SGS Pasture Model

Project number HRZ.120
Final Report prepared for MLA by:

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Project HRZ.120: SGS Pasture Model

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Introduction

This documents accompanies the second milestone report for project HRZ.120 and the release of the SGS Pasture Model version 3.1.8, which can be downloaded from www.imj.com.au/sgs/phase2. During installation, use the serial number:

SGS3.55555.1953.UMLA

Note that:

- The program version number, 3.1.8, relates to my own programming strategy – it has no meaning in the context of this project!
- Model documentation is given in the "Help" file.
- The default simulation which can be run just by firing up the model and clicking the "Run" button uses generic climatic patterns. This simulation is not meant to be particularly realistic. During the next milestone I'll be generating simulations from the SGS NE project.
- This program is quite demanding on the computer system. As the program runs it stores a lot of information to allow all the graphs to be drawn and also for the subsequent detailed export of information. The system requirements are mentioned on the web page.

The *Schedule* in the contract have been completed, with one exception in that specific treatment of leaf and stem components of dry weight has not been incorporated. There are good reasons for this, which are discussed below.

In this document some issues in relation to the work that has been done are considered, simulation output for a simulation based on Greg Lodge's SGS site is discussed, and some comments are given on future possible work with the Model.

Model overview

The biophysical nature of the model allows effective assessment of pasture growth and utilization in response to environmental conditions. The principal components are:

- Pasture growth. Physiologically based model with multiple species that can be C3, C4, perennial, annual, legume. In addition, the model includes the option to apply pasture heterogeneity and its influence on growth.
- Animal intake. Pasture intake responds to the pasture state, and supplementary feeding of both concentrate and forage is also available.
- Animal metabolism. Energy based model that includes growth, maintenance, pregnancy and lactation.
- Water dynamics. Mechanistic model of water dynamics, including transpiration, evaporation (from canopy, litter and soil), infiltration (and therefore through drainage) and runoff.

- Nutrient dynamics. Organic matter turnover (from litter, dead roots, dung), and inorganic nutrient dynamics for N, P, K, S. The model includes plant uptake, leaching, atmospheric N losses, NH_4 to NO_3 transformations.
- The model also includes the ability to run up to 100 paddocks simultaneously that can each be defined with individual parameter sets, such as soil characteristics, pasture species and so on.
- There is a range of management options including set-stocked, variable stocked continuous grazing, as well as time or feed budget based rotational grazing strategies. Cutting regimes can also be included.
- Fertilizer and irrigation options are also available.
- Climate data are read from Excel files.
- Simulations can be run for up to 100 years (this could easily be extended), and detailed simulation output can be exported to an Excel file.
- The model has a highly intuitive interface for creating and running simulations.

Progress to date

The *Schedule* is attached as an appendix. These have all been completed with the exception of the specific treatment of leaf, stem and sugars components. My reason for not doing this is not because the work was too difficult, but because I have come to the conclusion that it introduces unnecessary complexity to the model. However, a treatment of sugar concentration is incorporated although not with a specific sugars pool – this is discussed shortly. I am pleased with the way the model is performing and feel that it meets all of the intended objectives of this phase of the work.

Several new features have been added to the model that are not specifically mentioned in the *Schedule*, but that improve the general versatility of the model . For example, it is now possible to toggle between having the graphs displayed or not, since the graphics tend to slow things down a bit, so the graphic can be switched on or off during the simulation. Another example is the option to have different management routines for different times of the year, which is particularly useful for regions with fairly predictable weather patterns, such as winter dominant rainfall, where the management rules in spring may be different to those in autumn.

The Model is giving good representation of pasture growth for a range of species in a range of locations. In the related DairyMod project, the same pasture routines have been applied for annual ryegrass in WA; C3 and C4 mixtures in SA; ryegrass and white clover pastures in Vic; kikuyu and annual ryegrass pastures in Northern NSW; Rhodes grass and annual ryegrass pastures in Qld; and a few other combinations. Using this current version of the SGS Model, I have been able to simulate mixed native C3 and C4 pastures in the Tamworth region, as well as phalaris and sub-clover pastures in Western Vic. I am confident that the model will work well for all other former SGS sites.

I therefore questioned the wisdom of making the model more complex than it needs to be – fully appreciating that the suggestion to include these components was entirely my own! The leaf fraction is included implicitly and by having an explicit leaf fraction it would become necessary to start to ascribe photosynthetic activity to the stem as well. Similarly, to introduce a sugars component would require some assumptions about diurnal variation in sugars, since these increase quite considerably in leaves during the day, falling off towards the end of the day and in the night as they are utilised. While these are important physiological considerations, my view is that it is unnecessary and undesirable to include them. Unnecessary because I don't think the model will perform any better (an may be worse), and will require more parameters. Undesirable because it is likely to slow the model down and the optimisation schemes need a fast model. Optimisation is discussed later.

One of the *Schedule* items has been to incorporate pasture heterogeneity in to the Model, which has been done. However, as a result of my recent work with the Model, I feel that we should not use this feature routinely. While it provides interesting insights into the principles of pasture heterogeneity and allows the use of bite parameters for pasture intake, I realise that it does tend to slow the Model down and, for long-term scenario analyses, I do not think that it provides any improved performance. Thus, while pasture heterogeneity is included, it is not switched on by default, and I do not recommend its use for the sort of model applications that we are likely to do in the immediate future.

There are some things that I still wish to address as a matter of priority. These are:

- Re-visit the nutrient dynamics. Currently this component is working pretty well, but can require some judicious parameter adjustment to give sensible results. I have some ideas on how to stabilise this and don't anticipate it being a major job.
- Re-structure the main model window. Currently, there is the option to see either the animal or soil graphs, along with the pasture and climate graphs as well as the paddock grid which represents the relative pasture mass on each paddock. Sean Murphy pointed out that it would be good to be able to see both the animal and soil graphs and I intend to do this. The current structure is somewhat historical in that it caters for low monitor resolution.

I plan on working on these issues in the next couple of weeks.

Barraba Simulation

I have run a generic pasture simulation for Barabra, which is one of Greg Lodge and Sean Murphy's SGS sites. I have not attempted to work too closely with the site data, but rather to run long term simulations (1971-2001) and look for generic behaviour. The illustrations shown below are presented for various periods towards the end of the simulation, so that the behaviour of the Model can be observed after it has run for a number of years.

The features of the basic simulation are:

- Mixed C3, C4 native perennial pasture species;
- 6 wethers per ha;
- Either set-stocked or 4 paddock rotational grazing with the animals on each paddock for 4 weeks.

The simulation results are only shown for a few years, although it is encouraging to see how well the model was performing in relation to expectations when it was run for 30 years.

Set stocked simulation

The first set of graphs illustrate the Model behaviour under set stocking, and are taken directly from the Model interface. They show the pasture dry weight, and its components on the left, and the species dry weights on the right. They are shown for the period from the beginning of 1998 to the end of 2001. The legends are not very easy to read because I've shrunk the graphs to get them on the page. However, for the ones on the left they are:

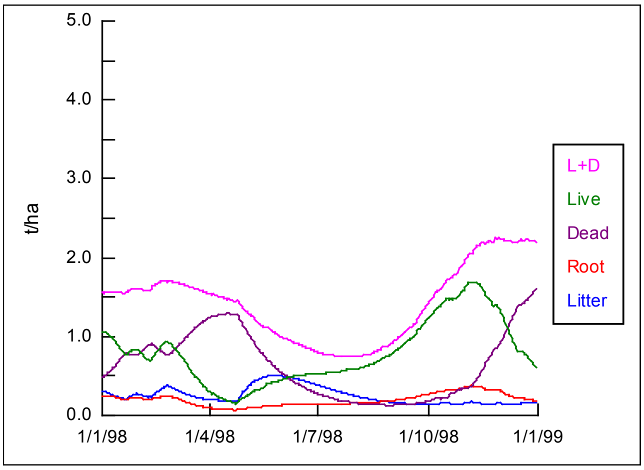
- L+D, which is live plus dead;
- Live
- Dead
- Root
- Litter

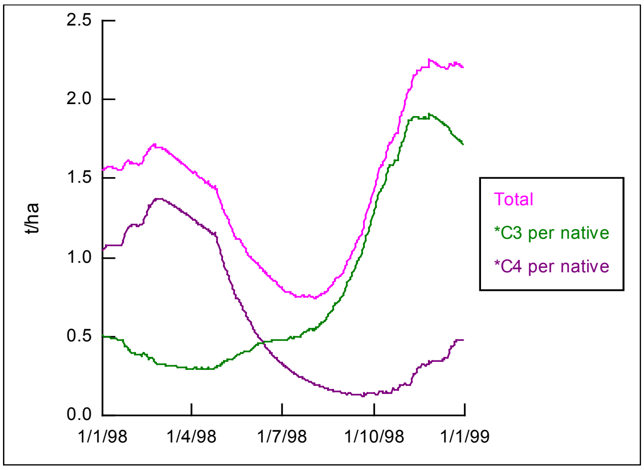
For all graphs the scale is 0 to 5 t/ha.

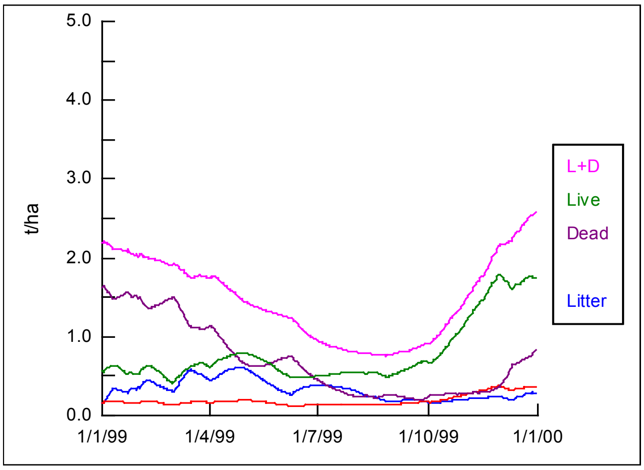
For the graphs on the right, the legends are:

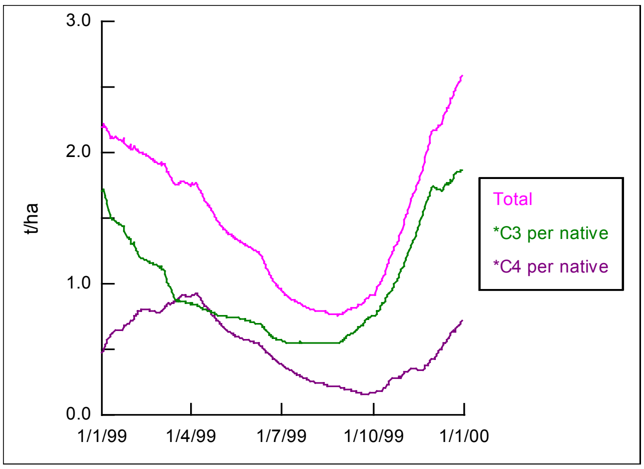
- C3 per (perennial) native;
- C4 per (perennial) native.

For these graphs the scales vary, but the main point to look at is the relative sizes of the species dry weights. The graphs display the simulation output for each year..









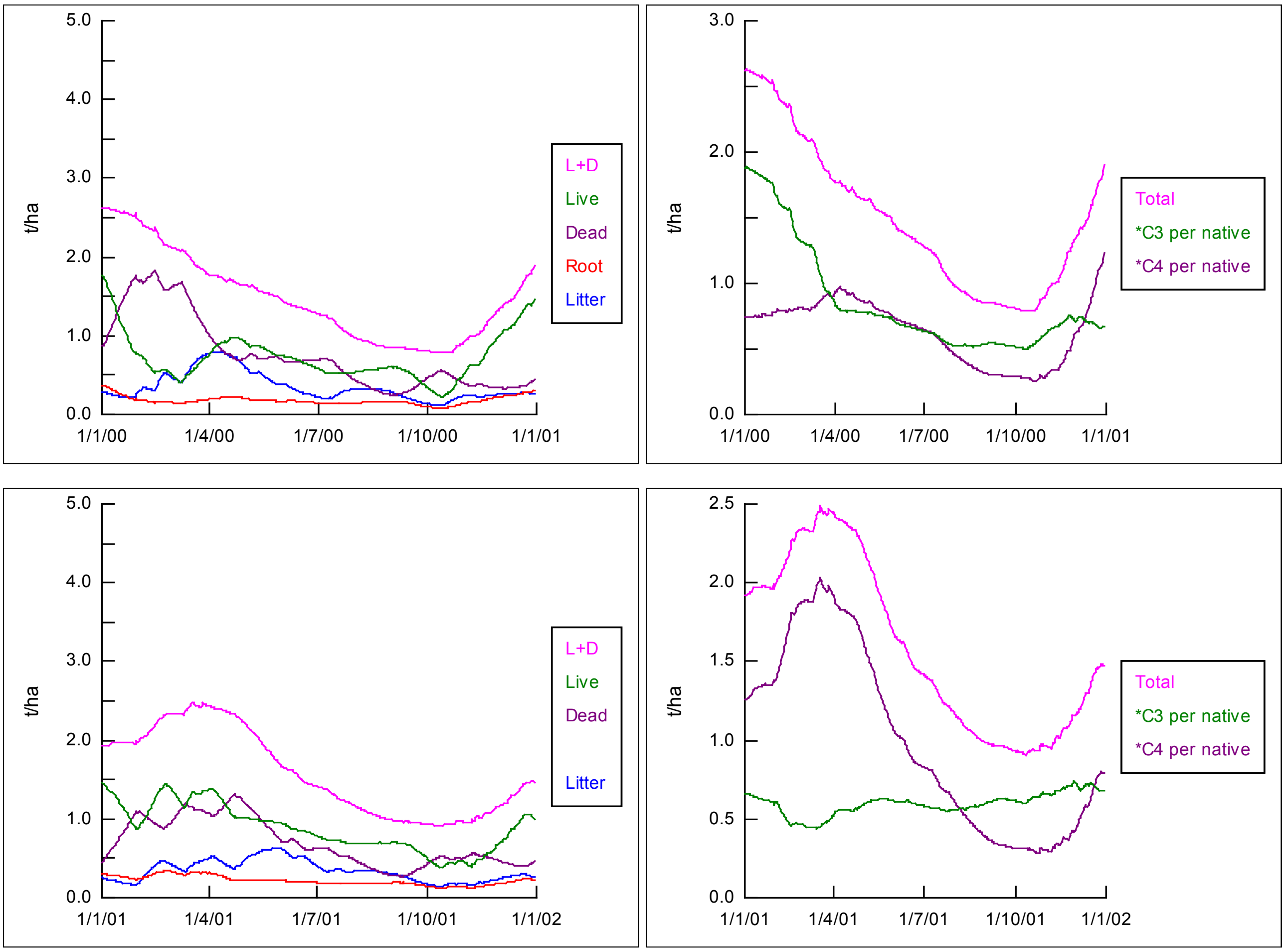


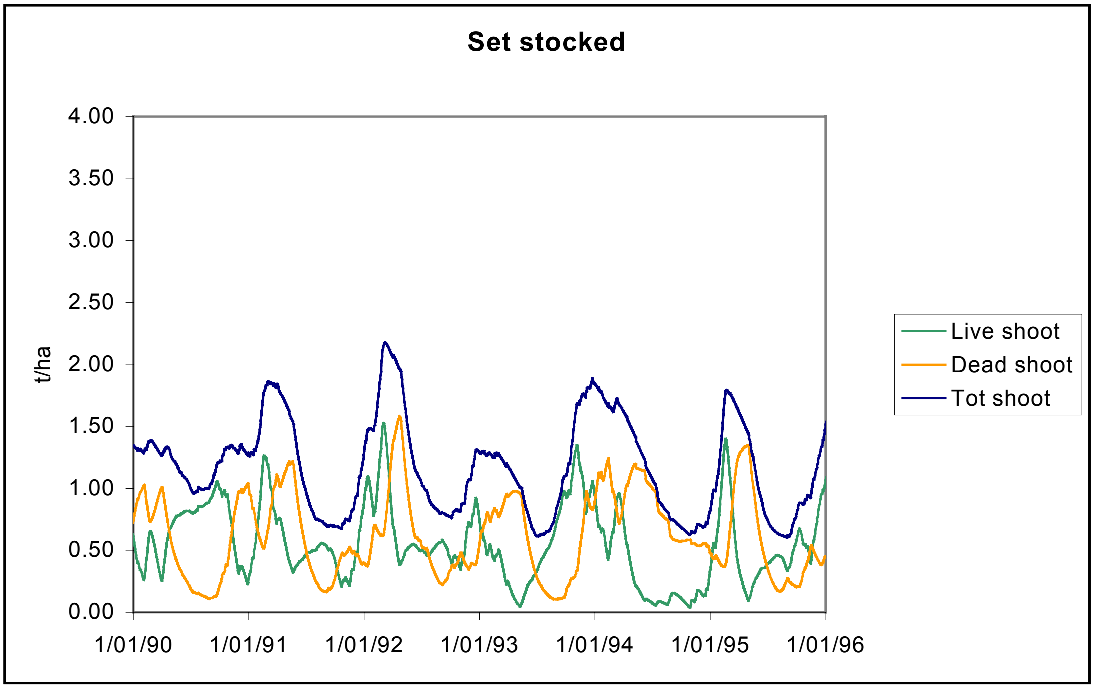
Figure 1: Set stocked simulation. Pasture live, dead and total (live +dead), root and litter dry weight, on the left; and species composition (C3 perennial native, C4 perennial native) on the right.

The key points to note from these graphs are that not only do the pasture dry weights vary considerably from year to year, but also the species composition which can be quite dramatic. These illustrations suggest that there is no absolute pattern for either pasture dry weight or species composition, but that these will vary considerably in response to climatic conditions. While variation in dry weight is to be expected in response to climatic conditions, it is interesting to note the variable species composition.

Comparison between set stocked and rotational grazing

Now consider the comparison between set stocked (SS) and rotational grazing (RG). It was generally observed by the Tamworth team (Greg Lodge and Sean Murphy) that RG resulted in greater ground cover, both for pasture dry weight and litter, with a corresponding improvement in animal production. Rather than repeat the graphs shown above, the following graphs are drawn from the Model output that was exported to Excel. These are shown for the period from the beginning of 1990 to the end of 1996.

The first pair of graphs show the pasture dry weight, as well as the live and dead components for the SS and RG simulations respectively. It is immediately clear that there is much greater ground cover with the RG simulation, which is consistent with the observations by the Greg and Sean.



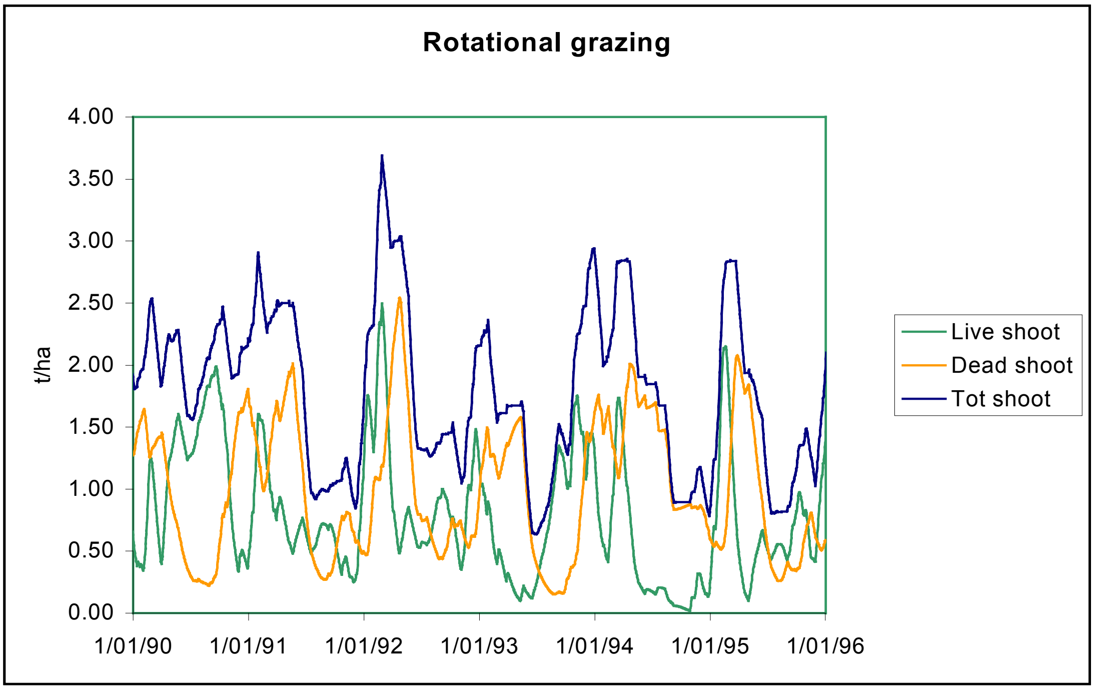
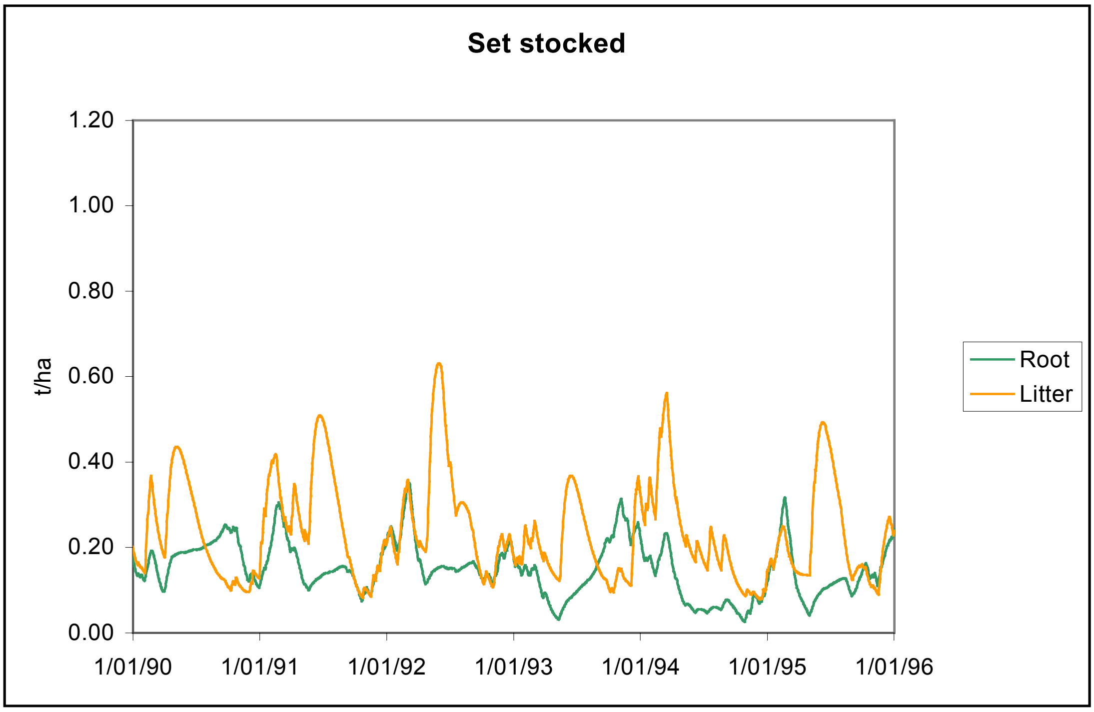


Figure 2: Comparisons between set stocked and rotational grazing of the total, live and dead shoot material, for set stocked and rotational grazing as indicated.

Root mass and litter are also important components in the system, and these are illustrated below for the period from the beginning of 1990 to the end of 1996 for the SS and RG systems. Again, the simulation results are consistent with expectations in that the litter and root dry weights are greater under rotational grazing.



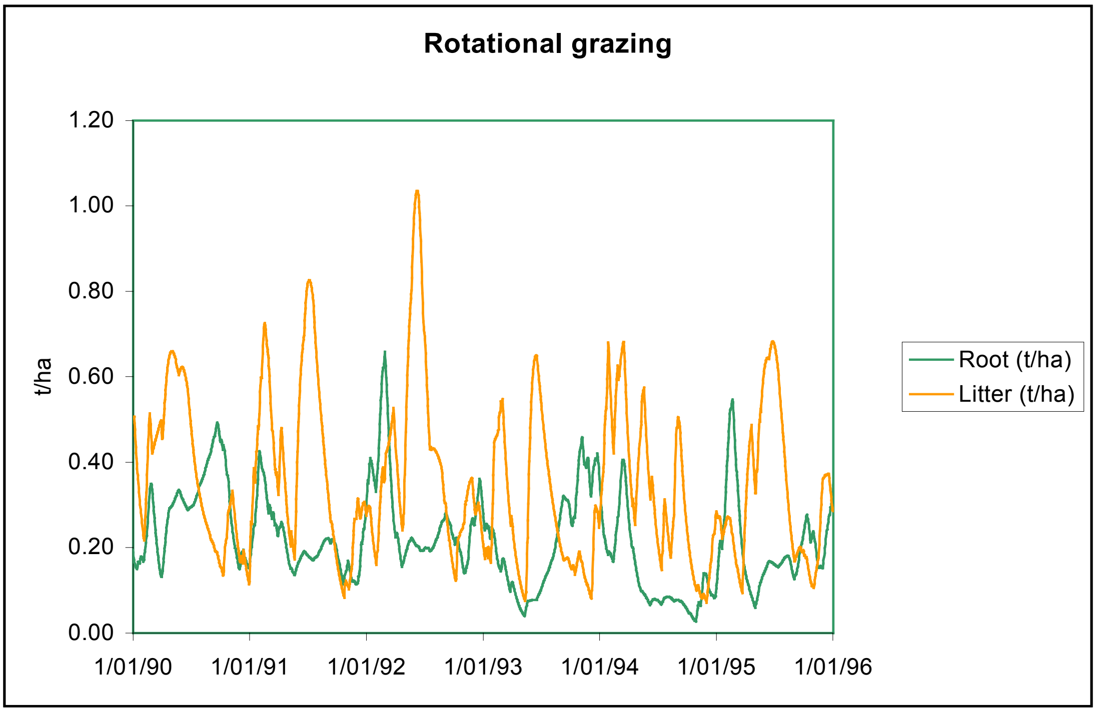


Figure 3: Comparisons between set stocked and rotational grazing of the root and litter material, for set stocked and rotational grazing as indicated.

For the RG system there was also variation in the individual paddocks as illustrated below. Here, the species composition is shown for each of the paddocks for the final year of the simulation. While these differences are not particularly dramatic, they do suggest that there is a combined impact of weather conditions and management on pasture state and species composition, and the paddocks in the rotation will have differences in pasture state in spite of being identical in terms of soil type, species present and so on.

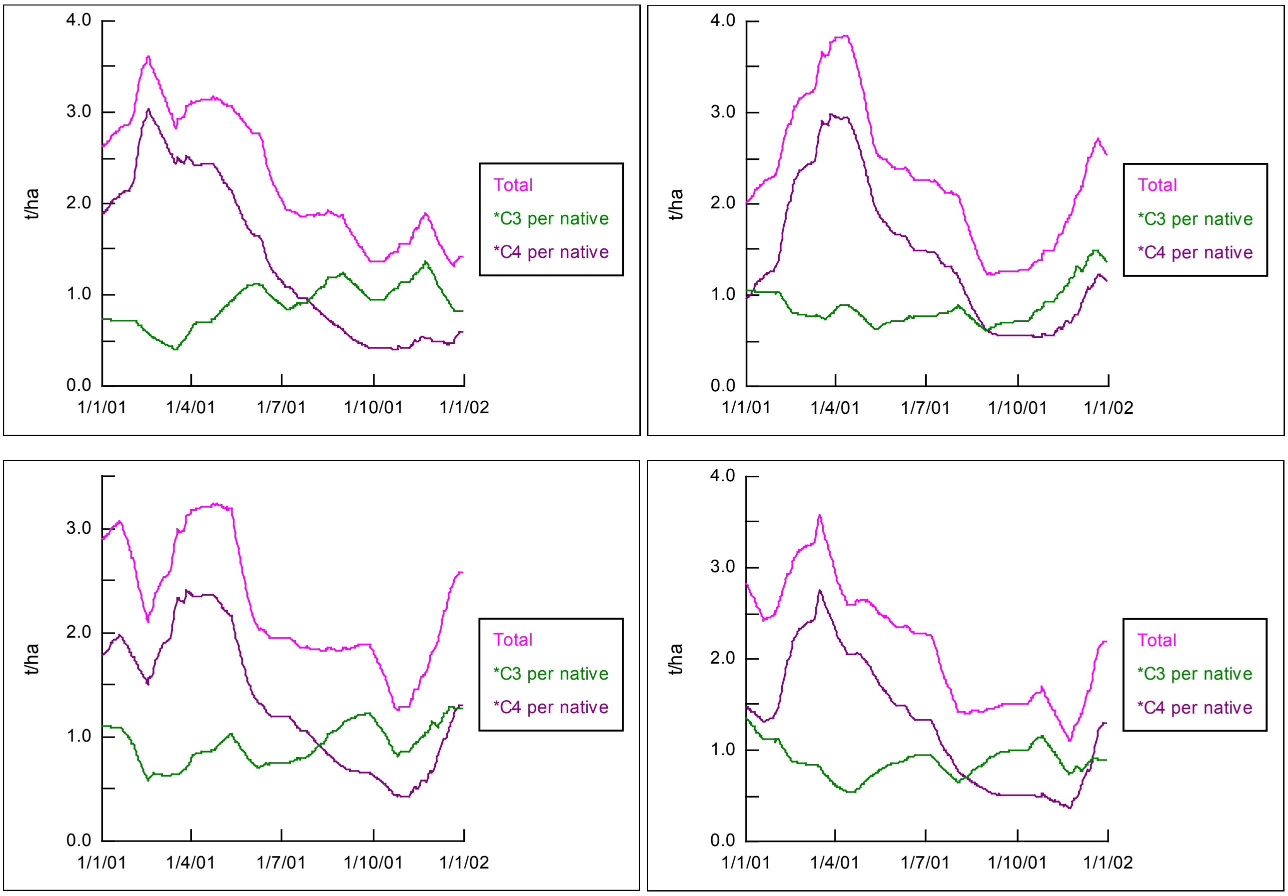


Figure 4: Rotational grazing for the final year of the simulation. The species composition is shown for each of the 4 paddocks.(C3 perennial native, C4 perennial native).

Animal production

Of course, pasture cover only tells part of the story, and we are also interested in animal production. The illustrations here are for a simple wether system and do not take account of stock replacement, aging and so on. Nevertheless, they can be used to assess general animal performance. The only restriction on the animal module was that animal weight was not allowed to fall below 30 kg – if it reached this level then the animals continued to eat as much as they could but their weight was not allowed to fall. In practice, the animals would either have been removed from the paddock or supplied with some form of supplementary feeding. (Supplementary feeding is incorporated in the model, but was not implemented for these simulations.) It is immediately clear from the figure that the RG system performed consistently better than the SS system.

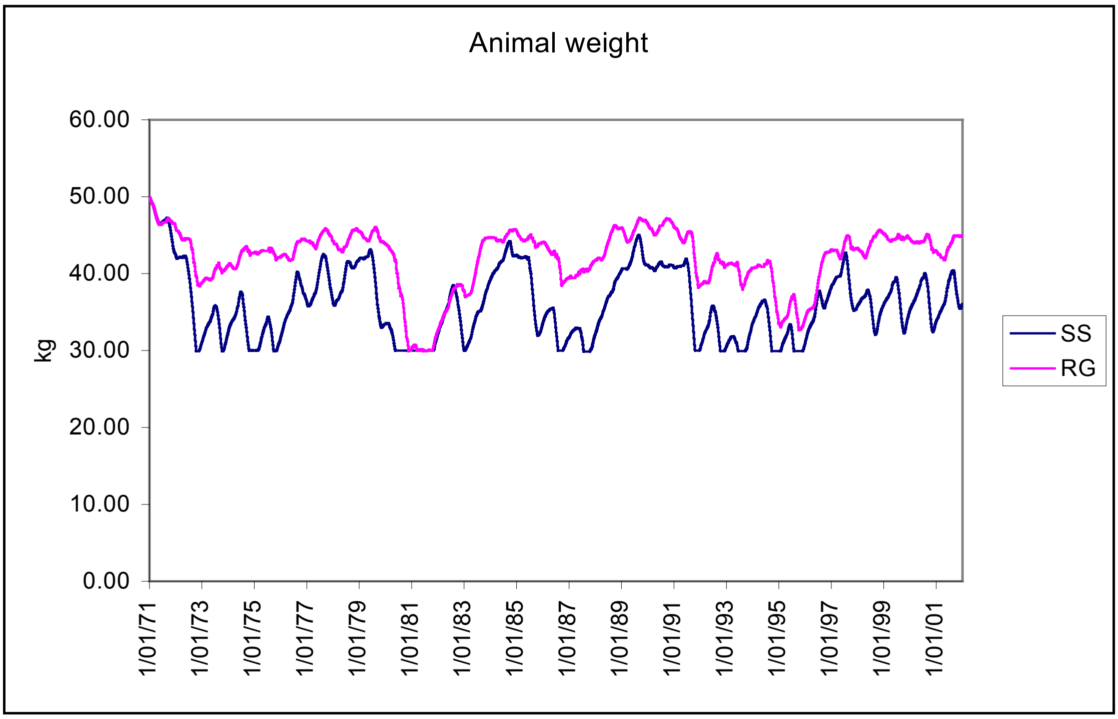


Figure 5: Comparison of animal weight between the set stocked and rotational grazing simulations as indicated for the period from 1971 to 2001.

The illustrations presented here provide a brief glimpse of the behaviour of the model and its potential for scenario analysis.

Where to from here?

The Model now has the scope and flexibility to be applied in a wide range of environments to analyse pasture production in the grazing industry. It is easy to use and gives ready access to the simulation output. There are a few suggestions I have for getting the Model used effectively and future Model developments.

User workshop

In spite of its simplicity, we are still dealing with a highly complex system and there is some degree of skill required to run the model in a sensible manner. In other projects that I'm involved with, there has been considerable value in holding workshops for users and I suggest we do the same here. These workshops are valuable both as a training exercise and also in allowing users to spend time with other users. They also allow people to discuss model applications and the system behaviour more generally.

I suggest we hold a workshop as soon as possible with representatives from MLA, the research community, and possibly advisors and farmers.

Further Model developments

The Model is working well and further developments that are required will become apparent as people use it. As mentioned earlier, there are some areas that I am currently looking at, such as parameter estimation for the organic matter dynamics component. As we see a shift from model development to application, we must recognise that each component must be critically assessed from time-to-time and improvements made as necessary.

As I've discussed before, and is addressed below, an area of considerable potential with the model is in the application of differential evolution (DE) optimisation techniques for analysing management options and parameter estimation. These techniques require multiple runs of the Model which, in turn, requires that the Model runs quickly. To run quickly, we must resist the urge to add more complexity in the Model, but should take advantage of its robustness at its present level of complexity. A typical simulation will currently run in around a second for a year and I am confident that with a little bit of effort I can bring this down considerably. This gives us serious potential to apply DE techniques to long(ish) term simulations with multiple paddocks to do some powerful risk analysis. I am therefore looking at ways of speeding the simulations up with a view to optimisation.

Scenario analysis

A brief analysis of the Barraba simulation has been presented here and I suggest that this be repeated for a few of the former SGS sites. My preliminary investigations suggest that this will be effective across a range of regions. This will give us a sound basis for model application.

Analysis of drought through simulation

The true value of the Model will be seen in the applications. As mentioned in the previous section, a key area is in risk analysis and optimisation, in particular in drought analysis. I have discussed this in the recent *Analysis of drought through simulation* proposal that was sent to MLA, and that is attached to this document. This is not discussed further here other than to say that there is considerable potential to provide some valuable insights into dealing with the risk associated with drought and to using weather forecasting as a management tool.

The use of weather forecasting in this way is not intended to clash with the current Spatial Toolsets project, but to complement it. That project is aiming to provide a tool for farmers in the short-term based on a simple model that gives an indication of potential pasture growth. The work here is a more complex Model that allows detailed assessment management strategies, pasture growth (including species), water and nutrient dynamics, and animal production.

Concluding remarks

The Model is now well developed and has the general scope and flexibility that was intended in this phase of the work. There is exciting potential to apply the model to address some key questions facing the grazing industry. To do so, I suggest that (as mentioned in this report):

- We hold a workshop for a group of potential users to help with training and Model application;
- Further Model development focuses on the application of differential evolution optimisation techniques to assist in the analysis of drought, including the application of weather forecasting methods.

The Model is unique in its scope, structure and ease of use, and I’m confident that it can play a valuable role for the grazing industry.

Appendix 1: Schedule, taken from HRZ.120 contract

Updating Modules of the SGS Pasture Model

Schedule

The following details are extracted from the current contract with MLA.

Pasture growth

- Re-work the carbon assimilation (growth) in the pasture model to give a more accurate response to temperature.
- Include specific treatment of leaf and stem components, along with soluble sugars in the Model. Currently a single dry weight component is used which can be limited in defining both growth and pasture digestibility.
- Include generic pasture species parameter sets. The Model requires the user to define the growth parameters for each species, whereas these parameters can be included in the interface.
- Include pasture heterogeneity. This includes patch dynamics which allow for a more accurate treatment of pasture growth as well as utilization by the grazing animals.

Pasture utilization

- Incorporate bite dynamics for pasture utilization. At present the Model defines intake in terms of total pasture in the paddock. However, by incorporating bite dynamics there is no increase in the number of required parameters, while these parameters have greater physiological interpretation. In addition, treatment of preference, or rejection, of pasture is more readily incorporated.

Animal growth

- The model uses a relatively simple ME (metabolisable energy) basis for defining growth and metabolism. However, the underlying parameters can be improved upon and can also be made accessible on the interface. In addition, the partitioning of energy during lactation requires revision.

Water dynamics

The water dynamics have been adapted from WaterMod (Greenhat Software).

- The treatment of runoff requires revision and it will be possible to incorporate the latest developments from WaterMod.
- Infiltration is strongly influenced by the unsaturated hydraulic conductivity. This has been developed further in WaterMod and can also be incorporated.

Nutrient dynamics

- The treatment of organic matter turnover in the Model requires the inclusion of adjustment parameters to give appropriate levels of nutrient composition in the soil organic matter. This has been re-worked and now gives more acceptable behaviour. The nutrient composition of organic matter will be displayed on the interface as the model runs.

Multiple paddocks

At present, the Model applies to a single paddock. However, it is possible to adapt this to multiple paddocks which will greatly enhance its scope and applicability. For example, it will be possible to look at the interaction between pasture growth and management for rotational grazing.

Appendix 2: Modelling the risk associated with drought

Modelling the risk associated with drought

Ian Johnson

22 May, 2004

Introduction

The need for the Australian grazing industry to have methods for identifying the onset of drought and management strategies that deal with drought is self-evident. DairyMod and the SGS Pasture Model have the potential to be used to address these issues. These models can help identify triggers of drought, assess the rainfall needed in the foreseeable future, say 1 to 3 months, to prevent the onset of drought, and management strategies that can respond to likely pasture growth. The analysis can also assess the risk of drought occurring and the effectiveness of management strategies to deal with that risk. Furthermore, one of the focus areas of EcoMod relates to climate change, and there are aspects of the work proposed here that could be adapted to address issues of climate change.

There is currently considerable interest in climate forecasting methods, and my involvement in MLA and DA projects that have been looking at climate forecasting has been valuable in acquainting me with the current methods that are being developed. These are primarily the MLA Spatial Toolsets project, which is being coordinated by Hutton Oddy, and the recent workshop that DA held with members of the APSRU group in Toowoomba. I must emphasise that the work I am proposing here is intended to work in parallel to the Spatial Toolsets project, and does not have the same objectives as that project.

Much of what is proposed here has arisen from discussions with Greg Lodge who had a major involvement with the SGS Pasture Model during the SGS Project. I hope that, should we proceed with this type of analysis, both Greg and Sean Murphy (also at Tamworth) will be involved.

Since MLA and DA are currently discussing ways of collaborating on future development of the SGS Pasture Model and DairyMod, I shall simply refer to the "Model". However, analyses would, of course, be industry specific where necessary, although the same core underlying biophysical components will be used.

The principal components of the Model are:

- Pasture growth. Physiologically based model with multiple species that can be C3, C4, perennial, annual, legume. In addition, the model includes pasture heterogeneity and its influence on growth.
- Animal intake. Intake is based on bite mechanics and interfaces smoothly with the heterogeneous pasture growth model. Supplementary feeding of both concentrate and forage is also available.
- Animal metabolism. Energy based model that includes growth, maintenance, pregnancy and milk production.
- Water dynamics. Mechanistic model of water dynamics, including transpiration, evaporation (from canopy, litter and soil), infiltration (and therefore through drainage) and runoff.
- Nutrient dynamics. Organic matter turnover (from litter, dead roots, dung), and inorganic nutrient dynamics for N, P, K, S. The model includes plant uptake, leaching, atmospheric N losses, NH_4 to NO_3 transformations.

- The model also includes the ability to run up to 100 paddocks simultaneously that can each be defined with individual parameter sets, such as soil characteristics, pasture species and so on.
- There is a range of management options including set-stocked, variable stocked continuous grazing, as well as a variety of rotational grazing strategies. Cutting regimes can also be included.
- Fertilizer and irrigation options are also available.
- The Model reads climate data from Excel files and detailed simulation output can be exported to Excel.

In this work, it will be necessary to run long-term simulations, which clearly requires some confidence in the Model. In the SGS Project, Greg Lodge and Sean Murphy ran 30 year simulations and then compared model predictions of soil water content, pasture dry weight and runoff with experimental observations for the last 3 years. These gave very good agreement. Similarly, Dave Chapman and others been running 40 year simulations with DairyMod to analyse pasture growth rate and, again, there has been good agreement with observations for a range of pasture species.

I am confident that the Model has potential to help analyse drought, and associated management strategies that can take advantage of climate forecast information.

Using climate forecasting

Climate forecasting, as applied by Greg Lauchlan's BRS group in the Spatial Toolsets project, generally uses indicators like the southern oscillation index (SOI) or surface sea temperatures (SST). There is some confidence in these forecasts for a period of up to 3 months, although the quality of the forecast does vary between regions. The methods are based on existing climate data and so there is plenty of information with which to assess the accuracy, or skills, of the forecasts. While these tests provide important measures of the forecasting skills, it is also necessary to identify the impact on actual pasture production, management strategies that can utilise the forecast information, and any risk associated with management decisions. One objective of the work proposed here will be to assess the value of forecasting information directly on pasture production and utilization.

Drought analysis

The Model has potential to be used to identify management strategies to deal with drought, to recognise conditions that indicate that drought may soon occur, and also the short-term rainfall required either to prevent or break the drought. The SGS Pasture Model was used as part of the SGS National Experiment (NE) and, as part of this work, Greg Lodge has run long-term simulations for the Barraba site using the SILO climate data set. These simulations have picked up all of the known droughts for the 40 years that the simulations were run and then showed good agreement with the measurements taken during the NE. This gives us confidence that the model is providing a good simulation of the interactions between climate, pasture growth, water dynamics and animal production.

Greg then went on to look at conditions that appear to lead up to drought, and it became apparent that this could be identified by the onset of a critical soil water content (SWC) which, in itself, may not be surprising. However, this SWC often occurred prior to any real indication that there was a drought. Furthermore, it was then possible to define how much rain would be required over the next month in order to prevent the onset of drought.

While Greg's work was not an extensive study, it demonstrated the potential for identifying the onset of possible drought and then the probability of the drought actually occurring. By looking at statistical probabilities of rainfall, along with weather forecasting, it would be possible to develop this approach to assess the likelihood and extent of pending drought.

Modelling strategy

The approach will be to run long-term simulations for a range of sites, combining actual, mean and forecast climate data. In all cases, a set of management rules will be applied that can respond to current conditions and expected climate.

Let the climate data sets be denoted by:

- C_a: actual daily values of rainfall, solar radiation, max and min temperatures.
- C_m: mean daily climate values taken for the period over which C_a applies. These values may need to be modified. For example, for regions that are subject to infrequent but heavy summer rainfall, averaging may result in regular, light rainfall. It will probably be necessary to use both rainfall frequency and amount to generate the mean climate conditions. I'm sure this is an issue that has been addressed previously.
- C_p: predicted climate values. The predicted climate values for any three month period will be based on predictions from the start of the period.

By running simulations with these three sets of climate data it will be possible to assess the effectiveness of forecasting information directly as it influences pasture production and utilization.

The model will be used to generate simulations using this climatic information. In all cases, management decisions will be made based on current conditions and expected climate, where the expected climate is either given by C_a, C_m or C_p. Clearly, C_a is never known but by using this in the simulations, we can compare the relative value of climate forecasting – that is, how good is it compared to perfect information.

Optimisation

The Model can be used with the climate information to analyse responses to management practices. However, given the range of management options, this will require a systematic approach to identify optimum management strategies. An exciting and innovative area for potential development is in optimisation. In a parallel project for MLA, working with Brian Kinghorn (UNE) we have demonstrated that differential evolution (DE) techniques can be effectively used with this type of simulation model. (DE is a similar technique to genetic algorithms.) These techniques can be used for both management optimisation and parameter estimation.

Management optimisation

While the management rules in the Model are relatively simple to implement, the range of parameters mean that there are considerable combinations of these parameters that may impact on the model predictions. For example, for rotational grazing we need to explore the stock number, paddock number, target grazing residual, conditions for excluding paddocks for cutting, conditions to actually cut and so on. With a livestock enterprise, decisions may focus on stocking rate, when to sell animals, and other factors such as supplementary feeding. Optimisation techniques allow for a systematic exploration of these parameters to identify the appropriate combination. By working with the range of management options in this way, we will be able conduct effective comparisons between the range of management options available.

In a related project, Johnson and Kinghorn (2002) demonstrated that these techniques could be applied to the SGS Pasture Model. In that study, a simple cash balance model was incorporated in relation to buying and selling ewes, selling lambs and buying supplementary feed. It was primarily a "proof of concept" study aimed at demonstrating that the technique could work. Accordingly, it was assumed that all management decisions were made on one day of the year and that the future climatic conditions for one year were known. The simulation period was 10 years and the optimum stocking rate for each year was estimated. The Model was also run for the same period but with a fixed stocking rate equivalent to the mean value derived from the optimisation analysis. The variable, optimised, stocking rate resulted substantially greater profit over the 10 year period, and demonstrates the potential of accurate forecast information in making management decisions.

Although that project used 12 months known forecast information, it could be readily adapted and developed to work with the climate information described above (actual, mean, forecast), with the forecast information available for any prescribed period.

Parameter estimation

Not all of the parameters in the Model are easy to estimate. For example, there is still discussion as to the actual maintenance energy costs in cows; soils can be very difficult to characterise; organic matter turnover parameters are difficult to measure. While considerable progress can be, and has been, made with our best parameter estimates, it is possible to use the model in conjunction with experimental data to derive some of these parameters.

As an example, Johnson *et al* (2002) used the SGS Pasture Model to estimate soil physical characteristics. With these parameters, the model was able to give very good agreement with measured soil water content, runoff, and pasture dry weight.

Computing requirements

Optimisation requires considerable computer grunt since it needs multiple simulation runs, often in the thousands. The work mentioned here was done for a single paddock on a computer that would now be deemed almost archaic! During our recent visit to Toowoomba for the joint APSRU / DA workshop, we were told of the cluster of computers that that group has, which currently stands at 30 dual processor machines. With that level of power optimisation becomes a realistic option. There is a range of approaches that may include hiring computer time, or leasing a number of computers. I am currently investigating this, but am confident that a cost-effective solution can be found.

Risk

The analyses mentioned so far will not only help identify conditions that indicate the onset of drought, and management strategies that deal with drought, but they can also be used to assess the risks associated with individual management decisions. Indeed, it could be argued that choices between crucial management decisions can only be made if there is some indication of the risk involved.

The Model has the potential to translate climate forecasting knowledge into actual risk in relation to management decisions.

Concluding remarks

I believe there is great potential for effective analysis of pasture systems using the Model. In addition, there is ample experimental data to ensure that the model is giving realistic simulation outputs. In particular, MLA has invested in the SGS National Experiment (NE) and the data is collated in the SGS Database, while DA has recently invested in the Dairy Pasture Growth Rate Database. In New Zealand, researchers in AgResearch are currently working with EcoMod under NZ conditions and are making excellent progress, which includes more detailed assessment of the soil nutrient component of the model than has previously been undertaken.

By working with the Model and available data, I am confident that we can assess the value of climate forecasting data, the risk of drought occurring, management strategies to deal with drought, and effective pasture management strategies in general.