Validating the GRAZPLAN pasture model for native grasslands of the Monaro region

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Abstract

Simulation modelling can provide a simultaneous analysis of the effects of livestock management on pasture composition and productivity, livestock production and its profitability, and a range of natural resource outcomes. Such analyses would be extremely useful in the Monaro region of New South Wales, where ground cover and the persistence of perennial pastures are largely determined by the interacting effects of climatic variability and graziers' livestock management. The GRAZPLAN pasture simulation model has been parameterized for three key genera of perennial native grasses growing in the Monaro (*Poa sieberiana*, *Austrostipa* spp. and *Austrodanthonia* spp.) and tested against two detailed experimental data sets. The model successfully captured the dynamics of grassland composition over both the short- and the long-term. Simulated pasture yield and quality were acceptably accurate (root-mean-square errors for pasture mass were 610 kg/ha at the Bungarby site and 285 kg/ha at Berridale). Local graziers have assessed these validations and long-term simulations of sheep production, and have concluded that the new pasture parameter sets are of sufficient quality to enable the GrassGro decision support tool to be employed in the Monaro region.

Key Words

GRAZPLAN, GrassGro, *Poa sieberiana*, *Austrostipa*, *Austrodanthonia*

Introduction

The GRAZPLAN grassland simulation models (Donnelly et al. 2002; www.csiro.au/grazplan) are used widely to evaluate grazing enterprises across southern Australia that are based on improved pastures. Via their implementation in the GrassGro decision support tool (Moore et al. 1997), the GRAZPLAN models are used by producers and their advisors to understand and manage the consequences of grazing systems management on production, risk and natural resource management outcomes. To use these simulation models in a region, however, the physiological and agronomic characteristics of the main pasture types have to be described as a set of "genotypic parameters". Prior to this study, such parameters were not available for important pasture species of the Monaro region such as *Poa sieberiana* and *Austrostipa* spp. The aim of this work was to derive genotypic parameters for key native grasses of the Monaro region, so as to enable the use of GrassGro by local graziers and their advisors.

Methods

Derivation of genotypic parameters

Genotypic parameters were derived for three functional groups of forage plants: *Poa sieberiana* (henceforth *Poa*), *Austrostipa* spp. and *Austrodanthonia* spp. Knowledge of the physiology of these pasture plants is highly incomplete, and so parameter values had to be derived through a mix of different approaches. Existing, preliminary parameter sets for *Austrodanthonia* and *Austrostipa* were used as starting points, while the *Poa* parameter set was built from scratch. The parameter set for *Austrostipa* was based on that for *Stipa grandis*, a closely-related species of the grasslands of Northern China that has similar morphology. *S. grandis* had been described for the GRAZPLAN pasture model in an earlier collaboration with the Chinese Academy of Agricultural Sciences. Comparative data on relevant attributes of the native perennial grasses were drawn from the literature (Archer and Robinson 1988, Lodge and

Whalley 1983, Robinson and Archer 1988). Particular attention was paid to digestibility dynamics of leaf and stem as the forage quality of these grasslands is known to constrain production. Unpublished data of D. Tanner were used to derive parameters for specific leaf area. Some parameters (e.g. the relationship between digestibility and crude protein content were given generic values that apply to most grasses.

Parameters describing radiation use efficiency and its response to temperature, allocation of assimilate between root and shoot and the re-translocation of dry matter from the root back into the shoot, the rate at which shoot nutritive value declined and the rate of fall of standing dead shoots were calibrated to the experimental data described below. The rate at which standing dead shoots fall was greatly reduced for *Poa*, allowing the model to represent the typical tussock form of *P. sieberiana* in which live shoots are intermingled with previous years' dead shoots. Since both *P. sieberiana* and *Austrostipa* take a tussock form, their availability to grazing livestock was set to a relatively high level by assigning them low values for sward bulk density. Sward bulk density for *Austrodanthonia* was set to a value intermediate between that of the tussock grasses and of improved grasses such as *Phalaris aquatica*.

Testing of genotypic parameters

A set of simulations was carried out that replicated the experimental results over 2004-08 at the two sites of the Monaro Grasslands Research and Demonstration Project (MGRDP; Powells 2007). Each site has 3 experimental treatments, each replicated 3 times: an unfertilized control and two levels of fertilizer application combined with increased stocking rate (Table 1). Experimental plots have been grazed by wethers and dry ewes at different times; stocking rates have been varied to adapt to seasonal conditions and changing fertility. Pasture growth, composition and quality and animal live weights for each treatment were predicted by the GRAZPLAN models.

Table 1 Summary of site attributes and experimental treatments at the two MGRDP sites.

	Bungarby		Berridale	
Soil parent material	Basalt		Granite	
Main perennial grass	*Poa sieberiana*		*Austrostipa spp, Austrodanthonia spp*	
	Topsoil	Subsoil	Topsoil	Subsoil
Depth to base of horizon (mm)	300	1000	300	1000
Bulk density (Mg/m^3)	1.16	1.20	1.45	1.66
Wilting point (m^3/m^3)	0.22	0.37	0.07	0.11
Field capacity (m^3/m^3)	0.35	0.45	0.18	0.20
Saturated hydraulic conductivity (mm/d)	100	10	100	10

“Low” fertilizer+grazing treatment	125 kg/ha gypsum	125 kg/ha super
“High” fertilizer+grazing treatment	125 kg/ha gypsum + 125 kg/ha super	250 kg/ha super + 125 kg/ha gypsum?
2008 treatment stocking rates in control, “low” and “high” treatments (sheep/ha)	3.4, 4.8, 6.0	2.2, 3.5, 4.3

Weather data to drive the validation simulations were taken from automatic weather stations at the sites. Soil attributes required to initialise the model were measured from undisturbed soil cores taken from the A and B horizons at each site (Table 1). Pastures at Berridale were modelled as a five-component mixture (*P. sieberiana*, *Austrostipa* spp., *Austrodanthonia* spp., legume and other broadleaf) and those at Bungarby as a mixture of *P. sieberiana*, *Austrostipa* spp. and legume. The fertilizer and livestock management of the 3 experimental treatments at each site were closely mimicked using the AusFarm modelling software.

Long-term behaviour of the native grassland model

A complementary set of long-term simulations for the Bungarby and Berridale sites was carried out using the GrassGro decision support tool (version 3.1.3). The purpose of these simulations was to examine the behaviour of the model against a wider range of climatic variability than that encountered during the MGRDP experiments. Evaluation of the results necessarily relied on the judgment of local producers and advisory staff. Weather records were extracted for the nearest point in the SILO Data Drill database (www.longpaddock.qld.gov.au/silo). Soil fertility was set to the same levels used for the control treatment in the validation simulations (a “fertility scalar” of 0.65 at Bungarby and 0.55 at Berridale) and a low stocking rate was used (3.5 wethers/ha at Bungarby and 2.5 wethers/ha at Berridale). The simulated pastures were simplified for the long-term runs (Figure 1). A fine-wool medium Merino wether enterprise was simulated (breed standard reference weight 50 kg; average simulated fleece fibre diameter 19 micron). Modelled monthly rates of pasture growth and change in fleece-free weight of sheep, and the time course of pasture composition, were used to evaluate long-term model performance.

Results

Validation simulations

Results of the validation simulations are presented in Figure 1. The general patterns of pasture growth and hence green pasture mass are quite well captured, although spring growth rates are somewhat too high for *Austrostipa* in 2005 and too low for *Poa* in 2005 and 2007. The model successfully captures the large stocks of standing dead herbage in the *Poa* tussocks, especially at Bungarby. Root-mean-square prediction errors for pasture mass were 610 kg/ha at Bungarby and 285 kg/ha at Berridale; these values are consistent with those obtained for other validation studies with the GRAZPLAN pasture model.

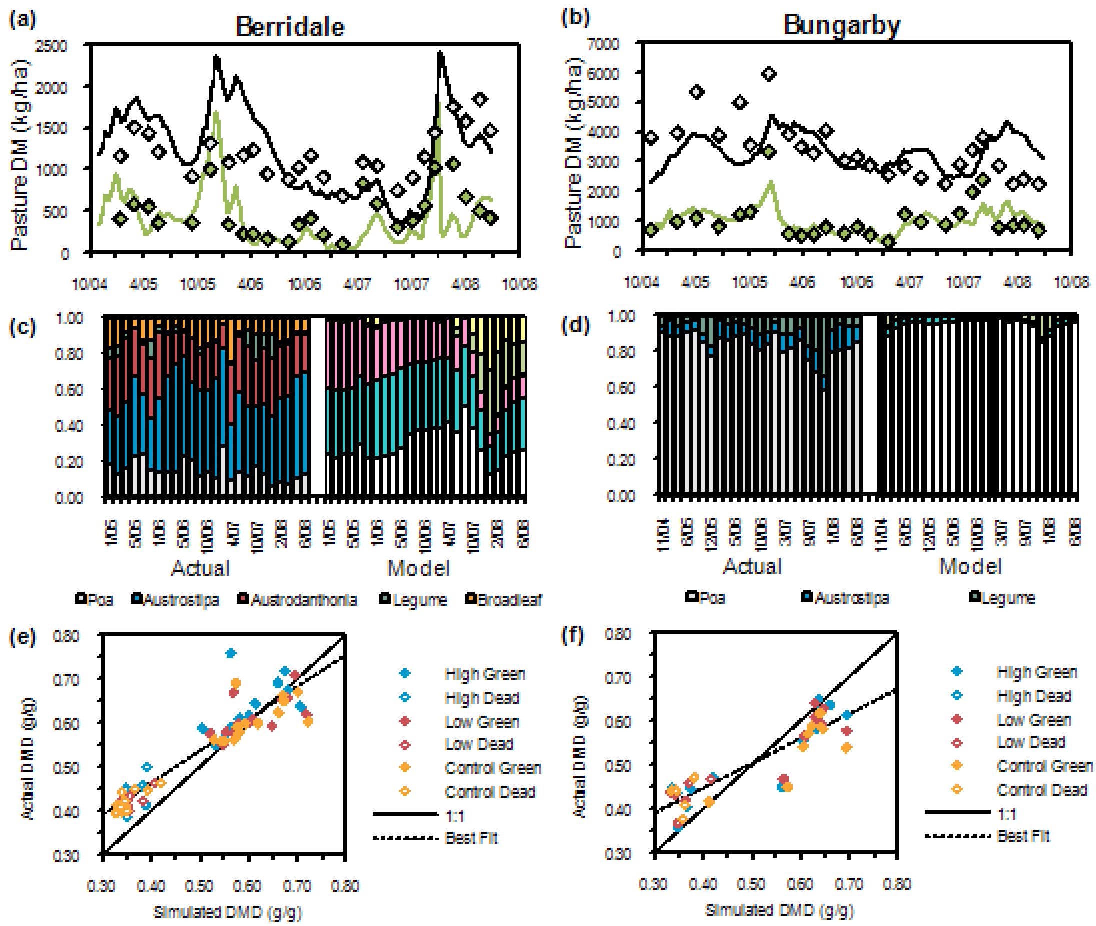

Figure 1. Simulations of (a, b) green and total herbage mass, (c, d) pasture composition and (e, f) pasture digestibility at the MGRDP experimental sites. Only the "low"fertilizer+stocking rate treatment at each site is shown in (a-d). In (a) and (b), symbols show measured data and solid lines the results of the simulations; green lines and symbols denote live pasture mass and grey symbols and black lines show total pasture mass.

Capturing the dynamics of pasture species composition is a very difficult problem, and in this light the predictions of compositional change in Figure 1 are pleasing. The model correctly predicted that there was very little compositional change between the management intensity treatments. An increase in the proportion of annual plants in spring 2007 at both sites was also represented correctly by the model. Predicted DMD values for green pasture (Figure 1(e-f)) were reasonably accurate given the errors inherent in DMD measurement and in matching the measured and modelled herbage pools. Predictions for green *Poa* at Bungarby are better than those for other species and for the whole pasture at Berridale. The model did not, however, capture the increased pasture DMD associated with the fertiliser treatments, and the predicted digestibilities for dead pasture were systematically too low.

Long-term model behaviour

Results from the long-term simulations are presented in Figure 2. A severe limitation to winter growth and highly variable rates of growth at other times of the year can be seen. The simulation at Berridale retains all three perennial grasses over a 39-year simulation, with roughly equal amounts of *Austrostipa* and *Austrodanthonia* and a smaller proportion of *Poa*. Long-term average digestibility of green *Poa* pasture never reaches a high value, with the result that rapid growth by wethers is not seen. Nonetheless, the sheep maintain their weight on average, with relatively infrequent periods of rapid weight loss being balanced by longer periods of modest weight gain (very little supplement was fed in either long-run simulation).

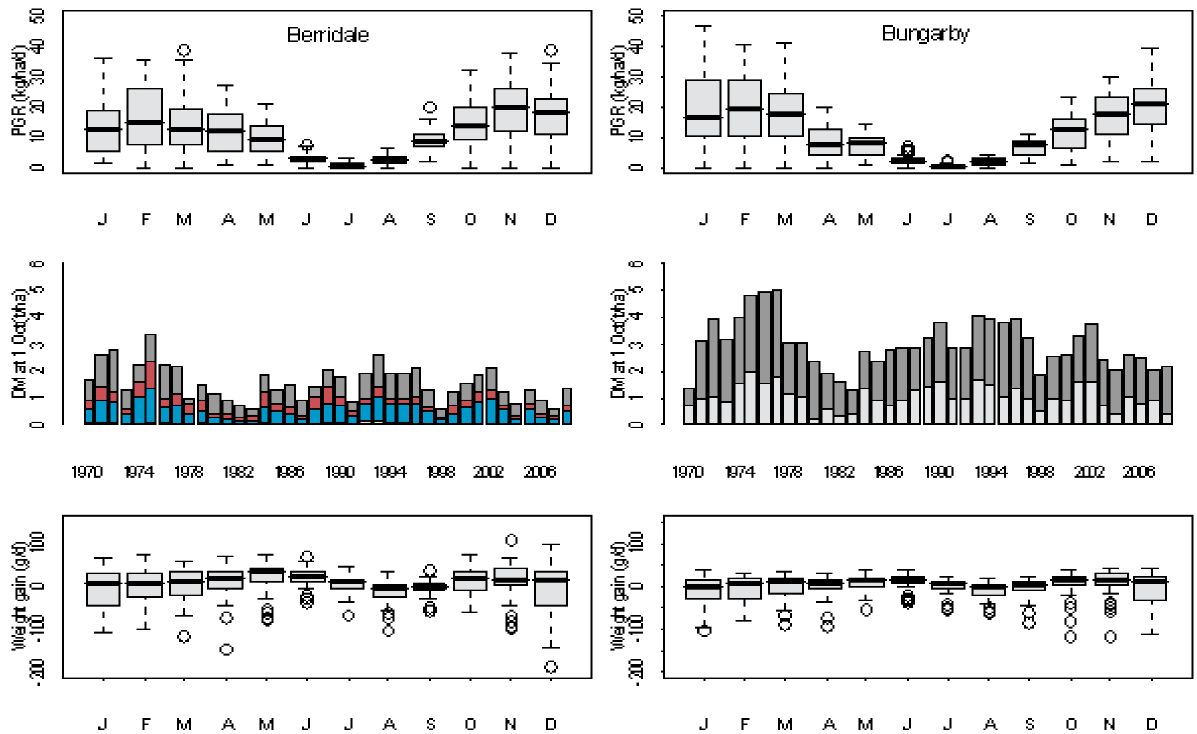

Figure 2. Long-term simulations (1970-2008) at the two MGRDP sites. (a, b) Box plots of monthly average pasture growth rates. (c, d) Box plots of monthly average weight change of wethers.

Conclusion

Land degradation risks and graziers' economic sustainability in the Monaro region of New South Wales are largely determined by the interaction between climatic variability and graziers' livestock management, through their effects on the persistence of perennial plant species and on the level of ground cover. A local producer group has evaluated our modelling work and, as a result, is now enthusiastically adopting GrassGro as a way of better understanding and managing this interaction.

Acknowledgments

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