Using modelling to explore the relationships between predicted long-term stocking rate and sheep intake of pasture and supplement for a native perennial grass-based pasture near Barraba, New South Wales

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Abstract. *The SGS Pasture Model was used to explore the long-term (1906–2004) predicted relationship between stocking rate and sheep intake for a native pasture in northern New South Wales. Increasing stocking rate from 2 to 3 wethers/ha increased predicted mean annual supplement intake from 0.05 to 0.25 t DM/ha, while increases from 4 to 8 wethers/ha increased predicted mean annual supplement intake from 0.56 to 2.0 t DM/ha. This reflected a decline in the percentage of total intake provided by the native pasture from a mean of 93 per cent at 2 wethers/ha, to 59 per cent at 4 wethers/ha and 23 per cent at 8 wethers/ha. With monthly adjustment of wether numbers to achieve a target residual pasture herbage mass of 1 tonne DM/ha, the mean annual stocking rate was 3.1 wethers/ha and negligible (0.02 t/ha) supplement was required. These analyses indicated that the mean annual long-term stocking rate of a continuously grazed native pasture would be less than 3 wethers/ha, which is lower than that obtained from grazing studies (1970s–1990s) and an on-farm survey taken when annual rainfall was substantially above the long-term average. Varying stocking rate on a monthly basis resulted in 40 per cent greater pasture utilisation with substantially less supplement required, indicating that simple variable stocking rate strategies may be of considerable long-term benefit.*

Introduction

Grasslands dominated by summer-growing, native perennial grasses occupy more than 44 per cent of the Namoi Catchment in northern New South Wales (NSW) (Bureau of Rural Sciences 2003). The characteristics of the major native grasses dictate their productive use; being frost susceptible they produce little green growth in winter-early spring and with generally low levels of metabolisable energy (ME), crude protein and digestibility (Lodge and Whalley 1983), they are generally not suited to livestock enterprises that involve fattening or breeding.

Up until the mid-1980s the most common use of these native pastures was grazing by wethers for wool production. However, since that time there has been a trend towards increasing numbers of cattle and a marked decline in sheep numbers, with few producers now grazing only wethers. Relatively short-term (3–5 years duration) grazing experiments on the North-West Slopes of NSW (Lodge and Roberts 1979; Lodge and Whalley 1985; Lodge *et al.* 2003a, 2003b) indicated potential stocking rates for unfertilised native pastures of 3–5 dry sheep equivalents (DSE) per ha, depending on seasonal conditions. In 1986, a survey of district properties indicated actual stocking rates of 1–5 DSE/ha on native pastures, with the average being 3.5 DSE/ha (Lodge *et al.* 1991). However, these stocking rates may not apply in the long-term since climate variability is a feature of the region.

An analysis of annual weather records (1882–2004, Clewett *et al.* 2003) for Barraba (Lodge and Johnson 2007) indicated that although the mean annual rainfall was 692 mm it ranged from 326 to 1174 mm/year and was on average 99 mm higher in the second half of the last century compared with the first half. Lodge and Johnson (2007) also used the capability of the SGS Pasture Model (Johnson *et al.* 2003) to predict total annual pasture intake (t dry matter (DM)/ha/year) of sheep grazing native pasture and to partition intake into the amount supplied by the pasture and the amount that would need to be supplemented to maintain daily ME requirements. In the current paper, we have extended this analysis to examine the long-term (99-year) relationship between annual stocking rate and intake from a native pasture and supplementary feed. We have also used variable stocking rates to estimate the long-term carrying capacity of the unfertilised native pasture described by Lodge *et al.* (2003a).

Methods

The site on which the simulations were based was at 'Springmount' (30º 34'S; 150º 38'E; 510 m above sea level) 20 km south-east of Barraba on the North-West Slopes of NSW, and was part of the Sustainable Grazing Systems (SGS) 'National Experiment'. Modelling was undertaken using the SGS Pasture Model (Johnson *et* *al.* 2003), parameterised for soil characteristics, pasture and sheep production using experimental data from 1998–2001 (Lodge *et al.* 2003a). The site, on a Red Chromosol soil (Isbell 1996), was dominated by both C4 (summer growing) and C3 (year-long green) perennial native grasses, with few legumes and forbs present.

For the simulations described, daily changes in pasture growth/quality, animal productivity and soil water content (mm of water to a depth of 2.1 m) were modelled for an unfertilised, C4/C3 native pasture. All simulations were for a 100 ha area, and were for the 99-year period from 1 January 1906 to 31 December 2004, with the pasture being grazed to a residual herbage mass level of 1.0 t DM/ha. Wethers were assumed to have a normal mature liveweight of 50 kg and were provided with supplement feed if their ME intake declined to <60% of their daily requirement. In the model, supplement was taken to be any other feed source, including pastures, forages or feed mixes that provided the required amount of ME. Long term (1900–2004) daily interpolated weather data for the site latitude/longitude coordinates were abstracted from the SILO Data Drill (Jeffery *et al.* 2001).

Two different simulation strategies were used. Firstly, to establish the predicted relationship between stocking rate (wethers/ha) and mean intake from pasture and supplement (t DM/ha/year), simulations were run for continuous stocking rates of 2, 3, 4, 6 and 8 wethers/ha. Secondly, to determine the predicted mean long-term carrying capacity of the native pasture being modelled, wether numbers were periodically adjusted to achieve a target residual herbage mass of 1.0 t DM/ha. Mean annual predicted pasture and supplement intakes were calculated. Using this approach, wether numbers were adjusted every 30 (monthly) or 90 (seasonally) days, or annually.

Results and discussion

At a continuous stocking rate of 2 wethers/ha, mean total intake over the 99-year period was predicted to be 0.74 t DM/ha/year or approximately 1 kg DM/head/day. As stocking rate increased to 8 wethers continuously grazed, per hectare mean total intake was predicted to be 2.60 t DM/ha/year (approximately 0.9 kg DM/head/day).

Increasing the continuous grazed stocking rate from 2 to 4 wethers/ha increased predicted mean annual pasture intake from 0.69 to 0.82 t DM/ha (Figure 1), but as stocking rate increased to 8 wethers/ha predicted mean annual pasture intake declined to 0.60 t DM/ha. However these effects on pasture intake were small compared with the effect of increasing stocking rate on the amount of supplement that needed to be provided (Figure 1). As stocking rate increased from

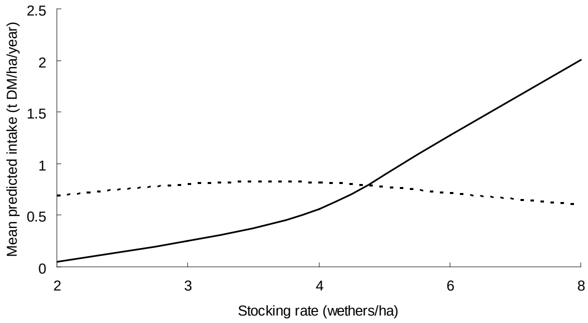

Figure 1. Predicted mean annual intake (t DM/ha/year) from native pasture (broken line) and supplement (solid line) over a 99-year period (1906–2004) at stocking rates of 2, 3, 4, 6 and 8 continuously grazed wethers/ha.

2 to 3 wethers/ha, predicted mean annual supplement intake increased from 0.05 to 0.25 t DM/ha (Figure 1); increasing from 4 to 8 wethers/ha increased predicted mean annual supplement intake from 0.56 to 2.0 t DM/ha. This represented a decline in the percentage of total intake provided by the pasture from a mean of 93% at 2 wethers/ha, to 59% at 4 wethers/ha and 23% at 8 wethers/ha.

The effects of varying stocking rate using monthly, seasonal or annual adjustments to wether numbers are shown in Table 1. As the length of the adjustment period increased, predicted mean annual stocking rate and intake of supplement increased, while predicted mean annual intake of pasture tended to decline. With monthly adjustment of wether numbers the mean annual stocking rate was 3.1 wethers/ha, ranging from zero in 1919, 1940 and 1946 to 7.7 wethers/ha in 1984. At a mean annual stocking rate of 3.1 wethers/ha predicted mean annual intake of pasture and supplement was 0.80 and 0.02 t DM/ha, respectively. In comparison, grazing at a continuous stocking rate of 3 wethers/ha had a similar predicted annual pasture intake of 0.80 t DM/ha, but a supplementary feeding requirement of 0.25

Table 1. Predicted mean annual stocking rate (wethers/ha) and intake of pasture and supplement (t DM/ha/year) when wether numbers were adjusted monthly, seasonally or annually to maintain a residual pasture herbage mass of 1.0 t DM/ha

Variable	Wether numbers adjusted		
	Monthly	Seasonally	Annually
Mean annual stocking rate (wethers/ha)	3.1	3.2	4.6
Mean intake of pasture (t DM/ha/year)	1.12	1.04	0.79
Mean intake of supplement (t DM/ha/year)	0.02	0.17	0.75

t/ha. Interestingly, even when the continuous stocking rate was as low as 2 wethers/ha there was still a mean annual predicted supplement requirement of 0.05 t/ha.

These analyses indicated that the mean annual long-term stocking rate of a continuously grazed native pasture, similar to that of the site used in the parameterisation, would be less than 3 wethers/ha. This rate is less than that expected from reported short-term grazing studies and an on-farm survey conducted in the 1980s (3–5 DSE/ha), but these latter values were obtained when annual rainfall was substantially above the long-term average. However, if stocking rates are adjusted monthly or seasonally in relation to available pasture, predicted pasture utilisation increased and supplementary feed requirements declined. These time-frames for adjusting stocking rate are feasible in practice and indicate that simple variable stocking rate strategies may be of considerable long-term benefit.

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