced' sales or purchases in June and November. The runs use the actual 108 years of weather data (as cleaned up for Stafford Smith and McKeon 1996) from 1887-1994, where 1994 refers to June 1994-May 1995 (Fig.3).

Some of the actual annual values are reported below (all were recorded in the simulations), but most results are discussed in terms of the overall mean values for the 108 years, and in some cases their standard deviations. Utilisation as referred to here is the actual achieved utilisation calculated as the total quantity eaten over the 108 years divided by the total pasture growth over the same period (various other measures can be nominated but this is compatible with past QDPI use).

An extensive exercise in sensitivity analysis of the linked model is now under way and will be reported fully as an outcome of a subsequent project (LUCNA, RIRDC project CCH-7); some preliminary results are described here. Additionally, the choice of strategies could depend on the expectations of managers as reflected in their discount rate. The cash flows are therefore expressed in net present value terms for different discount rates and for various baseline times.





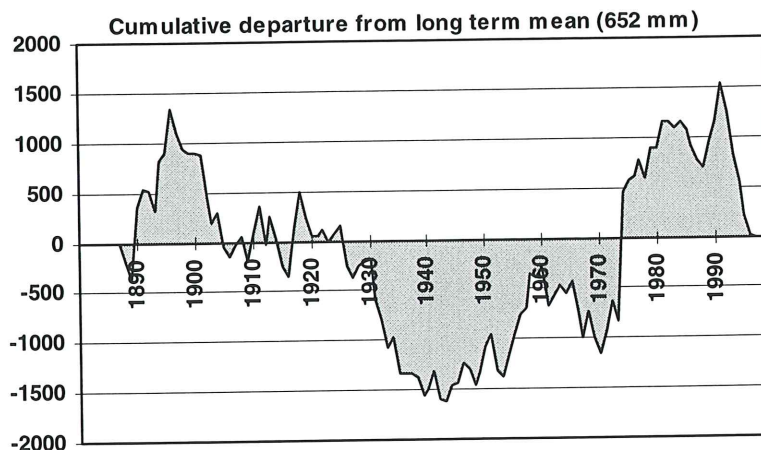
Finally, simplified were performed for a ignoring financial IEDs and livestock tax averaging for assumption that all production. The

**Net taxable income**  
(total costs) +  
(opening book  
- (any loss

**Tax for company =**  
income this

**Tax for individual**  
this year [if  
of last 5 years'  
>0]) / (average  
taxable income

**Net cash surplus** = (cash surplus) - (tax)



**Fig.3:** Annual rainfall records for Charters Towers, displayed as the annual cumulative departure from the long term mean (652 mm); the annual rainfall is calculated for June to May, 1887-1995. Note the dry periods in the 1900s, 1930s and 1990s, and wet periods in the 1890s and 1970s.

taxation calculations subset of results, instruments such as elections, but including individuals with the income is from primary calculations used were:

= (total income) -  
(closing book value) -  
value) - (depreciation  
carried forward)

0.36 \* (Net taxable  
year [if >0])

= (Net taxable income  
>0]) \* (tax on average  
Net taxable income [if  
of last 5 years' Net  
[if >0])

where *total income* - *total costs* is provided by Herd-Econ's cash surplus (assuming no net exchange of non-livestock assets or loans, etc, but allowing for capital replacement through depreciation, see below), the *book values* were calculated on AEs in Jun at an assumed average market value of \$495/AE (\$1.10 per kg for a 450kg beast - ie. comparable to the prices being received in the baseline runs and, by using AEs, allowing partially for changes in herd structure), *depreciation* was assumed to be a fixed amount over the run (\$48000/year to match the capital replacement value noted earlier) but is introduced here as a negative value to cancel out the otherwise uncaptured capital improvements, private tax is calculated according to the correct thresholds and rates for 1995 (based on Bob Douglas's tax macros; Tapp *et al.* 1995), and the *cash surplus* is as reported by Herd-Econ on the assumptions given earlier. The *Net cash surplus* figure was calculated for both company and private cases.

## Results

### General patterns

In all strategies, the variability of annual cash flow increases as target stocking levels increase; Fig.4 shows that the least variable line for each strategy is for the lowest target. In the case of the Constant strategies, this results from an increasing imbalance between pasture and stock numbers such that poor years result in severe livestock crashes, and then considerable build-up times. For the other strategies, buying and selling may largely maintain the intended balance between pasture and stock numbers, although complete build up becomes increasingly difficult to guarantee at the higher levels since there are caps on the maximum number of purchases permitted in any one year. Larger amounts of buying and selling are required to maintain the balance as target levels rise, thus also increasing variability in cash flow. Furthermore at the highest target levels, pasture condition declines markedly and sometimes permanently in the major droughts, leading to further instabilities or dramatic changes in production; this is visible in the drop of the C2750 curve from the 1960s onwards (where the vegetation finally reaches a permanently annual state in 1985), but occurs in some of the other high stocking rate options too.

As Fig.4 shows, the strategies which involve more active buying and selling also generally have higher levels of variability in cash flow, although this would change if tax smoothing was added. It is superficially surprising that the Reactor with two decision points is relatively stable; this seems to occur because the second adjustment is towards a constant number for a given utilisation target (ie. in November, it is towards the average summer growth times the target utilisation, rather than being affected either by different past growths at the June decision point, or variable growth estimates in summer as for the Forecast and Perfect decisions).



The main simulated outputs are shown for all strategies and target stocking levels in Fig.5. It can be seen that there is a more-or-less clear optimal level for each strategy in cash flow terms, and that, as mentioned above, the variability around the mean increases with increasing target stocking level for all options (Fig.5a). In general increased targets do mean increased stock numbers, although in some cases these increases cannot be sustained because of vegetation crashes or a greatly reduced capacity to recover from drought (Fig.5b); where they are sustained, increased numbers also imply increased variability. Similar results apply to cow numbers (Fig.5c).

The achieved utilisation level changes in a systematic way within each strategy (Fig.5c): in particular, the strategies with more information and a second decision point are able to meet their targets more effectively so that the relationship between target and achieved utilisation is more nearly a straight line. This is particularly so in the Perfect knowledge approach. Once utilisation rates reach damaging levels for the pasture, these strategies are also able to carry out this damage more efficiently too, leading to the sharpest thresholds beyond which production collapses. The nature of this collapse, and when it occurs during the hundred years, causes the apparent discontinuities at the higher stocking rate values in some of the strategies. (Note that the Reactor (Jun+growth) strategy effectively targets higher stocking levels for a given utilisation due to the way the target number is calculated, so collapses occur for lower target utilisations than the others, but still at about the same achieved utilisation: see Fig.5c, Table 3a.)





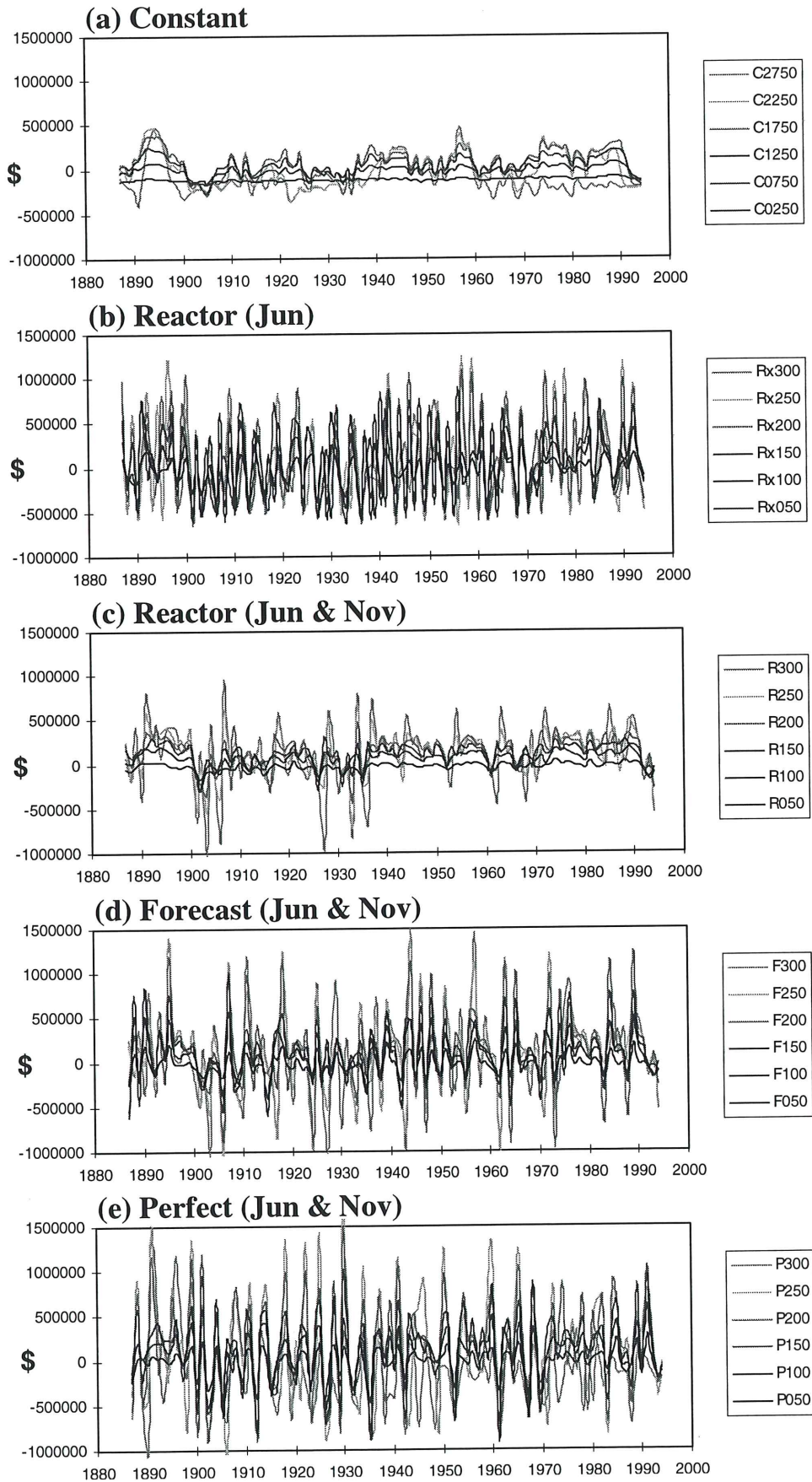
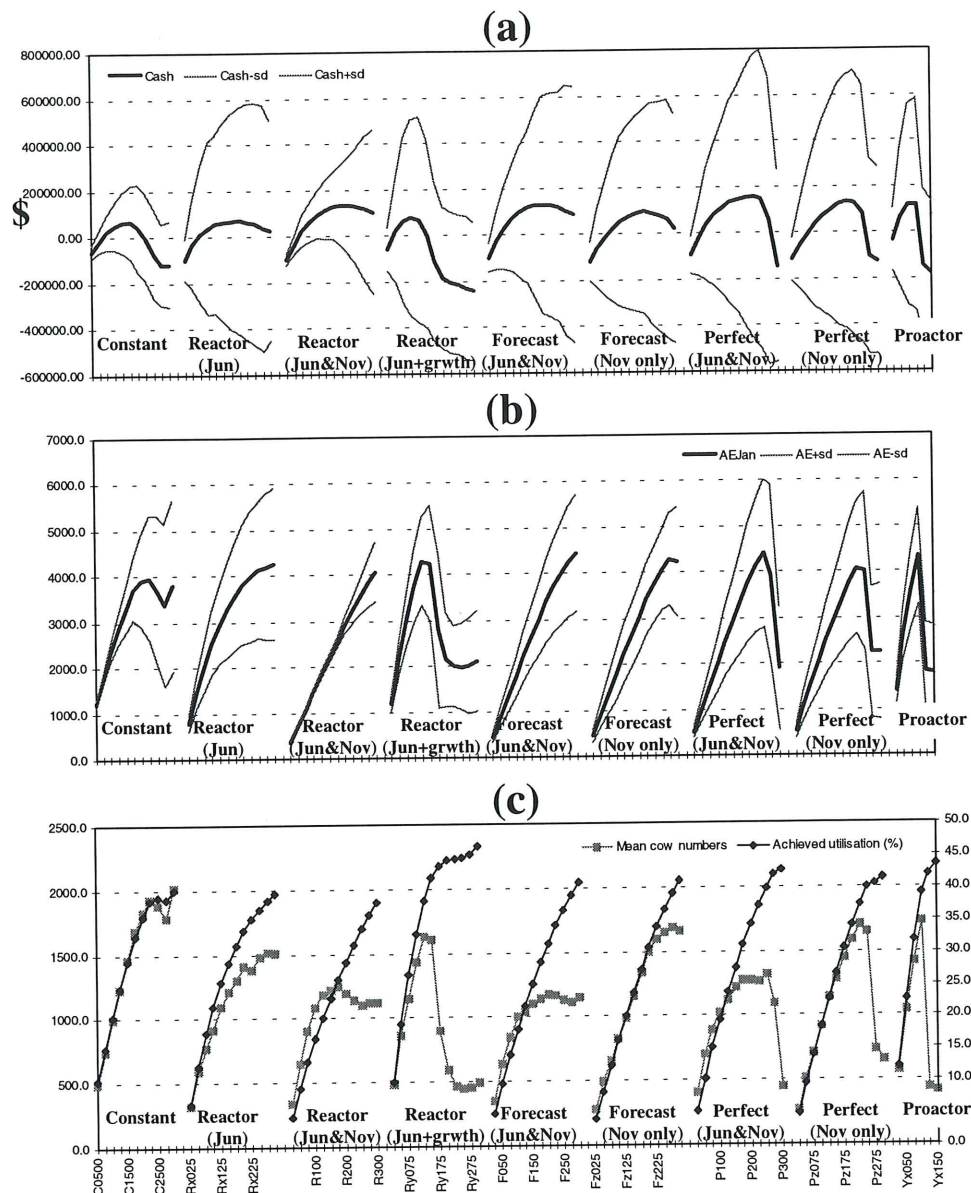


Fig.4: Simulated annual cash flows over 108 years from 1887 for selected target stocking rates for the main strategies, all shown on the same scale.





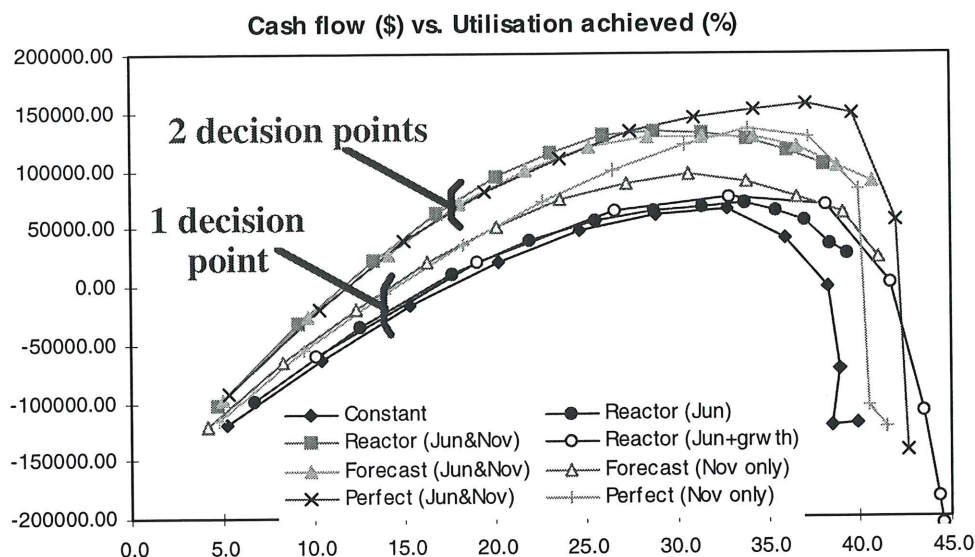


**Fig.5:** Simulated (a) mean ( $\pm$  standard deviation) annual cash flow, (b) mean ( $\pm$  standard deviation) animal equivalents (in January), and (c) mean achieved cow numbers (in June) and utilisation by strategy and target stocking rate. (Detailed source data in Table 3 and Appendix A.)

### Comparing the strategies: mean cash flow

Cash flow is plotted against achieved utilisation for all the strategies in Fig.6, where it is apparent that each reaches an economic optimum in the range of targets simulated. The results for these optimum levels only are reported in fuller detail in Table 3 (the results for all target levels are shown in Appendix A). The maximum cash flow for each strategy is usually obtained at achieved long-term utilisation rates of 28-34%, regardless of the target, and at similar mean numbers of animal equivalents (3-4000 over summer, even though these means are achieved with very different patterns of interannual variability).





**Fig.6:** Mean annual cash flow received for each strategy at different achieved utilisation rates; strategies involving a second decision point and stock adjustment consistently perform better in terms of means than those with one decision point. Within each group, Perfect knowledge always conveys a substantial advantage (but at a higher utilisation rate), while Forecast only helps for the single decision point. Results are dependent on assumed price regimes (see text and Table 4).

There is a clear separation between the group of strategies involving one decision point, and the group involving two (Fig.6). Within the single decision point group, there is little difference in the optimum mean cash flow for the Constant and two Reactor strategies, at around \$70,000 per year; the Forecast (Nov only) strategy improves on this by about \$25,000 per year, and Perfect knowledge (Nov) gains a further \$40,000 per year. Thus the Forecast strategy (for this set of prices and costs) achieves about 5/13ths or 38% of the improvement which is theoretically possible. This result is sensitive to various factors such as selling strategies and prices.

The strategies involving two decision points show a different pattern. There is negligible difference between Reactor (Jun&Nov) and Forecast (Jun&Nov), making about \$130,000 per year; Perfect knowledge improves on this by \$25,000 per year. (Forecast is slightly poorer than Reactor for the current price assumptions, but the difference is within any confidence limits we would place on the simulations.) This implies that (i) there is substantial intrinsic value in carrying out two decisions per year rather than one (perhaps \$20-30,000) and (ii) that a decision point in November may have some intrinsic value over the June time. This is counter-intuitive since there is little additional information available other than the realised outcome of the dry season, but implies that some of the Forecast strategy's gain with a single decision point may be a question of timing (a future study could check a Reactor (Nov only) strategy) - whether this is a real effect or one created by the simulations must be assessed with some caution, since the fact that liveweight gain is not simulated within the year means that the advantages of selling at the end of the dry season may be overstated. Even if it is real, markets and management may be unable to adjust to this option. In either case, though, it implies that the Forecast benefit on a single decision point is probably less than simulated, and it does not invalidate the suggestion that two decision points may be better than one.

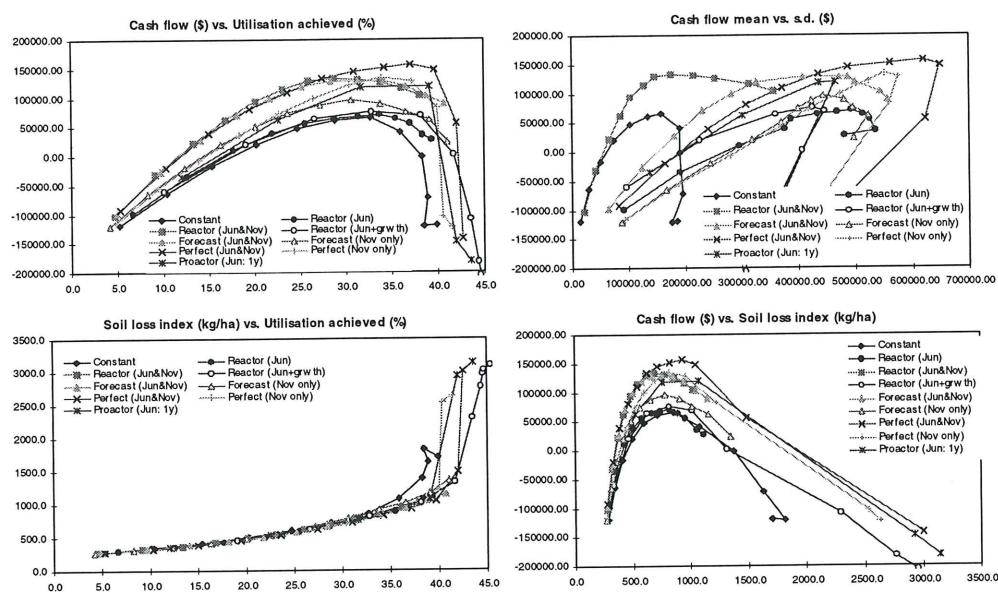
### Comparing the strategies: other measures

Cash flow (even corrected for tax) is not the only measure of importance either to day-to-day management or to long-term sustainability. Figs.7-9 illustrate aspects of economic risk which may affect short term management preferences, and the soil loss index which relates to long-term ecological risk. Fig.7 shows all strategies for comparison; single and double decision point groups are separated in Figs.8 and 9.

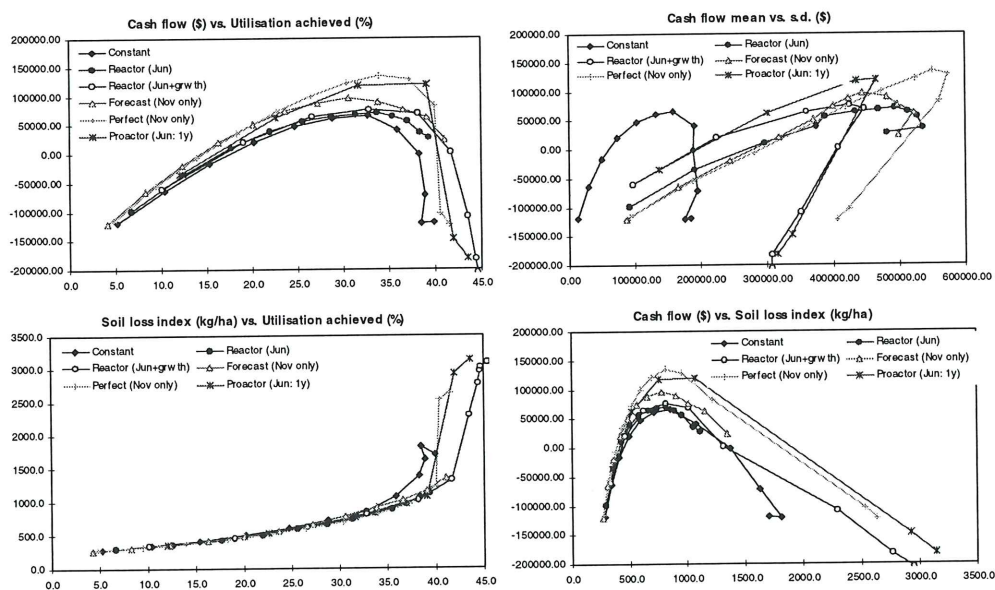




For a single decision point, Fig.8 confirms that all strategies other than Constant show high levels of financial variability relative to the mean returns (Fig.8, top right). Investment analysts suggest that typical responses to risk mean that people trade off risk against mean returns such that their preferred position will fall to the left of the top of these curves. Depending on their level of risk aversion, this trade-off will move more or less from the peak. Additionally, downside risk is often a greater concern than upside gain, so re-expression of the results in terms of mean annual cash flow against, for example, the frequency with which annual cash flow falls below zero can give a more useful assessment of response. This result can also be examined in cumulative probability distributions (*cf.* Stafford Smith *et al.* 1995). Additional analyses of this nature are now being undertaken.

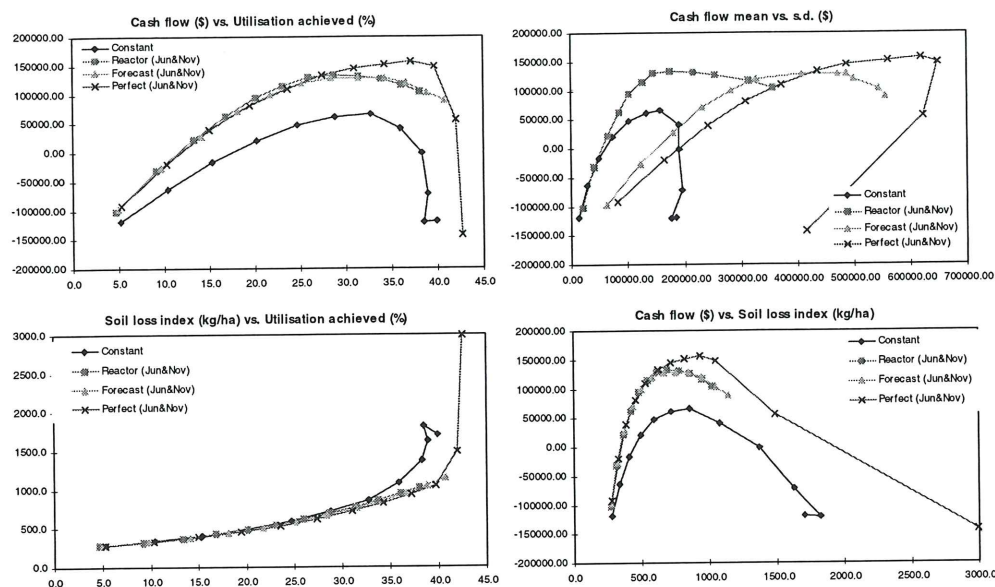


**Fig.7:** Relationships between cash flow and soil loss risk and achieved utilisation rates(left), and between cash flow and risk factors (right), for various stocking strategies at different target stocking rates: all strategies.



**Fig.8:** Relationships between cash flow and soil loss risk and achieved utilisation rates(left), and between cash flow and risk factors (right), for various stocking strategies at different target stocking rates: strategies involving one decision point each year.





**Fig.9:** Relationships between cash flow and soil loss risk and achieved utilisation rates(left), and between cash flow and risk factors (right), for various stocking strategies at different target stocking rates: the Constant strategy and strategies involving two decision points each year.

Environmental risks (Fig.8, bottom right) can be examined in two useful ways. On the one hand, choosing a given risk of soil loss results in a wide variation in mean annual cash flow according to the management strategy implemented - *eg.* at a soil loss index of 750kg/ha/yr, mean annual cash flow varies from about \$60,000 (Constant) to \$130,000 (Perfect Knowledge). Alternatively, a given level of cash flow can be achieved for a variety of different levels of soil loss risk, with the range increasing with the cash flow sought - *eg.* the maximum cash flow level for Constant, about \$65,000, can be achieved for soil indices anywhere between 400 and 850 kg/ha/yr (ignoring the same levels on the descending limb of the graph). This highlights the fact that Forecast strategies may play a bigger role in long-term resource protection than in improving cash flow.

Broadly similar conclusions can be drawn from the strategies with two decision points (Fig.9), where the Constant strategy is repeated for comparison. Here it is notable that the Reactor (Jun&Nov) strategy manages to improve mean annual cash flow at little cost in terms of increased variability, making it an extremely attractive strategy relative even to the Perfect Knowledge result which improves mean cash flow modestly at a major cost in variability (again, this effect would be reduced by tax averaging, but still has implications for market variability, etc). Up to the point of the optimal Reactor (Jun&Nov) cash return, there is a negligible gain in reduced soil loss risk over the Forecast or Perfect Knowledge strategies. Another measure of environmental risk could be the frequency with which it was possible to burn the pasture (*ie.* the proportion of years with total standing dry mass greater than a critical threshold), which will generally decrease with increasing stocking rates (*cf.* Table 3b, Appendix Table A.1b). Inasmuch as fire management is important for controlling the invasion of undesirable woody weeds, this would reflect how much increased returns were coming at the cost of reduced opportunities for using this long-term pasture management tool.

None of the strategies caused other than modest reversible changes in short-to-medium term pasture productivity at their economic optima as shown. However, the shape of the curve around this point is important: the steeper thresholds are clearly more dangerous in terms of the risk of making errors and having severe effects on the resource base. Flatter curves imply that the choice of precise target is less critical both for economic and environmental outcomes.





Finally, Fig.8 includes the 'Proactor' strategy, looking a year ahead with perfect knowledge. This outperforms all single decision point strategies except Perfect (Nov), and has a better risk performance up to its optimum return. This is encouraging, since we have captured only a very simple management response to 12 months forecast information here; there is little doubt that in reality producers would find more sophisticated and profitable ways of using this much advance intelligence. On the other hand, as simulated the strategy achieves this at quite high utilisation rates (due to its perfect knowledge), which may be unsustainable for other reasons.

**Table 3: Simulated outputs for the target stocking level for each strategy which achieves the highest mean annual cash flow (see Appendix for full listing of all stocking levels): (a) mean annual and standard deviations of key measures, (b) mean annual biophysical measures, (c) mean annual management measures.**

| (a)<br>Strategy / target    | Utilisation<br>achieved (%) | Annual cash flow<br>(\$) |         | AEs in January<br>(450 kg steer equivalents) |      |
|-----------------------------|-----------------------------|--------------------------|---------|----------------------------------------------|------|
|                             |                             | Mean                     | SD      | Mean                                         | SD   |
| Constant<br>1750 cows       | 32.7                        | * 65,673                 | 158,221 | 3712                                         | 667  |
| Reactor (Jun)<br>20%        | 33.7                        | * 70,033                 | 492,804 | 3802                                         | 1295 |
| Reactor (Jun+grwth)<br>10%  | 32.9                        | * 75,616                 | 425,449 | 3727                                         | 784  |
| Reactor (Jun&Nov)<br>20%    | 28.7                        | 132,828                  | 175,727 | 2896                                         | 182  |
| Forecast (Jun&Nov)<br>17.5% | 28.4                        | 128,531                  | 408,469 | 3003                                         | 768  |
| Forecast (Nov only)<br>20%  | 30.7                        | * 95,047                 | 444,684 | 3415                                         | 768  |
| Perfect (Jun&Nov)<br>22.5%  | 37.2                        | 155,889                  | 618,701 | 4122                                         | 1444 |
| Perfect (Nov only)<br>20%   | 34.0                        | * 134,758                | 550,354 | 3724                                         | 1262 |
| Proactor<br>10%             | 39.1                        | * 120,082                | 464,843 | 4333                                         | 1053 |

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





Table 3 (continued)

| (b)                         | Grass basal area | Total standing dry matter | Soil loss index | Perennial index | Liveweight gain |
|-----------------------------|------------------|---------------------------|-----------------|-----------------|-----------------|
| Strategy / target           | (%)              | (kg/ha)                   | (kg/ha)         | (Index 0-11)    | (kg/hd/yr)      |
| Constant<br>1750 cows       | 2.72             | 1400                      | 858             | 0.27            | 101             |
| Reactor (Jun)<br>20%        | 2.74             | 1391                      | 818             | 0.21            | 102             |
| Reactor (Jun+grwth)<br>10%  | 2.76             | 1545                      | 692             | 0.07            | 107             |
| Reactor (Jun&Nov)<br>20%    | 2.74             | 1407                      | 813             | 0.18            | 102             |
| Forecast (Jun&Nov)<br>17.5% | 2.76             | 1544                      | 666             | 0.06            | 109             |
| Forecast (Nov only)<br>20%  | 2.75             | 1471                      | 777             | 0.09            | 105             |
| Perfect (Jun&Nov)<br>22.5%  | 2.73             | 1312                      | 932             | 0.08            | 103             |
| Perfect (Nov only)<br>20%   | 2.75             | 1402                      | 814             | 0.03            | 107             |
| Proactor<br>10%             | 2.69             | 1236                      | 1074            | 0.51            | 98              |

| (c)                         | Number of cows in June | Branding rate | Number of births | Mortality rate (cows) | Total no. of mortalities |
|-----------------------------|------------------------|---------------|------------------|-----------------------|--------------------------|
| Strategy / target           | (mean)                 | (%)           | (mean/yr)        | (%)                   | (mean/yr)                |
| Constant<br>1750 cows       | 1680                   | 55.6          | 846              | 9.4                   | 225                      |
| Reactor (Jun)<br>20%        | 1403                   | 55.9          | 709              | 9.1                   | 207                      |
| Reactor (Jun+grwth)<br>10%  | 1195                   | 58.5          | 589              | 8.6                   | 160                      |
| Reactor (Jun&Nov)<br>20%    | 1430                   | 56.0          | 740              | 9.3                   | 205                      |
| Forecast (Jun&Nov)<br>17.5% | 1137                   | 59.5          | 582              | 8.3                   | 149                      |
| Forecast (Nov only)<br>20%  | 1497                   | 57.6          | 743              | 9.0                   | 195                      |
| Perfect (Jun&Nov)<br>22.5%  | 1267                   | 56.7          | 639              | 8.3                   | 175                      |
| Perfect (Nov only)<br>20%   | 1588                   | 58.6          | 806              | 8.1                   | 182                      |
| Proactor<br>10%             | 1728                   | 53.4          | 876              | 8.9                   | 219                      |

Given the fact that the optimal returns are all achieved at about the same long-term stocking rate and long-term utilisation levels, it is worth asking whether some simplified relationships can be developed as rules of thumb. For example, it is clear from Fig.7 that soil loss risk can be described by a simple function of achieved utilisation up to about 30%, for all management strategies despite their very different patterns of inter-annual stocking rates. GRASP models soil loss instantaneously as a function of rainfall and cover; since cover is related to utilisation for a given climate sequence, the simplification is perhaps not surprising but it hides a great deal of inter-annual variation. Such simplifications would be useful for other models with less process resolution. Similar results could probably be derived for some other key biological parameters, but evidently cannot be developed for economic returns across strategies, nor, unfortunately, for the relationship between means and variability for economic outputs.



## Sensitivity analyses

The preliminary sensitivity analysis (Table 4) is reported for Constant and Reactor strategies only (the complete results for these are listed in Appendix B). Amendments to the representation of management and of biology can alter the optimum target within a strategy and sometimes alter the relative success of different strategies. A 'dirty' weather file (in which correlations between climate variables had not been fully accounted for in filling in element for the earlier records) had only a modest effect on results; this probably resulted mainly from adjustments to the extremes of wet and dry years.

While it is not surprising that changes in purchase and sale prices in drought will have an effect on the long-term cash flow, these were modest and predictable. On the other hand, it is notable that 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 much larger effects.

**Table 4: Simplified sensitivity analyses of the simulation runs for Constant and Reactor strategies; the results are summarised as the change to the optimal mean annual cash flow caused by various adjustments, and whether this affected the optimum target within a strategy and the relativities of the strategies. The change in the optimal cash flow is given relative to the baseline optimum (*ie.* C1750 and R200 which differed by \$4,360- see Table 3).**

| Factor altered                                | Constant                      |                           | Reactor                       |                           | Alters which strategy is better? |
|-----------------------------------------------|-------------------------------|---------------------------|-------------------------------|---------------------------|----------------------------------|
|                                               | Change in cash flow from base | Change in optimum target? | Change in cash flow from base | Change in optimum target? |                                  |
| <b>Weather file:</b>                          |                               |                           |                               |                           |                                  |
| Use of 'dirty' climate sequence               | -\$7,374                      | -                         | -\$5,566                      | R175                      | -                                |
| <b>Prices:</b>                                |                               |                           |                               |                           |                                  |
| Bought Steers up \$50/hd                      | 0                             | -                         | -\$19,588                     | -                         | Yes                              |
| Buying cows, up \$50/hd                       | 0                             | -                         | -\$4,928                      | -                         | Yes                              |
| Selling steers up 10c/kg in drought           | 0                             | -                         | \$4,941                       | -                         | -                                |
| <b>Drought sale tactics:</b>                  |                               |                           |                               |                           |                                  |
| Sell only across all ages of cows             | 0                             | -                         | -\$13,565                     | R175                      | Yes                              |
| Sell heifers first, then cows, etc            | 0                             | -                         | -\$27,560                     | R175                      | Yes                              |
| Sell bought steers, then heifers              | 0                             | -                         | -\$40,691                     | R175                      | Yes                              |
| <b>Animal biology:</b>                        |                               |                           |                               |                           |                                  |
| Decrease birth rate cap 80 to 75%             | -\$7,101                      | -                         | -\$6,634                      | -                         | -                                |
| Increase birth rate cap 80 to 85%             | \$4,454                       | -                         | \$1,758                       | -                         | -                                |
| Adjust slope of birth rate equation           | \$15,828                      | -                         | \$11,150                      | -                         | -                                |
| Increase minimum mortality                    | -\$14,667                     | -                         | -\$15,776                     | -                         | -                                |
| <b>Pasture biology</b>                        |                               |                           |                               |                           |                                  |
| Pastures forced to 90% perennial              | \$6,667                       | -                         | \$2,227                       | -                         | Yes                              |
| Pastures forced to 88% perennial <sup>1</sup> | -\$30,508                     | -                         | -\$33,641                     | R175                      | -                                |
| Pastures forced to 1% perennial               | -\$255,012                    | <C1250                    | -\$247,607                    | <R150                     | -                                |

<sup>1</sup> this effect is unexpectedly large; it has been checked but needs further investigation in the vegetation sub-model.





The results here are not so responsive to changes in the equations for biological rates; notably, the order and relative profitability of the strategies tested were little affected, which is encouraging since our knowledge is poor in this area. The absolute effects on cash flow are considerable, however, and it is possible that the effects are minimised for these runs because these are bullock selling strategies - the results might be more sensitive if the age of turn-off was younger (this will be tested under LUCNA). All this highlights the need for good on-property records where possible.

Finally, changes in pasture growth parameters, represented by forcing these to take on a particular level of perennality, could have a large impact on cash flow. The baseline runs started with 90% perennials and generally changed little at the stocking level with optimum cash flows; consequently forcing the pasture to remain perennial had little impact. However, forcing the pasture into a less perennial state had a big impact, given the assumptions used.

Not obvious from Table 4 is the fact that all sensitivity changes had greater effects at higher stocking rates (except for drought selling and buying changes for Constant which contains no such activity at any stocking rate). In the case of the pasture changes, the effects become more significant once the baseline simulation run has some changes in pasture perennality; this usually starts to occur close to the targets with the best cash flows, so the optimum stocking target is quite sensitive to assumptions related to pasture change.

### Taxation and Net Present Values

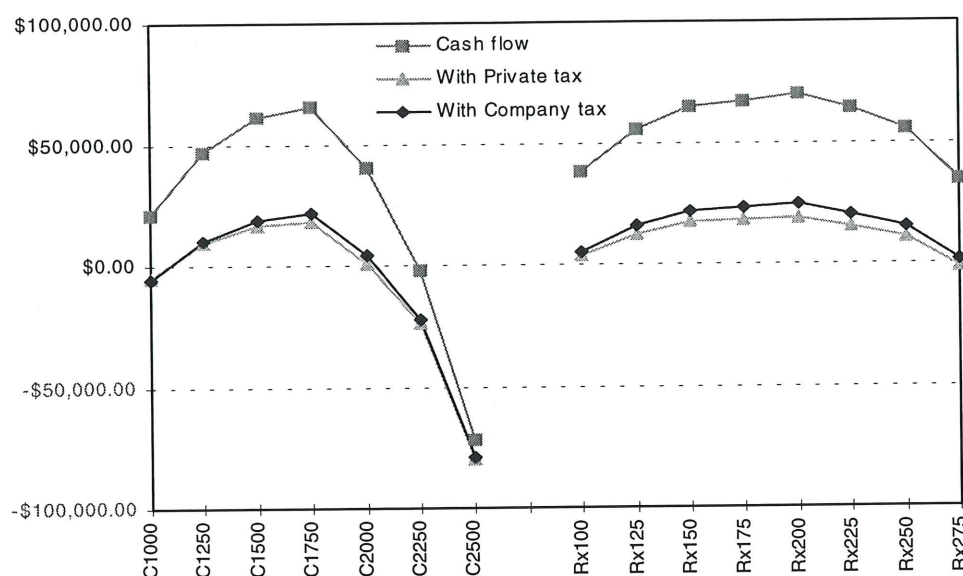
Converting cash flows into post tax income surprisingly never altered which stocking target produced the maximum returns, and also had little effect on the relative values of different strategies (Table 5). In general a flat company tax rate provided better returns in the long-term than tax averaging for a private business, although for a real enterprise there could be many factors which might alter this. The effect of taxation was to dull the variability of returns somewhat (*cf.* Table 3), although generally only in proportion to the reduced return. (Although the calculation of taxable income takes account of changing herd values, only the effect on cash-on-hand is reported here; variability in true profit and loss figures would be much more damped since the effects of buying and selling are accounted for in changes in capital values.)

However, importantly, Fig.10 illustrates that in most cases taxation made the optimisation surface flatter (*ie.* the difference between best and neighbouring stocking targets became smaller). Since there is no change in the underlying biology or soil loss risk through applying taxation, this implies that the probability of making a mistake by overstocking slightly is increased so that the risk of errors in environmental management could be increased. A more thorough analysis would be to examine the shape of the cumulative distribution of annual income to look at the effect of taxation on downside risk; this is beyond the scope of the current paper.

**Table 5: Mean annual net annual income after tax, assuming regular capital replacement schedules and ignoring off-farm income and financial instruments such as IEDs; tax has been calculated with tax averaging for a private business (with the appropriate tax thresholds, *etc.*, for 1995) and for a company (with a flat 36% tax rate). Approximately real market values are used for livestock book values (a sensitivity analysis shows that this has only a minor effect on the long-term results, *eg.* a reduction in book value for 1 AE from \$495 to \$300 increased the long term mean outcome by up <\$1,000 at the optimal level). The major strategies are shown, with the stocking target on either side of that resulting in highest mean annual cash flow (shown in *italics*).**

| Strategy / target | Unmodified cashflow (\$/yr) | Net annual post-tax income, company taxation (\$) |                | Net annual post-tax income, private taxation (\$) |                |
|-------------------|-----------------------------|---------------------------------------------------|----------------|---------------------------------------------------|----------------|
|                   |                             | Mean                                              | SD             | Mean                                              | SD             |
| Constant          |                             |                                                   |                |                                                   |                |
| 1500 cows         | 61,309                      | 18,787                                            | 103,283        | 16,155                                            | 100,655        |
| <i>1750 cows</i>  | <i>65,673</i>               | <i>21,326</i>                                     | <i>124,269</i> | <i>18,017</i>                                     | <i>120,824</i> |
| 2000 cows         | 39,947                      | 4,483                                             | 154,709        | 1,086                                             | 150,744        |
| Reactor (Jun)     |                             |                                                   |                |                                                   |                |
| 17.5%             | 67,213                      | 23,246                                            | 429,588        | 18,693                                            | 426,270        |
| 20%               | <i>70,033</i>               | <i>25,025</i>                                     | <i>443,513</i> | <i>19,814</i>                                     | <i>438,645</i> |
| 22.5%             | 63,680                      | 20,943                                            | 466,100        | 16,301                                            | 461,210        |
| Reactor (Jun&Nov) |                             |                                                   |                |                                                   |                |





**Fig.10: Response of cash flow before and after tax to target stocking rate for the core levels of Constant and Reactor (Jun), showing that taxation flattens the response curve.**

| Strategy / target   | Unmodified cashflow (\$/yr) | Net annual post-tax income, company taxation (\$) |         | Net annual post-tax income, private taxation (\$) |         |
|---------------------|-----------------------------|---------------------------------------------------|---------|---------------------------------------------------|---------|
|                     |                             | Mean                                              | SD      | Mean                                              | SD      |
| 17.5%               | 129,827                     | 61,913                                            | 121,168 | 54,277                                            | 118,134 |
| 20%                 | 132,828                     | 63,484                                            | 148,147 | 55,405                                            | 145,469 |
| 22.5%               | 131,071                     | 61,772                                            | 187,013 | 53,675                                            | 183,912 |
| Forecast (Jun&Nov)  |                             |                                                   |         |                                                   |         |
| 15%                 | 119,668                     | 57,292                                            | 282,199 | 50,587                                            | 276,780 |
| 17.5%               | 128,531                     | 62,385                                            | 362,896 | 54,835                                            | 357,414 |
| 20%                 | 128,322                     | 60,695                                            | 421,678 | 52,483                                            | 415,388 |
| Forecast (Nov only) |                             |                                                   |         |                                                   |         |
| 17.5%               | 87,180                      | 35,100                                            | 384,667 | 31,359                                            | 381,780 |
| 20%                 | 95,047                      | 39,227                                            | 404,254 | 34,435                                            | 400,732 |
| 22.5%               | 88,480                      | 34,648                                            | 439,811 | 29,264                                            | 435,313 |
| Perfect (Jun&Nov)   |                             |                                                   |         |                                                   |         |
| 20%                 | 151,939                     | 76,784                                            | 505,179 | 67,148                                            | 498,348 |
| 22.5%               | 155,889                     | 79,515                                            | 559,653 | 69,720                                            | 552,356 |
| 25%                 | 147,522                     | 74,053                                            | 593,785 | 65,014                                            | 587,244 |
| Perfect (Nov only)  |                             |                                                   |         |                                                   |         |
| 17.5%               | 121,577                     | 57,105                                            | 478,469 | 50,303                                            | 474,013 |
| 20%                 | 134,758                     | 65,259                                            | 501,964 | 57,390                                            | 496,656 |
| 22.5%               | 127,493                     | 60,386                                            | 524,871 | 52,900                                            | 519,859 |

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

Discounting had dramatic effects on both absolute and relative net present values for different strategies and stocking targets, particularly with respect to the starting time. Table 6 shows when the optimum targets were affected for the Constant and Reactor strategies, and whether there was a change in which strategy was best. In general, higher Constant stocking rates were favoured starting in 1940s and 1980s, and lower in the dry 1960s; there was a similar variation for Reactor, but the highest targets were favoured in the 1900s and lowest in the 1920s. 1902-1905 was a major drought, so the 1900s produce poor NPVs anyway, and the value for Reactor seems to be driven in this case by the substantial sales on entering the drought.



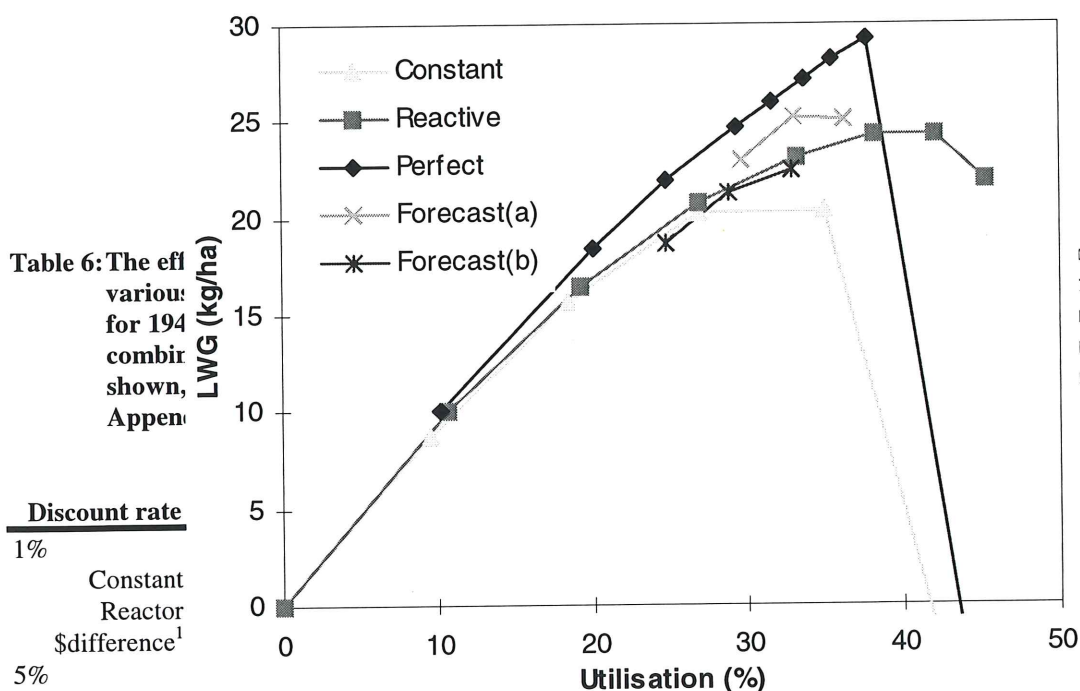


Although Reactor remains the preferred option in most cases, the margin varies, and in the 1920s the Constant strategy would have been preferred at any discount rate. The discount rate used also affects the outcome. There are small changes in the optimal stocking targets as the discount rate increase, generally increasing the departure from the undiscounted state (*ie.* to lower stocking targets in the 1920s and higher in the 1980s). There are also decreasing differences between strategies as the discount rate increases, reflecting generally smaller absolute NPVs. Although not shown here, comparable effects were obtained with other strategies.

Inasmuch as an NPV starting in a dry decade reflects differently on a manager's expectations to one starting in a wet decade (*cf.* Fig.3), the results confirm that early experiences could dramatically alter what stocking rate strategy and level is likely to be favoured. These NPVs reflect exactly the same overall set of climatic conditions ordered in the same way, and even the same overall sequence of annual cash flows, so this is simply an effect of the economic logic of discounting. If anything, the effect becomes more notable when one moves from a small (social) discount rate to a higher rate more typical of private interests. It is not surprising that a pastoral community contains people with many different attitudes to stocking rates.

### Comparison with Working Paper 8

Finally, we present the results obtained in Working Paper 8 (Fig.11 - see Fig.13(e) in WP8), where the system was simulated to the point of liveweight gain only, without including the feedbacks from herd dynamics and management. This should be compared with cash flow results in this paper (Fig.6); since all simulations are for the same area of property, these show the shape of the economic production per unit area (but note that cash flow has no absolute zero, unlike liveweight gain).



present values based on the later starting dates, *eg.* site-by-starting time provides the maximum NPV is detailed data is provided in

|               |          |         |                           |
|---------------|----------|---------|---------------------------|
| Discount rate | Constant | Reactor | \$difference <sup>1</sup> |
| 1%            | 147,178  | 106,718 | 44,729                    |
| 5%            | 150,000  | 106,718 | 44,729                    |
| 10%           | 150,000  | 106,718 | 44,729                    |

<sup>1</sup> the amount by which the Reactor cash flow exceeds the Constant cash flow at the optimum of each (negative values, in italics, means Constant is the preferred strategy); the undiscounted value of Reactor (20.0%) - Constant (1750 cows) is \$4,360.

<sup>2</sup> in this case an optimum was not reached in the range analysed (although a target 27.5% utilisation is already causing significant pasture damage): the cash flow difference is a minimum (the pattern is actually bi-modal).





The very general pattern of increasing returns from Reactor over Constant, some forms of Forecast over Reactor, and Perfect Knowledge over the rest, are similar in both sets of results; optimum achieved utilisations also fall in a similar bracket. However, the shape of the response to different targets within a strategy, and the relativities between strategies, are very different. This mainly reflects the reality of maintaining stock numbers in the face of fluctuating mortality and reproduction rates in the full simulation, as well as the effects of buying and selling stock on non-neutral markets. First, the GRASP-only simulations tend to show much steeper slopes on either side of the optimum targets levels for any strategy; the linked simulations show that these optima are usually much flatter in terms of cash flow (but not necessarily pasture damage and soil loss risk). Thus the linked model helps to show that *the link between economic production and resource damage is less tight or more lagged than suggested by simulating primary and secondary productivity alone* as in Fig.11; this could result in a greater risk of error from overstocking in real systems. Second, *the real benefits of any of the utilisation-driven strategies are dulled by the difficulties in maintaining the target numbers of animals*; thus even Perfect knowledge cannot return anything near the 50% increase in production over Constant as implied by Fig.11, and the benefits of the Reactor strategy are overstated. The modest performance of Forecasting with current levels of skill is consistent in both approaches, however.

## Discussion

The exercise summarised in this Working Paper has achieved a considerable number of objectives, and laid the groundwork for subsequent case studies for industry.

### Developing a methodology

As far as we are aware this is the first time that a comprehensive package has been developed to link a process model of pasture function to a detailed herd economics model which incorporates an understanding of pastoral management tactics and strategies. The few past approaches to simulating the entire system have not had the opportunity to the level of detail at each stage considered here, and consequently have not been able to examine the relative influence of different processes in the system. Of course, combining this much detail has its own costs: a very comprehensive analysis is now needed of the behaviour of the linked package to ensure its validity, and this has only just begun. Notwithstanding the careful modular approach to components of the package, there are many places where errors could be introduced, particularly in the interfaces between components. Furthermore, the complexity of the package is such that it is not intended for on-farm decision support use; rather, it must be used to create case studies, and hence simplifications which capitalise confidently on the insights gained from the full model.

This said, the approach is already capable of providing insights and useful results for the small number of pastoral systems in which its use has been most carefully scrutinised. This paper reports on use for cattle enterprises in the northern speargrass community around Charters Towers in north Queensland; parallel work has developed a similar capability for sheep in the mulga zone of SW Queensland (see Stafford Smith and McKeon 1996). The development of a simulation capacity has thus been successful, subject to some caveats in terms of biology, discussed below.

Additionally, by incorporating a large number of processes, the study has shown that it is possible to assess the relative significance of different components. The package can now begin to be used to simplify and remove those that can be neglected, and focus on obtaining precision for those that are most critical. As a general statement, for example, it is clear that our understanding of the significance of tactical decision-making in relation to buying and selling lags far behind our understanding of the biological system. This of course is a well-known but poorly-acted-upon factor in extension, where narrow results of apparent significance within one scientific discipline are ignored by industry because they seem to have little short term effect in the context of the broader enterprise. We now have a tool which can help to assess these issues, and determine when the results are genuinely irrelevant, as opposed to the occasions when better information simply needs to reach producers.

### Testing a variety of strategies for managing climatic variability

The analysis of alternative strategies for the northern speargrass has highlighted a number of points.





- 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: to be tested under LUCNA*). It seems that this level is linked closely to the level of stocking at which 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*; for example, if extreme events are actually disproportionately 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);
  - the significance of this to the predicted optimal stocking rate varies greatly depending 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.*
- However, the actual mean *cash flow achieved at this utilisation differs considerably between strategies*, so that a given cash flow can be obtained by different strategies with very different implications for resource protection in terms of soil loss risk and change in pasture composition.
- *The number of decision points each year is itself a vital factor in determining profitability.* Although it is a little surprising that this effect is so substantial across widely-differing stocking strategies, this is a result which might be expected; many studies suggest that an increase in the tempo of management improves outputs. The simulations appear to confirm this from a very different approach to the issue. (This result must be regarded with some caution, since a limitation of the present model is that liveweight gains are simulated on an annual basis; it is therefore not clear that the impacts of changes in stocking rates halfway through the year are correctly modelled, in that the benefits of selling at the end of the dry season in terms of liveweight may be overstated.)
- Taking annual cash flow through to a simplified version of tax surprisingly had little effect on which stocking target and strategy appeared most profitable. However, it considerably reduced the differences between stocking rate targets (without, of course, changing the risk of soil loss). *Thus tax averaging reduces the likely perceived financial riskiness of overstocking.*
- Simulating beef production per ha only (*ie.* 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.*

It is encouraging that vegetation crashes as modelled here would not have happened at the economically-optimal stocking levels in any of the strategies (for the price regime used). However, this finding emphasises the importance of the vegetation change sub-model, which may still be erroneous. The present model may not deal sufficiently with extreme combinations of conditions, and it does not claim to model major shifts in species other than those in the pasture (*eg.* woody weed invasion is not considered). Working Paper 8 considers some aspects of this by calculating how often fire could be used to suppress woody weeds. At higher stocking levels which do cause a crash even in this resilient vegetation type, it is notable that the final step in the crash is usually associated with dry years a decade or so after a major drought: typical examples are 1912 or 1913 (after the 1902 drought) and 1981 (after the 1960s), and perhaps 1990 (after both 1960s and 1980s). Thus, even without modelling post-drought phenology in detail, the need to give vegetation time to recover after severe dry times is obvious.





## Assessing the value of forecasting

Both the simulations of this Working Paper and those of Working Paper 8 show modest to negligible gains 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. Even the single decision point strategies, where Forecast seems to have some benefits, are probably overstating its value due to the result being confounded with the issue of the timing of the decision point (see p.18). However, the present simulations include the 1920-1950s period when the relationship between SOI and rainfall broke down; this may have under-represented the value of SOI forecasts a little if we can be confident that the relationship will hold in the near future. It is also possible that there are other strategies of using the SOI (*eg.* using a  $\pm 7$  cut-off, though years with these would occur even less often) which would give better gains. However, the gains for economics are sufficiently marginal that it is not surprising that industry is hesitant to take up the idea. In fact the gains may be more important in terms of resource protection.

Optimistically, 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, however, gains could be made by increasing the tempo of decision-making and by close attention to buying and selling tactics in dry years. Both of these factors should be investigated a little further - the issue of decision frequency may depend more on market and mustering opportunities than suggested here, and a more sophisticated risk analysis (*cf.* Stafford Smith *et al.* 1995) of buying and selling prices is needed to confirm results on trading tactics.

## Providing a pathway to future work

Model development should never be an end in itself. The purpose of developing this simulation tool is primarily to provide a means for carrying out case studies on a wide range of issues, from identifying the best management strategies and tactics for handling climatic variability in a sustainable fashion, to determining the impacts of different policy and price changes on enterprise profitability and likely resource condition. In the course of carrying out these studies, the integrative nature of the tool also allows an assessment of the more critical knowledge gaps (if any) in providing reliable answers to different questions. This initial case study has already highlighted some of these which now need addressing:

- further *sensitivity analysis and model validation* against on-property data where possible is now needed;
- the critical importance of sensible *sub-models of long term vegetation change* has been highlighted, since this determines long term (as opposed to short term) optimality (including, in this environment, the effects of fire and soil loss feedbacks on vegetation composition, and the shorter term shifts between perennial and annual forage - in other environments, establishment of palatable shrubs would also be important);
- an acknowledged limitation of the present model is that liveweight gains are simulated on an annual basis; it is therefore not clear that the impacts of changes in stocking rates halfway through the year are correctly modelled. *A shorter time step liveweight gain model is urgently needed;*
- the link between animal growth and the population dynamics (birth and death rates) remains a severe weak point in terms of scientific confidence; the methodology is now clear but *the birth and death rate relationships need further work;*
- further exploration of the effects of different assumptions in terms of long and short term views (*eg.* through NPVs) and different climatic sequences would provide insights into the behaviour of managers at different times in the past;



- it is clear that *our understanding of tactical decision-making in relation to markets is deficient* despite its essential importance to profitability; further investigation of this issue in the context of the whole system is urgently needed;
- finally, the sum of all the foregoing will be a more reliable systems analysis, and from that a further round of model assessment and, especially, simplification should then take place; it may be that a simplified decision support tool can be devised (along the lines of GRASSMAN's derivation from GRASP). In any case it should be possible to extract some critical relationships such as that suggested here for the overall link between soil loss risk and utilisation. These can then be used as rules for input to decision-making in a simpler, more digestible fashion.

In summary, this small part of the overall DroughtPlan project has met its objectives of carrying out a case study of the value of forecasting in northern Australia, after developing a new linked systems model to do so. Several of the follow up tasks identified above are now being undertaken as part of other projects by CSIRO and QDPI/DNR, in order that the tool may be robust for future uses.

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## Appendix A: All summary outputs for all runs

This appendix list the summary outputs for all simulated strategies by target stock numbers (compare Table 3). The shaded lines identify the targets which are optimal in terms of highest mean annual cash flow.

**Table A.1:** (a) achieved utilisation, cash flow, AEs in January, (b) grass basal area, TSDM, soil loss index, perennial index, liveweight gain, (c) cow numbers in June, branding rate, numbers of births, mortality rate of cows, total numbers of mortalities, (d) total numbers of sales, and forced sales or purchases in June and in Nov.

| (a)<br>Strategy /<br>target | Utilisation<br>achieved<br>(%) | Annual cash flow |           | AEs in January             |        |
|-----------------------------|--------------------------------|------------------|-----------|----------------------------|--------|
|                             |                                | (\$)             |           | (450 kg steer equivalents) |        |
|                             |                                | Mean             | SD        | Mean                       | SD     |
| Constant                    |                                |                  |           |                            |        |
| C0250                       | 5.2                            | -118619.15       | 13517.31  | 615.9                      | 28.3   |
| C0500                       | 10.4                           | -63087.67        | 29596.08  | 1213.5                     | 68.8   |
| C0750                       | 15.4                           | -16623.59        | 50039.77  | 1788.7                     | 124.0  |
| C1000                       | 20.2                           | 20789.30         | 74029.06  | 2336.3                     | 203.2  |
| C1250                       | 24.7                           | 46933.64         | 103439.30 | 2842.1                     | 328.7  |
| C1500                       | 28.9                           | 61309.36         | 133076.58 | 3297.3                     | 494.8  |
| C1750                       | 32.7                           | 65673.26         | 158221.12 | 3711.8                     | 666.8  |
| C2000                       | 35.9                           | 39946.78         | 190709.79 | 3901.0                     | 1017.2 |
| C2250                       | 38.3                           | -2486.58         | 189857.12 | 3963.9                     | 1357.3 |
| C2500                       | 38.9                           | -71972.83        | 195965.84 | 3685.0                     | 1636.4 |
| C2750                       | 38.5                           | -120909.86       | 176325.67 | 3365.6                     | 1778.9 |
| C3000                       | 39.9                           | -118902.26       | 184834.35 | 3800.1                     | 1861.1 |
| Reactor (Jun)               |                                |                  |           |                            |        |
| Rx025                       | 6.7                            | -98521.00        | 91599.63  | 782.5                      | 172.2  |
| Rx050                       | 12.5                           | -36067.68        | 191180.36 | 1459.5                     | 354.1  |
| Rx075                       | 17.7                           | 9372.99          | 297526.47 | 2043.7                     | 538.8  |
| Rx100                       | 22.0                           | 37882.86         | 375058.91 | 2522.8                     | 699.3  |
| Rx125                       | 25.6                           | 55510.90         | 388166.37 | 2923.9                     | 856.2  |
| Rx150                       | 28.7                           | 64400.99         | 433399.95 | 3262.6                     | 1018.5 |
| Rx175                       | 31.4                           | 67212.73         | 468037.79 | 3551.0                     | 1174.3 |
| Rx200                       | 33.7                           | 70033.07         | 492804.24 | 3802.1                     | 1294.9 |
| Rx225                       | 35.5                           | 63680.09         | 512452.49 | 3978.2                     | 1412.6 |
| Rx250                       | 37.0                           | 55748.91         | 525739.33 | 4128.6                     | 1489.1 |
| Rx275                       | 38.4                           | 34783.88         | 535291.62 | 4193.2                     | 1591.0 |
| Rx300                       | 39.4                           | 26062.95         | 480272.92 | 4253.9                     | 1646.3 |
| Reactor (Jun&Nov)           |                                |                  |           |                            |        |
| R025                        | 4.7                            | -101694.43       | 20875.89  | 364.7                      | 7.9    |
| R050                        | 9.2                            | -32768.04        | 41688.32  | 731.6                      | 23.7   |
| R075                        | 13.3                           | 21331.50         | 64616.50  | 1101.5                     | 47.9   |
| R100                        | 16.8                           | 62461.85         | 85012.90  | 1469.5                     | 62.1   |
| R125                        | 20.1                           | 94018.55         | 103406.85 | 1835.8                     | 84.8   |
| R150                        | 23.1                           | 113941.75        | 126213.13 | 2191.1                     | 91.6   |
| R175                        | 26.0                           | 129826.60        | 145173.52 | 2550.3                     | 116.3  |
| R200                        | 28.7                           | 132827.98        | 175726.55 | 2895.6                     | 182.3  |
| R225                        | 31.4                           | 131071.36        | 215976.38 | 3219.1                     | 268.0  |
| R250                        | 33.8                           | 126015.73        | 253293.50 | 3523.9                     | 375.1  |
| R275                        | 36.1                           | 116478.74        | 313731.27 | 3797.0                     | 520.5  |
| R300                        | 38.0                           | 103666.87        | 356382.35 | 4069.4                     | 654.8  |
| Reactor (Jun+grwth)         |                                |                  |           |                            |        |





**DROUGHTPLAN WORKING PAPER No.9: HERDGRASP ANALYSIS OF SOI**

| (a)<br>Strategy /<br>target   | Utilisation<br>achieved<br>(%) | Annual cash flow |           | AEs in January             |        |
|-------------------------------|--------------------------------|------------------|-----------|----------------------------|--------|
|                               |                                | (\$)             |           | (450 kg steer equivalents) |        |
|                               |                                | Mean             | SD        | Mean                       | SD     |
| <b>Ry025</b>                  | 10.1                           | -60457.78        | 96755.47  | 1180.6                     | 173.6  |
| <b>Ry050</b>                  | 19.0                           | 20471.38         | 225635.87 | 2193.3                     | 372.7  |
| <b>Ry075</b>                  | 26.6                           | 64092.19         | 360746.56 | 3044.2                     | 570.1  |
| <b>Ry100</b>                  | 32.9                           | 75616.41         | 425448.73 | 3727.0                     | 784.4  |
| <b>Ry125</b>                  | 38.2                           | 68916.98         | 446913.39 | 4286.5                     | 956.5  |
| <b>Ry150</b>                  | 41.7                           | 2484.15          | 407420.26 | 4244.9                     | 1262.5 |
| <b>Ry175</b>                  | 43.5                           | -110021.64       | 351351.76 | 2783.3                     | 1697.3 |
| <b>** Ry200</b>               | 44.4                           | -183858.14       | 307571.49 | 2146.3                     | 1030.0 |
| <b>Forecast (Jun&amp;Nov)</b> |                                |                  |           |                            |        |
| <b>F025</b>                   | 5.0                            | -97749.65        | 62965.09  | 434.7                      | 110.0  |
| <b>F050</b>                   | 9.7                            | -27386.22        | 123624.91 | 872.0                      | 221.8  |
| <b>F075</b>                   | 14.1                           | 27671.79         | 179454.81 | 1310.9                     | 329.6  |
| <b>F100</b>                   | 18.1                           | 70609.17         | 231812.02 | 1746.3                     | 434.1  |
| <b>F125</b>                   | 21.7                           | 99205.42         | 283600.80 | 2177.8                     | 544.6  |
| <b>F150</b>                   | 25.2                           | 119668.03        | 328385.36 | 2592.4                     | 645.3  |
| <b>F175</b>                   | 28.4                           | 128531.43        | 408469.43 | 3002.8                     | 767.8  |
| <b>F200</b>                   | 31.4                           | 128322.11        | 472597.69 | 3376.1                     | 883.2  |
| <b>F225</b>                   | 34.2                           | 128442.21        | 486950.42 | 3720.3                     | 1003.4 |
| <b>F250</b>                   | 36.6                           | 119319.39        | 499009.02 | 4015.0                     | 1117.1 |
| <b>F275</b>                   | 38.8                           | 103128.14        | 543219.68 | 4243.4                     | 1203.3 |
| <b>F300</b>                   | 40.8                           | 88378.24         | 555787.33 | 4442.8                     | 1260.9 |
| <b>Forecast (Nov only)</b>    |                                |                  |           |                            |        |
| <b>Fz025</b>                  | 4.2                            | -120633.42       | 86777.42  | 449.2                      | 138.3  |
| <b>Fz050</b>                  | 8.3                            | -66074.29        | 166898.08 | 899.4                      | 276.9  |
| <b>Fz075</b>                  | 12.3                           | -19706.55        | 245495.03 | 1351.2                     | 416.9  |
| <b>Fz100</b>                  | 16.3                           | 20449.46         | 319334.63 | 1801.4                     | 550.9  |
| <b>Fz125</b>                  | 20.1                           | 50648.69         | 370099.18 | 2221.5                     | 634.0  |
| <b>Fz150</b>                  | 23.6                           | 74112.90         | 399378.17 | 2622.7                     | 684.2  |
| <b>Fz175</b>                  | 27.2                           | 87180.35         | 423891.22 | 3021.0                     | 731.1  |
| <b>Fz200</b>                  | 30.7                           | 95046.67         | 444683.73 | 3415.3                     | 768.4  |
| <b>Fz225</b>                  | 33.9                           | 88480.35         | 480285.95 | 3762.0                     | 815.6  |
| <b>Fz250</b>                  | 36.6                           | 75760.45         | 496565.77 | 4061.7                     | 875.7  |
| <b>Fz275</b>                  | 39.1                           | 62671.27         | 522456.73 | 4286.7                     | 1009.6 |
| <b>Fz300</b>                  | 41.1                           | 23860.80         | 498004.03 | 4227.0                     | 1189.5 |
| <b>Perfect (Jun&amp;Nov)</b>  |                                |                  |           |                            |        |
| <b>P025</b>                   | 5.3                            | -93092.64        | 81581.54  | 518.8                      | 124.8  |
| <b>P050</b>                   | 10.3                           | -20007.52        | 164492.10 | 1023.3                     | 270.5  |
| <b>P075</b>                   | 15.0                           | 38294.77         | 242553.89 | 1516.4                     | 421.4  |
| <b>P100</b>                   | 19.4                           | 80121.37         | 309184.56 | 1998.1                     | 583.7  |
| <b>P125</b>                   | 23.6                           | 108624.04        | 372618.21 | 2468.4                     | 746.3  |
| <b>P150</b>                   | 27.4                           | 132153.55        | 435105.81 | 2922.6                     | 917.4  |
| <b>P175</b>                   | 31.0                           | 144501.59        | 486819.67 | 3364.2                     | 1099.4 |
| <b>P200</b>                   | 34.3                           | 151938.83        | 561005.32 | 3755.7                     | 1269.5 |
| <b>P225</b>                   | 37.2                           | 155889.44        | 618701.04 | 4122.2                     | 1443.9 |
| <b>P250</b>                   | 39.7                           | 147522.40        | 648604.95 | 4406.8                     | 1606.0 |
| <b>P275</b>                   | 42.0                           | 54884.10         | 622144.45 | 3931.5                     | 1966.4 |
| <b>P300</b>                   | 42.6                           | -142714.05       | 415587.68 | 1910.0                     | 1342.5 |
| <b>Perfect (Nov only)</b>     |                                |                  |           |                            |        |
| <b>Pz025</b>                  | 4.8                            | -115828.20       | 93124.06  | 524.9                      | 150.5  |



| (a)<br>Strategy /<br>target | Utilisation<br>achieved<br>(%) | Annual cash flow<br>( $\text{\$}$ ) |           | AEs in January<br>(450 kg steer equivalents) |        |
|-----------------------------|--------------------------------|-------------------------------------|-----------|----------------------------------------------|--------|
|                             |                                | Mean                                | SD        | Mean                                         | SD     |
| <b>Pz050</b>                | 9.5                            | -55437.66                           | 188961.42 | 1045.7                                       | 309.1  |
| <b>Pz075</b>                | 14.0                           | -6710.99                            | 281843.07 | 1544.1                                       | 461.1  |
| <b>Pz100</b>                | 18.3                           | 35308.11                            | 356497.88 | 2024.1                                       | 605.3  |
| <b>Pz125</b>                | 22.7                           | 72349.76                            | 418865.83 | 2487.7                                       | 770.6  |
| <b>Pz150</b>                | 26.5                           | 98319.98                            | 472785.76 | 2918.2                                       | 919.8  |
| <b>Pz175</b>                | 30.4                           | 121576.59                           | 523558.18 | 3336.3                                       | 1090.8 |
| <b>Pz200</b>                | 34.0                           | 134758.10                           | 550353.93 | 3723.6                                       | 1262.0 |
| <b>Pz225</b>                | 37.3                           | 127493.31                           | 574150.52 | 4060.3                                       | 1432.5 |
| <b>Pz250</b>                | 40.0                           | 83008.49                            | 559922.27 | 4001.4                                       | 1731.4 |
| <b>Pz275</b>                | 40.5                           | -104629.27                          | 423383.81 | 2252.2                                       | 1433.2 |
| <b>Pz300</b>                | 41.4                           | -123528.00                          | 405896.86 | 2256.6                                       | 1480.2 |
| <b>'Proactor'</b>           |                                |                                     |           |                                              |        |
| <b>Yx025</b>                | 12.0                           | -35677.56                           | 136500.96 | 1403.0                                       | 266.0  |
| <b>Yx050</b>                | 22.5                           | 61731.12                            | 301938.67 | 2592.4                                       | 544.7  |
| <b>Yx075</b>                | 31.7                           | 118255.41                           | 435908.68 | 3588.1                                       | 821.6  |
| <b>Yx100</b>                | 39.1                           | 120081.61                           | 464843.59 | 4332.9                                       | 1053.3 |
| <b>Yx125</b>                | 41.9                           | -147159.65                          | 337935.87 | 1819.3                                       | 1061.2 |
| <b>** Yx150</b>             | 43.6                           | -181393.95                          | 316369.23 | 1792.9                                       | 1025.5 |

\*\* in these cases the calculation meant that achieved utilisations were much higher for a given target utilisation than in other strategies, so the upper targets (with very negative cash flows) are omitted from the listing

| (b)<br>Strategy /<br>target | Grass basal<br>area<br>(%) | Total<br>standing dry<br>matter<br>(kg/ha) | Soil loss<br>index<br>(kg/ha) | Perennial<br>index<br>(0-11, more<br>annuals) | Liveweight<br>gain<br>(kg/head/yr) |
|-----------------------------|----------------------------|--------------------------------------------|-------------------------------|-----------------------------------------------|------------------------------------|
| <b>Constant</b>             |                            |                                            |                               |                                               |                                    |
| C0250                       | 2.84                       | 2125.9                                     | 282.5                         | 0.00                                          | 131.7                              |
| C0500                       | 2.82                       | 1992.7                                     | 340.6                         | 0.00                                          | 126.7                              |
| C0750                       | 2.81                       | 1864.1                                     | 408.9                         | 0.00                                          | 121.7                              |
| C1000                       | 2.79                       | 1736.5                                     | 493.5                         | 0.01                                          | 116.8                              |
| C1250                       | 2.77                       | 1615.5                                     | 595.6                         | 0.04                                          | 111.4                              |
| C1500                       | 2.75                       | 1505.1                                     | 716.2                         | 0.13                                          | 106.2                              |
| C1750                       | 2.72                       | 1399.1                                     | 857.9                         | 0.27                                          | 101.0                              |
| C2000                       | 2.63                       | 1260.6                                     | 1079.1                        | 0.85                                          | 92.8                               |
| C2250                       | 2.51                       | 1126.8                                     | 1377.0                        | 1.67                                          | 83.2                               |
| C2500                       | 2.36                       | 1009.8                                     | 1629.3                        | 2.79                                          | 74.2                               |
| C2750                       | 2.25                       | 939.4                                      | 1817.1                        | 3.56                                          | 69.8                               |
| C3000                       | 2.35                       | 986.4                                      | 1703.7                        | 3.13                                          | 69.7                               |
| <b>Reactor (Jun)</b>        |                            |                                            |                               |                                               |                                    |
| Rx025                       | 2.83                       | 2091.8                                     | 292.6                         | 0.00                                          | 130.4                              |
| Rx050                       | 2.82                       | 1942.0                                     | 357.6                         | 0.00                                          | 124.7                              |
| Rx075                       | 2.80                       | 1810.4                                     | 429.3                         | 0.01                                          | 119.9                              |
| Rx100                       | 2.79                       | 1698.8                                     | 503.2                         | 0.01                                          | 115.9                              |
| Rx125                       | 2.78                       | 1603.4                                     | 581.7                         | 0.06                                          | 111.9                              |
| Rx150                       | 2.76                       | 1520.0                                     | 662.6                         | 0.11                                          | 108.2                              |
| Rx175                       | 2.75                       | 1451.3                                     | 741.3                         | 0.11                                          | 105.2                              |
| Rx200                       | 2.74                       | 1390.8                                     | 817.9                         | 0.21                                          | 102.0                              |





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| (b)<br>Strategy /<br>target   | Grass basal<br>area<br>(%) | Total<br>standing dry<br>matter<br>(kg/ha) | Soil loss<br>index<br>(kg/ha) | Perennial<br>index<br>(0-11, more<br>annuals) | Liveweight<br>gain<br>(kg/head/yr) |
|-------------------------------|----------------------------|--------------------------------------------|-------------------------------|-----------------------------------------------|------------------------------------|
| <b>Rx225</b>                  | 2.72                       | 1343.5                                     | 887.3                         | 0.28                                          | 99.1                               |
| <b>Rx250</b>                  | 2.71                       | 1301.7                                     | 957.4                         | 0.34                                          | 97.0                               |
| <b>Rx275</b>                  | 2.67                       | 1241.7                                     | 1056.2                        | 0.68                                          | 93.5                               |
| <b>Rx300</b>                  | 2.65                       | 1209.5                                     | 1117.0                        | 0.91                                          | 90.5                               |
| <b>Reactor (Jun&amp;Nov)</b>  |                            |                                            |                               |                                               |                                    |
| <b>R025</b>                   | 2.84                       | 2157.2                                     | 274.2                         | 0.00                                          | 132.2                              |
| <b>R050</b>                   | 2.83                       | 2057.0                                     | 319.0                         | 0.00                                          | 127.9                              |
| <b>R075</b>                   | 2.82                       | 1959.4                                     | 370.0                         | 0.00                                          | 123.8                              |
| <b>R100</b>                   | 2.81                       | 1870.7                                     | 423.0                         | 0.01                                          | 120.2                              |
| <b>R125</b>                   | 2.79                       | 1784.7                                     | 481.0                         | 0.01                                          | 117.0                              |
| <b>R150</b>                   | 2.78                       | 1702.4                                     | 546.1                         | 0.03                                          | 113.8                              |
| <b>R175</b>                   | 2.77                       | 1623.0                                     | 616.6                         | 0.03                                          | 110.6                              |
| <b>R200</b>                   | 2.76                       | 1545.0                                     | 692.1                         | 0.07                                          | 107.2                              |
| <b>R225</b>                   | 2.74                       | 1472.4                                     | 774.0                         | 0.15                                          | 103.9                              |
| <b>R250</b>                   | 2.73                       | 1405.0                                     | 858.0                         | 0.23                                          | 100.7                              |
| <b>R275</b>                   | 2.70                       | 1332.1                                     | 947.5                         | 0.37                                          | 97.0                               |
| <b>R300</b>                   | 2.69                       | 1274.4                                     | 1019.9                        | 0.51                                          | 93.5                               |
| <b>Reactor (Jun+grwth)</b>    |                            |                                            |                               |                                               |                                    |
| <b>Ry025</b>                  | 2.83                       | 2002.6                                     | 331.9                         | 0.00                                          | 127.1                              |
| <b>Ry050</b>                  | 2.80                       | 1772.0                                     | 460.6                         | 0.01                                          | 118.5                              |
| <b>Ry075</b>                  | 2.77                       | 1570.3                                     | 623.8                         | 0.06                                          | 110.1                              |
| <b>Ry100</b>                  | 2.74                       | 1406.7                                     | 812.8                         | 0.18                                          | 101.9                              |
| <b>Ry125</b>                  | 2.70                       | 1265.0                                     | 1016.9                        | 0.36                                          | 94.3                               |
| <b>Ry150</b>                  | 2.53                       | 1079.7                                     | 1317.5                        | 1.75                                          | 81.9                               |
| <b>Ry175</b>                  | 1.93                       | 647.0                                      | 2290.9                        | 5.18                                          | 57.2                               |
| <b>** Ry200</b>               | 1.66                       | 462.4                                      | 2765.1                        | 6.90                                          | 44.8                               |
| <b>Forecast (Jun&amp;Nov)</b> |                            |                                            |                               |                                               |                                    |
| <b>F025</b>                   | 2.84                       | 2147.3                                     | 276.2                         | 0.00                                          | 132.1                              |
| <b>F050</b>                   | 2.83                       | 2036.8                                     | 324.0                         | 0.00                                          | 127.5                              |
| <b>F075</b>                   | 2.82                       | 1929.0                                     | 379.2                         | 0.00                                          | 123.3                              |
| <b>F100</b>                   | 2.80                       | 1827.0                                     | 439.2                         | 0.01                                          | 119.5                              |
| <b>F125</b>                   | 2.79                       | 1729.6                                     | 504.6                         | 0.01                                          | 116.1                              |
| <b>F150</b>                   | 2.78                       | 1635.3                                     | 580.2                         | 0.03                                          | 112.4                              |
| <b>F175</b>                   | 2.76                       | 1544.2                                     | 665.7                         | 0.06                                          | 108.7                              |
| <b>F200</b>                   | 2.75                       | 1461.6                                     | 754.3                         | 0.09                                          | 105.1                              |
| <b>F225</b>                   | 2.73                       | 1385.5                                     | 849.6                         | 0.19                                          | 101.6                              |
| <b>F250</b>                   | 2.71                       | 1314.9                                     | 946.5                         | 0.37                                          | 97.7                               |
| <b>F275</b>                   | 2.68                       | 1242.9                                     | 1049.5                        | 0.66                                          | 93.1                               |
| <b>F300</b>                   | 2.66                       | 1181.9                                     | 1145.8                        | 0.81                                          | 89.5                               |
| <b>Forecast (Nov only)</b>    |                            |                                            |                               |                                               |                                    |
| <b>Fz025</b>                  | 2.84                       | 2157.5                                     | 270.1                         | 0.00                                          | 132.9                              |
| <b>Fz050</b>                  | 2.83                       | 2055.6                                     | 310.7                         | 0.00                                          | 129.1                              |
| <b>Fz075</b>                  | 2.82                       | 1953.5                                     | 359.1                         | 0.00                                          | 125.3                              |
| <b>Fz100</b>                  | 2.81                       | 1849.7                                     | 417.4                         | 0.00                                          | 121.4                              |
| <b>Fz125</b>                  | 2.80                       | 1752.9                                     | 483.5                         | 0.00                                          | 117.6                              |
| <b>Fz150</b>                  | 2.78                       | 1657.8                                     | 562.2                         | 0.02                                          | 113.8                              |
| <b>Fz175</b>                  | 2.76                       | 1562.1                                     | 655.5                         | 0.07                                          | 109.2                              |
| <b>Fz200</b>                  | 2.75                       | 1471.1                                     | 776.6                         | 0.09                                          | 104.8                              |
| <b>Fz225</b>                  | 2.72                       | 1376.5                                     | 909.0                         | 0.33                                          | 99.6                               |
| <b>Fz250</b>                  | 2.69                       | 1291.4                                     | 1019.6                        | 0.59                                          | 94.8                               |



**DROUGHTPLAN WORKING PAPER No.9: HERDGRASP ANALYSIS OF SOI**

| (b)<br>Strategy /<br>target  | Grass basal<br>area<br>(%) | Total<br>standing dry<br>matter<br>(kg/ha) | Soil loss<br>index<br>(kg/ha) | Perennial<br>index<br>(0-11, more<br>annuals) | Liveweight<br>gain<br>(kg/head/yr) |
|------------------------------|----------------------------|--------------------------------------------|-------------------------------|-----------------------------------------------|------------------------------------|
| <b>Fz275</b>                 | 2.65                       | 1204.2                                     | 1159.1                        | 0.90                                          | 89.8                               |
| <b>Fz300</b>                 | 2.54                       | 1086.6                                     | 1349.1                        | 1.66                                          | 82.8                               |
| <b>Perfect (Jun&amp;Nov)</b> |                            |                                            |                               |                                               |                                    |
| <b>P025</b>                  | 2.84                       | 2136.1                                     | 279.1                         | 0.00                                          | 132.0                              |
| <b>P050</b>                  | 2.83                       | 2016.9                                     | 329.8                         | 0.00                                          | 127.5                              |
| <b>P075</b>                  | 2.82                       | 1901.0                                     | 389.1                         | 0.00                                          | 123.4                              |
| <b>P100</b>                  | 2.80                       | 1788.6                                     | 458.3                         | 0.01                                          | 119.6                              |
| <b>P125</b>                  | 2.79                       | 1681.1                                     | 535.6                         | 0.01                                          | 116.0                              |
| <b>P150</b>                  | 2.78                       | 1579.6                                     | 622.7                         | 0.01                                          | 112.6                              |
| <b>P175</b>                  | 2.76                       | 1483.1                                     | 717.0                         | 0.01                                          | 109.6                              |
| <b>P200</b>                  | 2.75                       | 1394.5                                     | 821.8                         | 0.03                                          | 106.5                              |
| <b>P225</b>                  | 2.73                       | 1311.6                                     | 932.2                         | 0.08                                          | 103.4                              |
| <b>P250</b>                  | 2.70                       | 1231.3                                     | 1048.0                        | 0.40                                          | 98.9                               |
| <b>P275</b>                  | 2.41                       | 986.3                                      | 1488.0                        | 2.32                                          | 84.7                               |
| <b>P300</b>                  | 1.58                       | 406.1                                      | 2993.6                        | 9.36                                          | 40.3                               |
| <b>Perfect (Nov only)</b>    |                            |                                            |                               |                                               |                                    |
| <b>Pz025</b>                 | 2.84                       | 2143.1                                     | 274.8                         | 0.00                                          | 132.5                              |
| <b>Pz050</b>                 | 2.83                       | 2027.4                                     | 321.6                         | 0.00                                          | 128.3                              |
| <b>Pz075</b>                 | 2.82                       | 1914.6                                     | 375.2                         | 0.00                                          | 124.4                              |
| <b>Pz100</b>                 | 2.81                       | 1804.4                                     | 439.9                         | 0.01                                          | 120.6                              |
| <b>Pz125</b>                 | 2.79                       | 1693.7                                     | 516.4                         | 0.01                                          | 116.8                              |
| <b>Pz150</b>                 | 2.78                       | 1594.9                                     | 597.9                         | 0.01                                          | 113.4                              |
| <b>Pz175</b>                 | 2.76                       | 1494.6                                     | 697.5                         | 0.01                                          | 110.0                              |
| <b>Pz200</b>                 | 2.75                       | 1401.5                                     | 814.2                         | 0.03                                          | 106.6                              |
| <b>Pz225</b>                 | 2.72                       | 1306.7                                     | 957.2                         | 0.26                                          | 101.9                              |
| <b>Pz250</b>                 | 2.56                       | 1142.8                                     | 1226.8                        | 1.32                                          | 92.4                               |
| <b>Pz275</b>                 | 1.80                       | 586.4                                      | 2529.1                        | 6.93                                          | 57.1                               |
| <b>Pz300</b>                 | 1.76                       | 543.3                                      | 2628.1                        | 7.48                                          | 52.0                               |
| <b>'Proactor'</b>            |                            |                                            |                               |                                               |                                    |
| <b>Yx025</b>                 | 2.82                       | 1955.7                                     | 351.5                         | 0.00                                          | 126.1                              |
| <b>Yx050</b>                 | 2.79                       | 1683.0                                     | 522.7                         | 0.01                                          | 117.0                              |
| <b>Yx075</b>                 | 2.75                       | 1444.3                                     | 757.5                         | 0.05                                          | 108.6                              |
| <b>Yx100</b>                 | 2.69                       | 1235.6                                     | 1074.2                        | 0.51                                          | 97.6                               |
| <b>Yx125</b>                 | 1.59                       | 424.8                                      | 2920.6                        | 8.16                                          | 45.7                               |
| <b>** Yx150</b>              | 1.52                       | 359.9                                      | 3138.4                        | 9.94                                          | 32.0                               |

| (c)<br>Strategy /<br>target | Cow<br>numbers<br>(mean in<br>June) | Branding<br>rate<br>(%) | Number of<br>births<br>(mean per<br>year) | Mortality<br>rate (cows)<br>(%) | Number of<br>mortalities<br>(total, mean<br>per year) |
|-----------------------------|-------------------------------------|-------------------------|-------------------------------------------|---------------------------------|-------------------------------------------------------|
| <b>Constant</b>             |                                     |                         |                                           |                                 |                                                       |
| <b>C0250</b>                | 248.6                               | 70.6                    | 154.6                                     | 6.8                             | 25.4                                                  |
| <b>C0500</b>                | 496.9                               | 68.4                    | 300.3                                     | 7.0                             | 51.4                                                  |
| <b>C0750</b>                | 745.1                               | 66.0                    | 435.5                                     | 7.3                             | 79.1                                                  |
| <b>C1000</b>                | 991.4                               | 63.5                    | 558.9                                     | 7.6                             | 109.3                                                 |
| <b>C1250</b>                | 1230.9                              | 60.7                    | 667.9                                     | 8.1                             | 143.9                                                 |
| <b>C1500</b>                | 1459.6                              | 58.1                    | 763.5                                     | 8.7                             | 183.2                                                 |
| <b>C1750</b>                | 1680.2                              | 55.6                    | 845.6                                     | 9.4                             | 225.2                                                 |



| (c)<br>Strategy /<br>target   | Cow<br>numbers<br>(mean in<br>June) | Branding<br>rate<br>(%) | Number of<br>births<br>(mean per<br>year) | Mortality<br>rate (cows)<br>(%) | Number of<br>mortalities<br>(total, mean<br>per year) |
|-------------------------------|-------------------------------------|-------------------------|-------------------------------------------|---------------------------------|-------------------------------------------------------|
| <b>C2000</b>                  | 1823.8                              | 51.9                    | 866.9                                     | 10.6                            | 264.7                                                 |
| <b>C2250</b>                  | 1922.2                              | 48.2                    | 851.8                                     | 11.5                            | 296.5                                                 |
| <b>C2500</b>                  | 1879.8                              | 43.8                    | 758.6                                     | 13.0                            | 325.1                                                 |
| <b>C2750</b>                  | 1781.4                              | 41.2                    | 672.1                                     | 14.0                            | 331.3                                                 |
| <b>C3000</b>                  | 2019.4                              | 40.5                    | 756.3                                     | 13.7                            | 370.2                                                 |
| <b>Reactor (Jun)</b>          |                                     |                         |                                           |                                 |                                                       |
| <b>Rx025</b>                  | 325.5                               | 70.1                    | 205.6                                     | 6.9                             | 33.0                                                  |
| <b>Rx050</b>                  | 591.4                               | 67.6                    | 359.9                                     | 7.1                             | 62.8                                                  |
| <b>Rx075</b>                  | 773.3                               | 65.3                    | 456.6                                     | 7.4                             | 88.9                                                  |
| <b>Rx100</b>                  | 918.4                               | 63.4                    | 527.3                                     | 7.7                             | 114.0                                                 |
| <b>Rx125</b>                  | 1089.7                              | 61.3                    | 604.0                                     | 8.0                             | 140.2                                                 |
| <b>Rx150</b>                  | 1209.7                              | 59.3                    | 649.6                                     | 8.4                             | 163.9                                                 |
| <b>Rx175</b>                  | 1297.0                              | 57.6                    | 671.2                                     | 8.7                             | 184.9                                                 |
| <b>Rx200</b>                  | 1403.1                              | 55.9                    | 708.8                                     | 9.1                             | 206.7                                                 |
| <b>Rx225</b>                  | 1379.9                              | 54.3                    | 681.7                                     | 9.5                             | 221.9                                                 |
| <b>Rx250</b>                  | 1482.3                              | 53.1                    | 711.2                                     | 9.8                             | 241.0                                                 |
| <b>Rx275</b>                  | 1516.0                              | 51.2                    | 699.1                                     | 10.2                            | 257.0                                                 |
| <b>Rx300</b>                  | 1502.6                              | 49.9                    | 677.0                                     | 10.6                            | 264.9                                                 |
| <b>Reactor (Jun&amp;Nov)</b>  |                                     |                         |                                           |                                 |                                                       |
| <b>R025</b>                   | 340.6                               | 70.8                    | 199.7                                     | 6.8                             | 27.6                                                  |
| <b>R050</b>                   | 648.5                               | 68.9                    | 369.8                                     | 6.9                             | 54.7                                                  |
| <b>R075</b>                   | 905.7                               | 67.1                    | 502.2                                     | 7.2                             | 79.6                                                  |
| <b>R100</b>                   | 1084.8                              | 65.3                    | 582.6                                     | 7.3                             | 100.9                                                 |
| <b>R125</b>                   | 1182.7                              | 63.7                    | 621.4                                     | 7.6                             | 119.0                                                 |
| <b>R150</b>                   | 1220.7                              | 62.0                    | 628.4                                     | 7.9                             | 134.0                                                 |
| <b>R175</b>                   | 1248.6                              | 60.3                    | 630.6                                     | 8.2                             | 148.4                                                 |
| <b>R200</b>                   | 1195.4                              | 58.5                    | 589.0                                     | 8.6                             | 160.4                                                 |
| <b>R225</b>                   | 1135.3                              | 56.8                    | 549.1                                     | 8.9                             | 170.2                                                 |
| <b>R250</b>                   | 1101.9                              | 55.1                    | 521.2                                     | 9.4                             | 182.7                                                 |
| <b>R275</b>                   | 1121.5                              | 53.1                    | 518.2                                     | 9.9                             | 201.3                                                 |
| <b>R300</b>                   | 1119.2                              | 51.7                    | 506.1                                     | 10.4                            | 219.5                                                 |
| <b>Reactor (Jun+grwth)</b>    |                                     |                         |                                           |                                 |                                                       |
| <b>Ry025</b>                  | 484.4                               | 68.6                    | 299.1                                     | 7.0                             | 50.5                                                  |
| <b>Ry050</b>                  | 864.7                               | 64.5                    | 506.8                                     | 7.5                             | 98.1                                                  |
| <b>Ry075</b>                  | 1149.0                              | 60.2                    | 634.5                                     | 8.1                             | 147.0                                                 |
| <b>Ry100</b>                  | 1429.9                              | 56.0                    | 740.1                                     | 9.3                             | 205.1                                                 |
| <b>Ry125</b>                  | 1632.9                              | 52.1                    | 785.8                                     | 10.2                            | 259.5                                                 |
| <b>Ry150</b>                  | 1604.5                              | 46.0                    | 699.0                                     | 11.4                            | 282.9                                                 |
| <b>Ry175</b>                  | 896.7                               | 34.5                    | 343.3                                     | 15.7                            | 218.9                                                 |
| <b>** Ry200</b>               | 593.3                               | 29.0                    | 173.9                                     | 17.8                            | 206.8                                                 |
| <b>Forecast (Jun&amp;Nov)</b> |                                     |                         |                                           |                                 |                                                       |
| <b>F025</b>                   | 346.3                               | 70.8                    | 202.0                                     | 6.8                             | 28.4                                                  |
| <b>F050</b>                   | 635.1                               | 68.8                    | 360.7                                     | 6.9                             | 54.9                                                  |
| <b>F075</b>                   | 842.6                               | 66.9                    | 463.8                                     | 7.2                             | 77.8                                                  |
| <b>F100</b>                   | 999.4                               | 65.1                    | 537.9                                     | 7.4                             | 98.7                                                  |
| <b>F125</b>                   | 1036.3                              | 63.4                    | 548.6                                     | 7.6                             | 113.3                                                 |
| <b>F150</b>                   | 1105.3                              | 61.5                    | 572.4                                     | 7.9                             | 132.1                                                 |
| <b>F175</b>                   | 1137.1                              | 59.5                    | 581.7                                     | 8.3                             | 149.4                                                 |
| <b>F200</b>                   | 1171.6                              | 57.5                    | 587.6                                     | 8.7                             | 168.0                                                 |
| <b>F225</b>                   | 1167.2                              | 55.6                    | 576.6                                     | 9.0                             | 182.2                                                 |





**DROUGHTPLAN WORKING PAPER NO.9: HERDGRASP ANALYSIS OF SOI**

| (c)<br>Strategy /<br>target  | Cow<br>numbers<br>(mean in<br>June) | Branding<br>rate<br>(%) | Number of<br>births<br>(mean per<br>year) | Mortality<br>rate (cows)<br>(%) | Number of<br>mortalities<br>(total, mean<br>per year) |
|------------------------------|-------------------------------------|-------------------------|-------------------------------------------|---------------------------------|-------------------------------------------------------|
| <b>F250</b>                  | 1128.6                              | 53.4                    | 541.7                                     | 9.6                             | 198.1                                                 |
| <b>F275</b>                  | 1107.4                              | 51.2                    | 513.0                                     | 10.2                            | 214.4                                                 |
| <b>F300</b>                  | 1142.6                              | 49.5                    | 511.7                                     | 10.7                            | 236.1                                                 |
| <b>Forecast (Nov only)</b>   |                                     |                         |                                           |                                 |                                                       |
| <b>Fz025</b>                 | 280.1                               | 71.2                    | 167.3                                     | 6.8                             | 23.6                                                  |
| <b>Fz050</b>                 | 490.6                               | 69.6                    | 285.9                                     | 6.9                             | 44.3                                                  |
| <b>Fz075</b>                 | 651.5                               | 67.9                    | 370.9                                     | 7.0                             | 62.6                                                  |
| <b>Fz100</b>                 | 820.1                               | 66.2                    | 455.4                                     | 7.3                             | 82.8                                                  |
| <b>Fz125</b>                 | 986.4                               | 64.2                    | 534.0                                     | 7.5                             | 104.2                                                 |
| <b>Fz150</b>                 | 1159.1                              | 62.2                    | 611.1                                     | 7.9                             | 128.8                                                 |
| <b>Fz175</b>                 | 1336.4                              | 59.8                    | 682.6                                     | 8.4                             | 161.0                                                 |
| <b>Fz200</b>                 | 1496.7                              | 57.6                    | 742.7                                     | 9.0                             | 194.5                                                 |
| <b>Fz225</b>                 | 1597.9                              | 54.9                    | 760.2                                     | 9.5                             | 224.8                                                 |
| <b>Fz250</b>                 | 1651.1                              | 52.4                    | 757.3                                     | 10.0                            | 252.8                                                 |
| <b>Fz275</b>                 | 1688.8                              | 49.8                    | 751.6                                     | 10.7                            | 274.1                                                 |
| <b>Fz300</b>                 | 1655.1                              | 46.4                    | 695.8                                     | 11.4                            | 286.4                                                 |
| <b>Perfect (Jun&amp;Nov)</b> |                                     |                         |                                           |                                 |                                                       |
| <b>P025</b>                  | 405.7                               | 70.8                    | 236.4                                     | 6.8                             | 31.4                                                  |
| <b>P050</b>                  | 700.4                               | 68.9                    | 399.0                                     | 6.9                             | 58.3                                                  |
| <b>P075</b>                  | 883.0                               | 67.0                    | 491.0                                     | 7.1                             | 79.8                                                  |
| <b>P100</b>                  | 1019.6                              | 65.3                    | 555.9                                     | 7.3                             | 98.9                                                  |
| <b>P125</b>                  | 1124.1                              | 63.5                    | 602.1                                     | 7.4                             | 117.4                                                 |
| <b>P150</b>                  | 1218.3                              | 61.8                    | 645.5                                     | 7.7                             | 135.3                                                 |
| <b>P175</b>                  | 1272.5                              | 60.1                    | 667.3                                     | 7.8                             | 150.1                                                 |
| <b>P200</b>                  | 1275.2                              | 58.5                    | 655.6                                     | 8.1                             | 163.6                                                 |
| <b>P225</b>                  | 1266.8                              | 56.7                    | 638.7                                     | 8.3                             | 175.2                                                 |
| <b>P250</b>                  | 1315.5                              | 54.1                    | 644.6                                     | 8.7                             | 193.7                                                 |
| <b>P275</b>                  | 1094.4                              | 46.5                    | 483.7                                     | 10.5                            | 192.1                                                 |
| <b>P300</b>                  | 452.4                               | 24.9                    | 137.3                                     | 18.5                            | 164.9                                                 |
| <b>Perfect (Nov only)</b>    |                                     |                         |                                           |                                 |                                                       |
| <b>Pz025</b>                 | 268.9                               | 71.0                    | 161.2                                     | 6.8                             | 24.3                                                  |
| <b>Pz050</b>                 | 507.3                               | 69.3                    | 297.1                                     | 6.9                             | 47.7                                                  |
| <b>Pz075</b>                 | 709.2                               | 67.6                    | 406.3                                     | 7.1                             | 69.3                                                  |
| <b>Pz100</b>                 | 915.6                               | 65.8                    | 511.7                                     | 7.2                             | 91.9                                                  |
| <b>Pz125</b>                 | 1134.6                              | 63.9                    | 620.1                                     | 7.4                             | 116.8                                                 |
| <b>Pz150</b>                 | 1280.5                              | 62.3                    | 685.9                                     | 7.6                             | 137.2                                                 |
| <b>Pz175</b>                 | 1439.5                              | 60.5                    | 752.0                                     | 7.9                             | 160.6                                                 |
| <b>Pz200</b>                 | 1588.1                              | 58.6                    | 805.5                                     | 8.1                             | 182.0                                                 |
| <b>Pz225</b>                 | 1705.8                              | 56.0                    | 827.2                                     | 8.5                             | 206.0                                                 |
| <b>Pz250</b>                 | 1645.0                              | 51.1                    | 745.0                                     | 9.7                             | 219.6                                                 |
| <b>Pz275</b>                 | 731.1                               | 32.9                    | 262.4                                     | 15.1                            | 166.0                                                 |
| <b>Pz300</b>                 | 657.9                               | 29.9                    | 220.3                                     | 16.1                            | 171.0                                                 |
| <b>'Proactor'</b>            |                                     |                         |                                           |                                 |                                                       |
| <b>Yx025</b>                 | 576.6                               | 68.4                    | 359.6                                     | 7.0                             | 59.5                                                  |
| <b>Yx050</b>                 | 1041.7                              | 64.1                    | 611.3                                     | 7.4                             | 113.3                                                 |
| <b>Yx075</b>                 | 1419.8                              | 59.7                    | 783.9                                     | 7.9                             | 164.0                                                 |
| <b>Yx100</b>                 | 1728.4                              | 53.4                    | 876.4                                     | 8.9                             | 219.0                                                 |
| <b>Yx125</b>                 | 437.7                               | 27.1                    | 150.1                                     | 17.2                            | 140.1                                                 |
| <b>** Yx150</b>              | 409.3                               | 20.7                    | 113.9                                     | 20.0                            | 168.1                                                 |



| (d)<br>Strategy /<br>target   | Total<br>number of<br>sales<br>(mean/year) | Net 'forced'<br>purchases/<br>sales in June<br>(mean/year) | Net 'forced'<br>purchases/<br>sales in Nov<br>(mean/year) |
|-------------------------------|--------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
| <b>Constant</b>               |                                            |                                                            |                                                           |
| C0250                         | 131.5                                      |                                                            |                                                           |
| C0500                         | 253.9                                      |                                                            |                                                           |
| C0750                         | 365.2                                      |                                                            |                                                           |
| C1000                         | 463.6                                      |                                                            |                                                           |
| C1250                         | 546.3                                      |                                                            |                                                           |
| C1500                         | 610.4                                      |                                                            |                                                           |
| C1750                         | 658.3                                      |                                                            |                                                           |
| C2000                         | 646.9                                      |                                                            |                                                           |
| C2250                         | 604.8                                      |                                                            |                                                           |
| C2500                         | 486.9                                      |                                                            |                                                           |
| C2750                         | 392.0                                      |                                                            |                                                           |
| C3000                         | 436.4                                      |                                                            |                                                           |
| <b>Reactor (Jun)</b>          |                                            |                                                            |                                                           |
| Rx025                         | 214.8                                      | 95.0                                                       |                                                           |
| Rx050                         | 402.4                                      | 145.7                                                      |                                                           |
| Rx075                         | 570.7                                      | 123.5                                                      |                                                           |
| Rx100                         | 699.5                                      | 82.2                                                       |                                                           |
| Rx125                         | 791.2                                      | 82.5                                                       |                                                           |
| Rx150                         | 880.4                                      | 53.1                                                       |                                                           |
| Rx175                         | 955.6                                      | -3.7                                                       |                                                           |
| Rx200                         | 1016.8                                     | -19.3                                                      |                                                           |
| Rx225                         | 1083.7                                     | -133.6                                                     |                                                           |
| Rx250                         | 1098.6                                     | -129.9                                                     |                                                           |
| Rx275                         | 1118.6                                     | -159.1                                                     |                                                           |
| Rx300                         | 1119.5                                     | -240.7                                                     |                                                           |
| <b>Reactor (Jun&amp;Nov)</b>  |                                            |                                                            |                                                           |
| R025                          | 527.3                                      | -340.5                                                     | 510.4                                                     |
| R050                          | 972.4                                      | -617.9                                                     | 923.9                                                     |
| R075                          | 1289.2                                     | -788.7                                                     | 1192.4                                                    |
| R100                          | 1422.5                                     | -816.6                                                     | 1262.4                                                    |
| R125                          | 1492.2                                     | -820.3                                                     | 1236.9                                                    |
| R150                          | 1522.7                                     | -826.6                                                     | 1151.8                                                    |
| R175                          | 1529.9                                     | -796.0                                                     | 1032.8                                                    |
| R200                          | 1494.3                                     | -757.8                                                     | 873.9                                                     |
| R225                          | 1475.4                                     | -728.5                                                     | 732.3                                                     |
| R250                          | 1470.5                                     | -708.3                                                     | 604.0                                                     |
| R275                          | 1480.5                                     | -660.8                                                     | 429.7                                                     |
| R300                          | 1485.9                                     | -630.8                                                     | 255.3                                                     |
| <b>Reactor (Jun+grwth)</b>    |                                            |                                                            |                                                           |
| Ry025                         | 285.8                                      | 117.6                                                      |                                                           |
| Ry050                         | 528.6                                      | 137.3                                                      |                                                           |
| Ry075                         | 736.9                                      | 75.2                                                       |                                                           |
| Ry100                         | 857.6                                      | 21.5                                                       |                                                           |
| Ry125                         | 976.8                                      | -91.6                                                      |                                                           |
| Ry150                         | 937.8                                      | -227.3                                                     |                                                           |
| Ry175                         | 704.2                                      | -359.9                                                     |                                                           |
| ** Ry200                      | 590.7                                      | -463.6                                                     |                                                           |
| <b>Forecast (Jun&amp;Nov)</b> |                                            |                                                            |                                                           |
| F025                          | 432.7                                      | -235.2                                                     | 403.9                                                     |





| (d)<br>Strategy /<br>target  | Total<br>number of<br>sales<br>(mean/year) | Net 'forced'<br>purchases/<br>sales in June<br>(mean/year) | Net 'forced'<br>purchases/<br>sales in Nov<br>(mean/year) |
|------------------------------|--------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
| <b>F050</b>                  | 786.8                                      | -415.3                                                     | 703.7                                                     |
| <b>F075</b>                  | 1027.5                                     | -520.0                                                     | 855.0                                                     |
| <b>F100</b>                  | 1150.5                                     | -516.5                                                     | 868.1                                                     |
| <b>F125</b>                  | 1215.8                                     | -515.4                                                     | 771.9                                                     |
| <b>F150</b>                  | 1279.3                                     | -498.7                                                     | 669.5                                                     |
| <b>F175</b>                  | 1337.2                                     | -422.5                                                     | 518.9                                                     |
| <b>F200</b>                  | 1385.4                                     | -359.1                                                     | 377.0                                                     |
| <b>F225</b>                  | 1438.1                                     | -299.7                                                     | 225.7                                                     |
| <b>F250</b>                  | 1479.7                                     | -269.7                                                     | 82.5                                                      |
| <b>F275</b>                  | 1516.0                                     | -270.9                                                     | -38.7                                                     |
| <b>F300</b>                  | 1544.7                                     | -246.2                                                     | -123.1                                                    |
| <b>Forecast (Nov only)</b>   |                                            |                                                            |                                                           |
| <b>Fz025</b>                 | 184.9                                      |                                                            | 126.3                                                     |
| <b>Fz050</b>                 | 334.6                                      |                                                            | 188.7                                                     |
| <b>Fz075</b>                 | 462.5                                      |                                                            | 201.3                                                     |
| <b>Fz100</b>                 | 587.6                                      |                                                            | 211.5                                                     |
| <b>Fz125</b>                 | 681.9                                      |                                                            | 212.2                                                     |
| <b>Fz150</b>                 | 752.1                                      |                                                            | 213.9                                                     |
| <b>Fz175</b>                 | 816.5                                      |                                                            | 207.8                                                     |
| <b>Fz200</b>                 | 874.9                                      |                                                            | 181.9                                                     |
| <b>Fz225</b>                 | 929.0                                      |                                                            | 119.3                                                     |
| <b>Fz250</b>                 | 961.1                                      |                                                            | 43.3                                                      |
| <b>Fz275</b>                 | 997.1                                      |                                                            | -34.7                                                     |
| <b>Fz300</b>                 | 948.2                                      |                                                            | -93.8                                                     |
| <b>Perfect (Jun&amp;Nov)</b> |                                            |                                                            |                                                           |
| <b>P025</b>                  | 322.2                                      | -83.7                                                      | 282.1                                                     |
| <b>P050</b>                  | 592.4                                      | -174.9                                                     | 480.4                                                     |
| <b>P075</b>                  | 811.5                                      | -279.0                                                     | 594.9                                                     |
| <b>P100</b>                  | 964.4                                      | -340.4                                                     | 623.6                                                     |
| <b>P125</b>                  | 1073.8                                     | -354.6                                                     | 593.5                                                     |
| <b>P150</b>                  | 1145.9                                     | -307.8                                                     | 498.6                                                     |
| <b>P175</b>                  | 1221.9                                     | -251.4                                                     | 353.1                                                     |
| <b>P200</b>                  | 1321.5                                     | -231.4                                                     | 231.1                                                     |
| <b>P225</b>                  | 1203.1                                     | -150.3                                                     | 17.4                                                      |
| <b>P250</b>                  | 608.1                                      | -74.4                                                      | -79.2                                                     |
| <b>P275</b>                  | 619.8                                      | -33.4                                                      | -147.3                                                    |
| <b>P300</b>                  | 808.5                                      | -59.5                                                      | -165.4                                                    |
| <b>Perfect (Nov only)</b>    |                                            |                                                            |                                                           |
| <b>Pz025</b>                 | 187.8                                      |                                                            | 96.3                                                      |
| <b>Pz050</b>                 | 364.5                                      |                                                            | 162.4                                                     |
| <b>Pz075</b>                 | 519.5                                      |                                                            | 197.1                                                     |
| <b>Pz100</b>                 | 654.0                                      |                                                            | 229.7                                                     |
| <b>Pz125</b>                 | 781.8                                      |                                                            | 277.8                                                     |
| <b>Pz150</b>                 | 882.6                                      |                                                            | 262.9                                                     |
| <b>Pz175</b>                 | 989.4                                      |                                                            | 265.8                                                     |
| <b>Pz200</b>                 | 1066.5                                     |                                                            | 256.3                                                     |
| <b>Pz225</b>                 | 882.5                                      |                                                            | 48.3                                                      |
| <b>Pz250</b>                 | 463.5                                      |                                                            | -119.1                                                    |
| <b>Pz275</b>                 | 469.9                                      |                                                            | -145.7                                                    |
| <b>Pz300</b>                 | 473.4                                      |                                                            | -192.7                                                    |



| (d)<br>Strategy /<br>target | Total<br>number of<br>sales<br>(mean/year) | Net 'forced'<br>purchases/<br>sales in June<br>(mean/year) | Net 'forced'<br>purchases/<br>sales in Nov<br>(mean/year) |
|-----------------------------|--------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------|
| <b>'Proactor'</b>           |                                            |                                                            |                                                           |
| Yx025                       | 351.7                                      | 150.7                                                      |                                                           |
| Yx050                       | 645.4                                      | 204.2                                                      |                                                           |
| Yx075                       | 882.6                                      | 179.4                                                      |                                                           |
| Yx100                       | 999.0                                      | 104.0                                                      |                                                           |
| Yx125                       | 555.1                                      | -359.8                                                     |                                                           |
| ** Yx150                    | 554.6                                      | -433.4                                                     |                                                           |

Total sales includes everything sold in any year; 'forced' sales and purchases are those made to adjust stocking rates. Blank cells indicate the option was not available. Positive values for the forced sales indicate that overall more stock were sold than bought, negative numbers that more were bought than sold; *NB these are means of the actions each year, so a zero value does not distinguish between no buying and selling and large but equal numbers of purchases and sales (see the original raw data for this information).*



## Appendix B: Sensitivity analysis results

This appendix reports the results of the preliminary sensitivity analysis for Constant and Reactor (Jun) strategies.

**Table B.1: Sensitivity analysis results. 'Difference' is the change from the Base simulation results for the option.**

|                  | Description                                                                              | C1250     | C1500     | C1750     | C2000      | C2250      | R150       | R175       | R200       | R250       | R300       |
|------------------|------------------------------------------------------------------------------------------|-----------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|
| <b>BASE</b>      | Main simulations                                                                         | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$64,401   | \$67,213   | \$70,033   | \$55,749   | \$26,063   |
| <b>WEATHER</b>   | Uses the "dirty" weather file CTOWERS.V51 (see main text)                                | \$45,757  | \$56,241  | \$58,299  | \$14,208   | (\$83,805) | \$57,450   | \$61,646   | \$59,049   | \$42,052   | \$11,736   |
| Difference       |                                                                                          | (\$1,177) | (\$5,068) | (\$7,374) | (\$25,739) | (\$81,319) | (\$6,951)  | (\$5,566)  | (\$10,984) | (\$13,697) | (\$14,327) |
| <b>PRICE A</b>   | Increase the buying price of Bought Steers (\$300 to \$350/head)                         | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$49,692   | \$49,379   | \$50,445   | \$30,860   | (\$2,208)  |
| Difference       |                                                                                          | \$0       | \$0       | \$0       | \$0        | \$0        | (\$14,709) | (\$17,834) | (\$19,588) | (\$24,889) | (\$28,271) |
| <b>PRICE B</b>   | Increase the buying price of Cows (\$300 to \$350/head)                                  | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$60,436   | \$62,697   | \$65,104   | \$50,330   | \$20,178   |
| Difference       |                                                                                          | \$0       | \$0       | \$0       | \$0        | \$0        | (\$3,965)  | (\$4,516)  | (\$4,929)  | (\$5,419)  | (\$5,885)  |
| <b>PRICE C</b>   | Increase selling price of Steers (\$1.20 to \$1.30/kg)                                   | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$68,870   | \$71,879   | \$74,974   | \$60,955   | \$30,620   |
| Difference       |                                                                                          | \$0       | \$0       | \$0       | \$0        | \$0        | \$4,469    | \$4,666    | \$4,941    | \$5,206    | \$4,557    |
| <b>PRICE D</b>   | Decrease selling price of all Cows (to \$450 from \$550 and \$540/head)                  | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$36,630   | \$38,627   | \$39,951   | \$26,718   | (\$1,253)  |
| Difference       |                                                                                          | \$0       | \$0       | \$0       | \$0        | \$0        | (\$27,771) | (\$28,585) | (\$30,082) | (\$29,031) | (\$27,316) |
| <b>TACTICS A</b> | Sell percentage of all age groups of cows, then sell Bought Steers, Steers, then Heifers | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$56,356   | \$56,468   | \$51,512   | \$39,643   | \$4,789    |
| Difference       |                                                                                          | \$0       | \$0       | \$0       | \$0        | \$0        | (\$8,045)  | (\$10,744) | (\$18,521) | (\$16,106) | (\$21,274) |
| <b>TACTICS B</b> | Sell Heifers, then balance as for Base                                                   | \$46,934  | \$61,309  | \$65,673  | \$39,947   | (\$2,487)  | \$36,887   | \$42,473   | \$38,000   | \$37,117   | \$1,391    |
| Difference       |                                                                                          | \$0       | \$0       | \$0       | \$0        | \$0        | (\$27,514) | (\$24,740) | (\$32,033) | (\$18,632) | (\$24,672) |





**DROUGHTPLAN WORKING PAPER No.9: HERDGRASP ANALYSIS OF SOI**

|                                         |                                                                       |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |
|-----------------------------------------|-----------------------------------------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| <b>TACTICS C</b><br>Difference          | Sell Heifers, then Bought Steers, then balance as for Base            | \$46,934<br>\$0            | \$61,309<br>\$0            | \$65,673<br>\$0            | \$39,947<br>\$0            | (\$2,487)<br>\$0           | \$38,499<br>(\$25,902)     | \$43,149<br>(\$24,064)     | \$44,004<br>(\$26,029)     | \$30,932<br>(\$24,817)     | \$6,090<br>(\$19,973)      |
| <b>TACTICS D</b><br>Difference          | Sell Bought Steers, Heifers, % of all ages of Cows, then Steers       | \$46,934<br>\$0            | \$61,309<br>\$0            | \$65,673<br>\$0            | \$39,947<br>\$0            | (\$2,487)<br>\$0           | \$29,243<br>(\$35,158)     | \$29,342<br>(\$37,871)     | \$26,684<br>(\$43,349)     | \$15,786<br>(\$39,963)     | (\$18,652)<br>(\$44,715)   |
| <b>BIOLOGY A</b><br>Difference          | Decrease the cap on birth rates (80% to 75%)                          | \$39,600<br>(\$7,334)      | \$54,110<br>(\$7,199)      | \$58,573<br>(\$7,101)      | \$34,580<br>(\$5,367)      | (\$6,471)<br>(\$3,984)     | \$57,784<br>(\$6,617)      | \$61,227<br>(\$5,986)      | \$63,399<br>(\$6,634)      | \$49,914<br>(\$5,835)      | (\$2,802)<br>(\$28,865)    |
| <b>BIOLOGY B</b><br>Difference          | Increase the cap on birth rates (80% to 85%)                          | \$52,058<br>\$5,125        | \$66,574<br>\$5,265        | \$70,127<br>\$4,454        | \$43,328<br>\$3,381        | \$1,082<br>\$3,569         | \$68,507<br>\$4,106        | \$70,225<br>\$3,012        | \$71,792<br>\$1,758        | \$55,909<br>\$160          | \$29,956<br>\$3,893        |
| <b>BIOLOGY C</b><br>Difference          | Alter liveweight factor in birth rate equation (0.655*lw to 0.700*lw) | \$59,170<br>\$12,236       | \$76,352<br>\$15,043       | \$81,501<br>\$15,828       | \$41,386<br>\$1,439        | \$4,644<br>\$7,130         | \$75,189<br>\$10,788       | \$80,092<br>\$12,879       | \$81,183<br>\$11,150       | \$65,388<br>\$9,639        | \$36,301<br>\$10,238       |
| <b>BIOLOGY D</b><br>Difference          | Increase death rate minima (for Cows 6% to 8%; for drys 2% to 3%)     | \$34,960<br>(\$11,973)     | \$48,048<br>(\$13,261)     | \$51,006<br>(\$14,667)     | \$26,292<br>(\$13,655)     | (\$26,670)<br>(\$24,183)   | \$51,476<br>(\$12,925)     | \$54,150<br>(\$13,062)     | \$54,257<br>(\$15,776)     | \$37,664<br>(\$18,085)     | (\$12,843)<br>(\$38,906)   |
| <b>ANNUAL PASTURES 1</b><br>Difference  | Perennial Index set to 1; ie 88% perennial species in the pasture     | \$22,149<br>(\$24,785)     | \$33,656<br>(\$27,654)     | \$35,166<br>(\$30,508)     | \$30,053<br>(\$9,897)      | \$16,881<br>\$19,367       | \$35,866<br>(\$28,535)     | \$36,392<br>(\$30,821)     | \$36,159<br>(\$33,874)     | \$18,606<br>(\$37,143)     | \$8,752<br>(\$17,311)      |
| <b>ANNUAL PASTURES 2</b><br>Difference  | Perennial index set to 11; ie 1% perennial species in the pasture     | (\$189,339)<br>(\$236,273) | (\$190,537)<br>(\$251,846) | (\$191,093)<br>(\$256,766) | (\$191,415)<br>(\$231,362) | (\$191,973)<br>(\$189,486) | (\$177,574)<br>(\$241,975) | (\$183,128)<br>(\$250,341) | (\$186,159)<br>(\$256,192) | (\$200,546)<br>(\$256,295) | (\$214,662)<br>(\$240,725) |
| <b>PERENNIAL PASTURES</b><br>Difference | Perennial index set to 0; ie 90% perennial species in the pasture     | \$47,750<br>\$816          | \$64,363<br>\$3,053        | \$72,340<br>\$6,667        | \$71,715<br>\$31,768       | \$64,223<br>\$66,709       | \$66,484<br>\$2,083        | \$68,416<br>\$1,204        | \$72,260<br>\$2,227        | \$63,887<br>\$8,138        | \$53,334<br>\$27,271       |



## Appendix C: Net present values for selected strategies

**Table C.1:** Net present values for various discount rates and starting years, for Constant and Reactor(Jun) strategies. Shaded cells show optimum cash flow (Reactor from 1920 attains the optimum above the range shown), italic lines show the optimum target level when not discounted.

|       | Baseline<br>Cashflow   | NPVs for 1% discount rate, and start year: |                         |                          |                         |                          |                         |
|-------|------------------------|--------------------------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|
|       |                        | 1887                                       | 1900                    | 1920                     | 1940                    | 1960                     | 1980                    |
| C1000 | \$20,789               | \$15,069                                   | -\$52,284               | \$22,827                 | \$65,419                | -\$17,760                | \$18,415                |
| C1250 | \$46,934               | \$43,636                                   | -\$37,844               | \$60,483                 | \$101,254               | -\$6,092                 | \$50,325                |
| C1500 | \$61,309               | \$57,934                                   | -\$35,880               | \$97,402                 | \$131,149               | -\$11,662                | \$80,096                |
| C1750 | <b><i>\$65,673</i></b> | <b><i>\$52,566</i></b>                     | <b><i>-\$35,153</i></b> | <b><i>\$121,768</i></b>  | <b><i>\$151,399</i></b> | <b><i>-\$18,889</i></b>  | <b><i>\$100,704</i></b> |
| C2000 | \$39,947               | \$39,843                                   | -\$40,737               | -\$81,354                | \$169,490               | -\$47,708                | \$112,896               |
| C2250 | -\$2,487               | \$6,089                                    | -\$88,769               | -\$123,393               | \$121,722               | -\$77,710                | \$7,636                 |
| R125  | \$55,511               | \$147,863                                  | -\$6,409                | -\$38,089                | \$302,469               | \$124,484                | \$107,402               |
| R150  | \$64,401               | \$239,441                                  | -\$27,621               | -\$29,884                | \$402,335               | \$147,869                | \$108,387               |
| R175  | \$67,213               | \$280,039                                  | -\$70,777               | -\$73,249                | \$373,040               | -\$66,686                | \$160,647               |
| R200  | <b><i>\$70,033</i></b> | <b><i>\$362,816</i></b>                    | <b><i>\$25,949</i></b>  | <b><i>-\$118,133</i></b> | <b><i>\$63,546</i></b>  | <b><i>-\$151,054</i></b> | <b><i>\$338,486</i></b> |
| R225  | \$63,680               | \$437,798                                  | \$76,489                | -\$120,850               | \$44,768                | -\$155,994               | \$315,991               |
| R250  | \$55,749               | \$204,254                                  | \$181,480               | -\$162,036               | \$70,719                | -\$132,631               | \$303,332               |
| R275  | \$34,784               | \$330,016                                  | \$244,981               | -\$176,036               | \$145,120               | -\$154,451               | \$262,312               |

|       | Baseline<br>Cashflow   | NPVs for 5% discount rate, and start year: |                        |                         |                         |                         |                        |
|-------|------------------------|--------------------------------------------|------------------------|-------------------------|-------------------------|-------------------------|------------------------|
|       |                        | 1887                                       | 1900                   | 1920                    | 1940                    | 1960                    | 1980                   |
| C1000 | \$20,789               | \$695                                      | \$1,095                | \$2,595                 | \$13,638                | -\$1,007                | \$553                  |
| C1250 | \$46,934               | \$6,617                                    | \$8,265                | \$9,042                 | \$19,998                | \$1,886                 | \$5,591                |
| C1500 | \$61,309               | \$10,075                                   | \$10,907               | \$19,154                | \$25,528                | \$401                   | \$10,013               |
| C1750 | <b><i>\$65,673</i></b> | <b><i>\$9,623</i></b>                      | <b><i>\$12,127</i></b> | <b><i>\$23,759</i></b>  | <b><i>\$31,019</i></b>  | <b><i>-\$1,309</i></b>  | <b><i>\$14,026</i></b> |
| C2000 | \$39,947               | \$7,580                                    | \$11,883               | -\$9,193                | \$35,655                | -\$8,749                | \$13,739               |
| C2250 | -\$2,487               | -\$222                                     | -\$602                 | -\$11,329               | \$18,481                | -\$12,901               | -\$11,245              |
| R125  | \$55,511               | \$56,456                                   | \$28,627               | -\$20,970               | \$90,445                | \$28,485                | \$5,378                |
| R150  | \$64,401               | \$83,684                                   | \$22,233               | -\$22,756               | \$131,721               | \$35,125                | -\$883                 |
| R175  | \$67,213               | \$96,963                                   | \$7,794                | -\$43,012               | \$113,181               | -\$39,027               | \$15,375               |
| R200  | <b><i>\$70,033</i></b> | <b><i>\$129,296</i></b>                    | <b><i>\$39,570</i></b> | <b><i>-\$56,846</i></b> | <b><i>-\$29,266</i></b> | <b><i>-\$66,749</i></b> | <b><i>\$90,764</i></b> |
| R225  | \$63,680               | \$157,253                                  | \$56,281               | -\$63,209               | -\$36,591               | -\$67,381               | \$93,668               |
| R250  | \$55,749               | \$81,896                                   | \$90,393               | -\$65,675               | -\$11,806               | -\$58,678               | \$85,999               |
| R275  | \$34,784               | \$121,531                                  | \$118,845              | -\$65,693               | \$35,695                | -\$64,954               | \$84,857               |

|       | Baseline<br>Cashflow   | NPVs for 10% discount rate, and start year: |                        |                         |                         |                         |                        |
|-------|------------------------|---------------------------------------------|------------------------|-------------------------|-------------------------|-------------------------|------------------------|
|       |                        | 1887                                        | 1900                   | 1920                    | 1940                    | 1960                    | 1980                   |
| C1000 | \$20,789               | \$174                                       | \$1,879                | \$874                   | \$6,835                 | -\$28                   | -\$148                 |
| C1250 | \$46,934               | \$3,219                                     | \$5,915                | \$3,863                 | \$9,912                 | \$1,592                 | \$2,204                |
| C1500 | \$61,309               | \$5,055                                     | \$7,514                | \$9,146                 | \$12,583                | \$885                   | \$4,171                |
| C1750 | <b><i>\$65,673</i></b> | <b><i>\$4,950</i></b>                       | <b><i>\$8,198</i></b>  | <b><i>\$11,233</i></b>  | <b><i>\$15,460</i></b>  | <b><i>\$17</i></b>      | <b><i>\$6,099</i></b>  |
| C2000 | \$39,947               | \$4,139                                     | \$8,137                | -\$4,386                | \$17,892                | -\$3,909                | \$5,455                |
| C2250 | -\$2,487               | \$180                                       | \$1,649                | -\$4,623                | \$8,581                 | -\$5,791                | -\$7,428               |
| R125  | \$55,511               | \$32,100                                    | \$19,276               | -\$10,387               | \$49,508                | \$12,788                | \$589                  |
| R150  | \$64,401               | \$46,840                                    | \$15,770               | -\$11,803               | \$73,521                | \$15,919                | -\$3,193               |
| R175  | \$67,213               | \$53,924                                    | \$7,976                | -\$23,126               | \$62,531                | -\$25,093               | \$6,072                |
| R200  | <b><i>\$70,033</i></b> | <b><i>\$72,378</i></b>                      | <b><i>\$25,182</i></b> | <b><i>-\$31,699</i></b> | <b><i>-\$20,356</i></b> | <b><i>-\$40,346</i></b> | <b><i>\$50,275</i></b> |
| R225  | \$63,680               | \$88,040                                    | \$34,502               | -\$35,578               | -\$25,085               | -\$40,470               | \$52,560               |
| R250  | \$55,749               | \$47,286                                    | \$52,871               | -\$36,186               | -\$8,940                | -\$35,895               | \$48,249               |
| R275  | \$34,784               | \$68,631                                    | \$68,883               | -\$35,881               | \$20,892                | -\$39,344               | \$48,306               |





## Appendix D: GRASP parameter values used for the runs

The following is the parameter file used for GRASP in these runs (CTOWERS.PRM) with its internal documentation more-or-less unedited, and the state initialisation file (CTOWERS.INV). Only tree basal area in the state initialisation file matters in this version of GRASP - other state initialisation values are relatively unimportant since they change during the initial stabilisation simulation (cf. Fig.2 and text thereon). Note that many of the PRM file values are unimportant in HerdGRASP (see 'Surfair GRASP' manual for more details and explanation of individual parameters).

**CTOWER.PRM**

```

PARAMETER
001 0.000000000000 Site number allocated by Kenneth A Day 071 611602 611082
002 0.000000000000 Tothill & Gillies local production unit
003 0.000000000000 If >0.0 <1.0 use .p51 met files & calc mean daytime VPD 7
005 4.000000000000 Initial plant density e.g. % basal area 7
006 5.000000000000 Potential daily regrowth rate (kg/ha/day/unit of density)
007 12.000000000000 Transpiration efficiency (kg/ha/mm of transpired at vpd 20 mb
008 12.000000000000 Radiation use efficiency kg/ha per MJ/sqm of solar radiation
009 0.100000000000 Soil water index. Maximum green cover = amin1(0.99,swix/p(9)) 10
010 0.002000000000 death constant ) DEATH = (P51*(1-swix) + P10) * green pool 10
011 0.000000000000 Minimum sreen temperature (c) at which green cover = 0% 10
015 0.750000000000 Proportion of pasture which can be eaten by stock. The rest is 11
016 0.040000000000 rate of litter breakdown when hot and wet 12
018 0.000000000000 Coefficient of stocking rate on litter breakdown 12
019 10.000000000000 AIRDRY Layer 1 air dry soil moisture content (mm). 1
020 100.000000000000 Thickness (mm) of soil layer 1 (surface 100mm approx)
021 400.000000000000 Thickness (mm) of soil layer 2. This layer cannot dry
022 500.000000000000 Thickness (mm) of soil layer 3. The lower limit of this
023 15.000000000000 SW(9,1) Starting value for soil moisture layer 1 (mm). 2
024 90.000000000000 SW(9,2) Starting value for soil moisture layer 2 (mm). 3
025 125.000000000000 SW(9,3) Starting value for soil moisture layer 3 (mm). 3
026 19.000000000000 SW(2,1) Layer 1 maximum soil moisture (mm). 1
027 128.000000000000 SW(2,2) Layer 2 maximum soil moisture (mm). 1
028 160.000000000000 SW(2,3) Layer 3 maximum soil moisture (mm). 1
029 10.000000000000 SW(3,1) Layer 1 wilting point soil moisture (mm). 2
030 60.000000000000 SW(3,2) Layer 2 minimum soil moisture (mm). 2
031 75.000000000000 SW(3,3) Layer 3 minimum soil moisture (mm). 2
033 8.000000000000 EPLIM Upper limit to daily soil evaporation (mm/day) 2
035 0.000000000000 If=1 cracking occurs with increased soil evaporation
036 0.000000000000 Soil evaporation when soil cracked (mm/day)
038 0.625000000000 SCOV mean ) SCOV = P38 +P39*cos(0.01720*(idayno+P40))
039 0.325000000000 SCOV amplitude ) = total surface cover calculated as a
040 -30.000000000000 SCOV lag ) function of time.(-30 : max cover=Jan30
041 0.425000000000 GCOV mean ) GCOV = P41 +P42*cos(0.01720*(idayno+P43))
042 0.325000000000 GCOV amplitude ) = green surface cover calculated as a
043 -30.000000000000 GCOV lag ) function of time.(-30 : max cover=Jan30
045 1000.000000000000 green yield (kg/ha) when green cover for transpiration is 50% 5
046 1000.000000000000 green yield (kg/ha) when radiation interception is 50% 7
047 0.000000000000 NOT USED MAX Green cover when SWI is low = amax1(p47,amin1(0.99,
051 0.013000000000 death slope ) where swix = soil water index 10
052 100.000000000000 Percentage of pasture burnt
053 2.000000000000 Daily minimum screen temperature for frost effect on quality
054 0.657000000000 Slope in lwg=p54*dietsn+p55
055 -0.405000000000 Intercept in lwg=p54*dietsn+p55
056 0.050000000000 Growth index for greenday/frost & wool climatic index
057 12.150000000000 Slope in %Dry Matter Digestibility DMD=p57*%Ndietsn+p58
058 39.190000000000 Intercept in %Dry Matter Digestibility DMD=p57*%Ndietsn+p58
059 0.150000000000 Slope in %Phosphorus =p59*%Ndietsn+p60
060 0.020000000000 Intercept in %Phosphorus =p59*%Ndietsn+p60
061 14.000000000000 If temp is less than P61, temperature index (TIX) is zero. 6
062 24.000000000000 As temp increases from P61 to P62, TIX increases from 0 to 1. 6
063 45.000000000000 As temp increases from P62 to P63, TIX remains at 1. 6
064 50.000000000000 As temp increases from P63 to P64, TIX decreases from 1 to 0.0 6
065 1.000000000000 Multiplier on rainfall 1.0= no change
066 0.000000000000 Change in minimum temperature
067 0.000000000000 Change in maximum temperature
068 0.000000000000 If=1 call climate change
069 0.000000000000 tgrowthgba3 total growth for basal calc
070 0.000000000000 teatgrgba green eaten used in pargrz
071 0.000000000000 teatdmgba
072 0.000000000000 proputilold used pargraz
073 0.000000000000 transtgba used for tgba calculation
074 0.000000000000 yld430 yield at April 30
075 0.000000000000 tgrowthgba2 total growth for basal calc
076 0.000000000000 tgrowthgba1 total growth for basal calc
077 0.000000000000 growly growth last year calc from accumulated ET
078 0.000000000000 etsu accumulated ET
079 0.000000000000 TSDM yield for destocking at change date
080 0.000000000000 Date for shearing,p80 before p247 and= p81 930 is 30th Sept
081 601.000000000000 Date for resetting stocking rate
082 0.000000000000 1=Constant, 2=%Use of TSDM for next year, 3=%Use of Growth
083 0.000000000000 %Utilisation of AveGR, or pasture yield
084 200.000000000000 Liveweight kg

```



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```

085 3.000000000000 Breed 1=XBRED 2=BRITISH 3=G2 XBRED, =11 for dry sheep equivalents
086 6.000000000000 Age in months
087 0.000000000000 Accumulated growth since 1201 ie 1st Dec
088 0.000000000000 Accumulated transpiration since p112
089 0.000000000000 Accumulated growth since p112
090 0.000000000000 N kg/ha per 1000 mm of rain
092 1.000000000000 Slope in diett=p92*dietquality+p93
093 0.000000000000 Intercept in diett=p92*dietquality+p93
094 1.500000000000 Multiplier of VPD for zero height
095 20.000000000000 Height at which VPD multiplier = 1.0
096 30.000000000000 Height (cm) of 1000 kg/ha
097 5.000000000000 N uptake (kg/ha) at zero transpiration, N=p(97)+p(98)*(trans/10024
098 10.000000000000 N uptake per 100 mm of transpiration
099 12.000000000000 Maximum N uptake (kg/ha)
100 2.500000000000 Maximum % N in growth
101 0.580000000000 % N at zero growth Nitrogen index = (%N-p101)/(p102-p101)
102 0.680000000000 % N at maximum growth Nitrogen index = (%N-p101)/(p102-p101)
103 1.000000000000 N uptake per 100 mm of soil water
104 0.900000000000 constant in I15 equation I15=p104+p105*cos(dayno+15)
105 0.700000000000 slope in I15 equation I15=p104+p105*cos(dayno+15)
106 0.500000000000 Relative supply of layer 3 cf layers 1,2. Usually 0.5
107 1.000000000000 A value to transform green cover to POT TRANS/PAN
108 0.000000000000 Proportional decline per day in % N for green material
109 0.015000000000 Proportional decline per day in % N for dead material
110 1.000000000000 Minimum % N in green & maximum in dead
111 0.400000000000 Minimum % N in dead
112 1015.000000000000 Date for resetting Nitrogen uptake
113 0.900000000000 Animal growth rate when greenleaf > glx2 eg 100 to 200 kg/ha
114 0.000000000000 Not used
115 0.000000000000 Animal growth rate for when zero greenleaf tsdm=300 kg/ha
116 -1.000000000000 Animal growth rate for when zero greenleaf & tsdm=0, eg -1kg/day
117 0.000000000000 Output for animal model to lw21.ogp 0=no output
118 18.000000000000 Default animal age (months) when LW's are reset
119 1.000000000000 No. of experimental treatment for liveweight gain
120 9.000000000000 Animal model; 0 =0.0, or 1 for utilization model,
121 0.493000000000 Animal growth rate for green days (native 0.493, imp 0.613)
122 -0.163000000000 Animal growth rate for non-green days (native -0.163, imp -0.043)
123 0.500000000000 Proportion of leaf of total growth (L/(L+S))
124 0.000000000000 Green yield at which stem growth begins
125 2.000000000000 Minimum screen temperature (c) at which green cover =100% =no del0
128 0.005000000000 Prop of Dead leaf detached per day from 1Dec to 30 April
129 0.005000000000 Prop of Dead stem detached per day from 1Dec to 30 April
130 0.002000000000 Prop of Dead leaf detached per day from 1May to 30 November
131 0.002000000000 Prop of Dead stem detached per day from 1May to 30 November
132 85.000000000000 Percentage of leaf/(leaf+stem) in diet at 50% leaf in sward
133 1.000000000000 Multiplier on total death for DM death of leaf
134 1.000000000000 Multiplier on total death for DM death of stem
135 50.000000000000 Green leaf
136 50.000000000000 Green stem
137 100.000000000000 Dead leaf
138 100.000000000000 Dead stem
139 250.000000000000 Litter
140 1016.000000000000 Date for resetting DRY MATTER, 930
141 0.000000000000 Accumulated consumption since 1201 ie 1st Dec
142 1.050000000000 Intercept in equation of reln between intake and utilisation
143 -0.200000000000 Slope in equation of reln between intake and utilisation
144 300.000000000000 Yield (kg/ha) at which intake restriction no longer operates
MSS 13/03/96: GM says compromise between 230 & 500
145 70.000000000000 Expected live weight gain (kg/hd) in summer at low stocking rate13
146 35.000000000000 Expected live weight gain (kg/hd) in autumn at low stocking rate13
147 0.000000000000 Expected live weight gain (kg/hd) in winter at low stocking rate13
148 5.000000000000 Expected live weight gain (kg/hd) in spring at low stocking rate13
149 0.400000000000 Soil water index at which above-ground growth stops.
150 0.000000000000 Initial stocking rate (weaners/ha, live weight = 200 kg)
151 0.500000000000 Min available water ratio in total profile required for planting
152 0.900000000000 Min available water ratio in layer one required for planting
153 0.300000000000 Max awr in layer one so it's dry enough to plant
154 0.000000000000 Prop of Dead leaf detached per day per 100 mm of (rain-p156)
155 0.000000000000 Prop of Dead stem detached per day per 100 mm of (rain-p156)
156 50.000000000000 Two-day rainfall required to initiate detachment caused by rain
157 430.000000000000 date (monthday) for annual change in tussock grass basal area
158 1.000000000000 minimum tussock grass basal area, TGBA=p158+p159*growth
159 1.000000000000 slope, TGBA=p158+p159* average growth year1+2 /1000
160 2.500000000000 maximum possible increase per year in TGBA e.g. 2.5 %units
161 5.000000000000 maximum possible tussock grass basal area
162 0.300000000000 swix 2+3 <threshold for counting drought days
163 0.500000000000 swix 2+3 >threshold for turning off drought
164 0.500000000000 Proportion of this year's growth affecting sward basal area
170 20.000000000000 Dry matter yield for each age class at which intake not limited in
171 -0.028600000000 K value for decline in diet preference with age
172 -0.102400000000 K value for decline in diet nitrogen with age
180 2.000000000000 If=1 change parameters as a function of utilisation 30th April
181 6.000000000000 p99 Maximum N uptake (kg/ha)
182 1600.000000000000 p45 Green yield (kg/ha) when green cover for transpiration is 50%
183 10.000000000000 p96 Height (cm) of 1000 kg/ha
184 1.000000000000 p101 % N at zero growth Nitrogen index = (%N-p101)/(p102-p101)
185 1.100000000000 p102 % N at maximum growth Nitrogen index = (%N-p101)/(p102-p101)
186 0.002000000000 p128 Prop of Dead leaf detached per day from 1Dec to 30 April
187 0.002000000000 p129 Prop of Dead stem detached per day from 1Dec to 30 April
188 0.002000000000 p130 Prop of Dead leaf detached per day from 1May to 30 November
189 0.002000000000 p131 Prop of Dead stem detached per day from 1May to 30 November
190 0.990000000000 p149 Soil water index at which above-ground growth stops.
191 0.500000000000 proportion green_eaten/growth at which pasture has

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# DROUGHTPLAN WORKING PAPER NO.9: HERDGRASP ANALYSIS OF SOI

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192 230.00000000000000 p144 Yield (kg/ha) at which intake restriction no longer operates
193 0.4000000000000000 p009 Soil water index. Maximum green cover = amin1(0.99,swix/p(9)
194 0.0000000000000000 Initial pasture condition 0=90% perennials,11=heavily grazed
195 1.0000000000000000 Resilience rate %util<22.5 1= 1 year equivalent on AA scale
196 1.0000000000000000 Degradation rate %util>34 1= 1 year equivalent on AA scale
197 0.0000000000000000 If=0 resource cannot return from heavily grazed state
198 0.0000000000000000 %Utilisation for increase in state to occur
199 0.0000000000000000 %Utilisation for decrease in state to occur
203 1900.00000000000000 Starting year of simulation; 1800 to begin at start of metfile. 14
204 7.0000000000000000 Starting month of simulation 14
206 0.0000000000000000 Number of days in simuln run,last date : 1st Mar 1986=198603 15
209 4.0000000000000000 TIX 1=FSS, 2=GP , 3= NP ,4= use p61 and p62 ,5= tix=1.0 6
210 2.0000000000000000 Selector for cover fuction; 1=f(time) P(38...43) ,2=f(yields).
211 0.0000000000000000 if=1-365 gives output of observed & predicted , and
212 330.00000000000000 Too few days for analysis of lwg when p289=4
213 400.00000000000000 Too many days for analysis of lwg when p289=4
220 1.0000000000000000 For year type 0 forecasting stocking rate multiplier
221 0.0000000000000000 For year type 1 forecasting stocking rate multiplier
222 0.0000000000000000 For year type 2 forecasting stocking rate multiplier
223 0.0000000000000000 For year type 3 forecasting stocking rate multiplier
224 0.0000000000000000 For year type 4 forecasting stocking rate multiplier
225 0.0000000000000000 For year type 5 forecasting stocking rate multiplier
226 0.0000000000000000 For year type 6 forecasting stocking rate multiplier
245 3.0000000000000000 Soil loss If=1 use Rose model, 2=Bob Miles, 3=Joe Scanlan
246 132.00000000000000 Output type: 80=80 column output, 132= 132 output 0=132 col
247 601.00000000000000 Output of totals:365 - 999=yr - obs.If=mndy & P249=0,print prob
248 0.0000000000000000 Output of model:365=yr,91=seas,30=mthly,7=wkly,1=daily,999=obs
249 0.0000000000000000 if=1,totals are summed;if=0 and P247=mndy then probs are printed
250 1.0000000000000000 if=1 full daily met data, if=3 weekly austclm 15
251 0.0000000000000000 If=1 call crop emergence subroutine and use options P252to 260.
252 901.00000000000000 First date for planting; month day 0901 = 1st Sept.
253 1231.00000000000000 Last date for planting; month day 1231 = 31st Dec.
254 25.0000000000000000 Yield at emergence (kg/ha)
255 10.0000000000000000 Number of days from planting to emergence
256 90.0000000000000000 Number of days from emergence to end of crop growth
257 401.00000000000000 End of crop on month, day due to temperature
259 0.0000000000000000 Output to screen: 1= stop screen scrolling
260 70.0000000000000000 Number of days from emergence to end of green growth
261 0.0000000000000000 Batch operation=0 ; interactive=1 ; replace original pars=2
262 979.00000000000000 Output to screen:365=yr,91=seas,30=mthly,7=wkly,1=daily,999=obs
263 0.0000000000000000 Station no. of AUSTCLIM station from menu option(39039=GAYNDAH) 15
264 55.0000000000000000 No. of daily (rainfall) station in pmbstat2.pat, 1=BrianPastures15
265 0.0000000000000000 If=1 call pasture burning subroutine and use options 266-7
266 1001.00000000000000 First date of burning; month day 1001 = 1st Oct
267 0.0000000000000000 Threshold yield required for burn; total standing DM kg/ha
268 2.0000000000000000 if=1 call dynamic basal area subroutine & reset when mrx=11
MSS 10/03/96: set to override above
269 0.0000000000000000 monthly climate station type 5 in pmbstat2, if=0 AUSTCLIM 16
270 1.0000000000000000 0 for free draining soils, 1for runoff as a f(yield) 3
271 1150.00000000000000 yield at 50% cover for run-off calculation 3
272 0.9500000000000000 k value in cover=y**k / (y**k + p271**k) 3
273 1.0000000000000000 maximum runoff of rainfall at zero cover, wet soil 3
274 0.0000000000000000 If=1 use denmead and shaw for limiting soil moisture index
275 13.0000000000000000 Layer 1 p275*awr1**2 mm/day
276 13.0000000000000000 Layer 2 p276*awr2**2 mm/day
277 3.6000000000000000 Layer 3 p277*awr3**2 mm/day
278 1.0000000000000000 % slope of land 0-20%
282 0.0000000000000000 If=1.0 reset to observed soil moisture in management file
283 0.0000000000000000 if=1 ET output to file sl8.ogp, p246 must be 132
284 0.0000000000000000 if=5 basal area utilisation
285 0.0000000000000000 if=2 monthly growth in rainman output
286 3.0000000000000000 if=1 rainfall use efficiency to r17.ogp, p246 must be 132
287 0.0000000000000000 if=1 runoff output to p19.ogp, only days with rain GE p287
288 5.0000000000000000 Water (ET) use efficiency for basal area change
289 5.0000000000000000 Output options for unit 21
290 0.0000000000000000 Date for resetting soil moisture to p23,24,25,299 930 is 30th Sep
291 4.5000000000000000 MATURE TREE BASAL AREA: LAI=0.15*TREE BASAL AREA
292 10.0000000000000000 Layer 1 minimum soil moisture (mm) with trees 23
293 48.0000000000000000 Layer 2 minimum soil moisture (mm) with trees. 24
294 59.0000000000000000 Layer 3 minimum soil moisture (mm) with trees. 24
295 100.00000000000000 Layer 4 available water (trees only) 24
296 200.00000000000000 Maximum depth (cm) of tree roots 24
297 1.4400000000000000 Tree Root length at surface, rl= p297*exp(-p298*z)
298 0.6100000000000000 Tree Root length exponent, rl= p297*exp(-p298*z)
299 20.0000000000000000 asw4 Starting value for soil moisture layer 4 (mm), trees only
300 0.0000000000000000 Indicates end of parameter file 25

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**CTOWERS.INV**

```
# Initial value file for GRASP.
sw1      15.00000000
sw2      90.00000000
sw3      125.00000000
sw4      20.00000000
beasts_ha 0.00000000
alw      200.00000000
green_leaf 50.00000000
green_stem 50.00000000
dead_leaf 100.00000000
dead_stem 100.00000000
litter   250.00000000
grass_ba  4.00000000
acc_growth 0.00000000
acc_growth2 0.00000000
acc_eaten 0.00000000
tree_ba   4.50000000      ***
acc_growth_for_N 0.00000000
acc_trans_for_N 0.00000000
acc_growth_last_summer 0.00000000
acc_ET_summer 0.00000000
## new state values follow MSS 23/09/95, MSS 06/02/96
      annual_woolgrowth 5.00
      sheep_lw_chg_shrg 0.00
      acc_months_et 100.00
      last_months_et 300.00
      acc_transpiration 0.00
      acc_gba_growth1 2500.00
      acc_gba_growth2 2400.00
      acc_pgrowth_fr_shrg 2000.00
      acc_intake_fr_shrg 800.00
      pasture_yield_last_shrg 1200.00
      nondrought_days_fr_shrg 90.00
      acc_thi_fr_shrg 0.00
      acc_growth_out 0.00
      acc_eaten_out 0.00
      cattle_year_lwg 0.00
      acc_soil_loss 0.00
      gix_days 0.00
      tot_gix_days 1.00
      acc_lw_losses 0.00
      acc_lw_growth 0.00
      acc_lw_eaten 0.00
      acc_gba_eaten 0.00
      prop_util_last_year 0.00
      perennial_idx 0.00
      acc_litter 0.00
```

\*\*\* only this value, the tree basal area, in the state file is invariant during the run.

