Long-term annual rainfall and the distribution of simulated annual pasture intake of ewes grazing different pastures on the North-West Slopes of New South Wales

G. M. Lodge and L. H. McCormick

Industry & Investment NSW, Primary Industries,
Tamworth Agricultural Institute, 4 Marsden Park Road, Calala NSW 2340
greg.lodge@industry.nsw.gov.au

Abstract: *Historical daily climate data (1906–2005) were used to examine the long-term performance of fertilised native pasture, fertilised native pasture oversown with subterranean clover, and lucerne by examining the percentile distribution of annual rainfall in relation to the proportion of total sheep intake provided by the pasture. Overall, mean predicted intake provided by lucerne pasture was only 47% of total intake, while for a fertilised native pasture it was 61%, and for a fertilised native pasture oversown with subterranean clover it was 73%.*

Introduction

Resilience of sown pasture species and their ability to adapt and respond to a variable climate are important features for their long-term productivity and persistence, particularly with the climate change scenarios (Lodge *et al.* 2009) forecast for northern New South Wales (NSW). One way of examining the 'fit' between climate variations and species response is to use simulation models to examine the ability of pastures to provide animal intake (Lodge & Johnson 2007) using long-term, historical climate data (Lodge *et al.* 2009).

In this paper, the relationship between total annual rainfall and simulated percent pasture intake was examined for three pasture types, by plotting the percentile distribution of each year for a 100-year period (1906–2005). The hypotheses being examined were that: (1) total annual rainfall distribution and the distribution of the predicted intake provided by the pasture would be correlated, and (2) the predicted intakes provided by different pasture types would have markedly different distributions.

Methods

The SGS Pasture Model (Johnson *et al.* 2003; version 4.8.6) and interpolated daily climate data from the SILO Data Drill (Jeffery *et al.* 2001) for Gowrie, located 20 km south-west of Tamworth, NSW (31°16'S 150°52'E; elevation 490 m a.s.l.) were used to simulate daily intake for Merino ewes and lambs. All simulations were for a 400 ha area, subdivided into four paddocks (each 100 ha) and rotationally grazed (on fixed time rotation with 14 days grazing and 42 days rest) at a stocking rate of 3.75 ewes/ha. All pastures were grazed to a residual herbage mass of 1 tonne of dry matter (t DM)/ha. Model parameterisation was as described by Johnson *et al.* (2003) and predicted annual animal intake (t DM/ha) of both pasture and supplementary feed was expressed as a proportion (%) of total intake.

The pastures modelled were: a fertilised native perennial grass pasture with C_3 and C_4 species; the same pasture oversown with subterranean clover (*Trifolium subterraneum*), and a fertilised lucerne (*Medicago sativa*) pasture. Fertiliser (phosphorus, potassium and sulfur) was applied at rates sufficient to maintain the soil nutrient status above a growth limiting factor of 0.75. In the model simulations, ewes were supplementary fed if their daily milk production was <95% of potential or the pasture provided <90% of their daily metabolisable energy (ME) requirement. Supplementary feed was taken to be any feed source (e.g. pastures, forages or feed mixes) that provided the required amount of ME. Simulations were from 1 January 1901, with the 100-year period, 1 January 1906–31

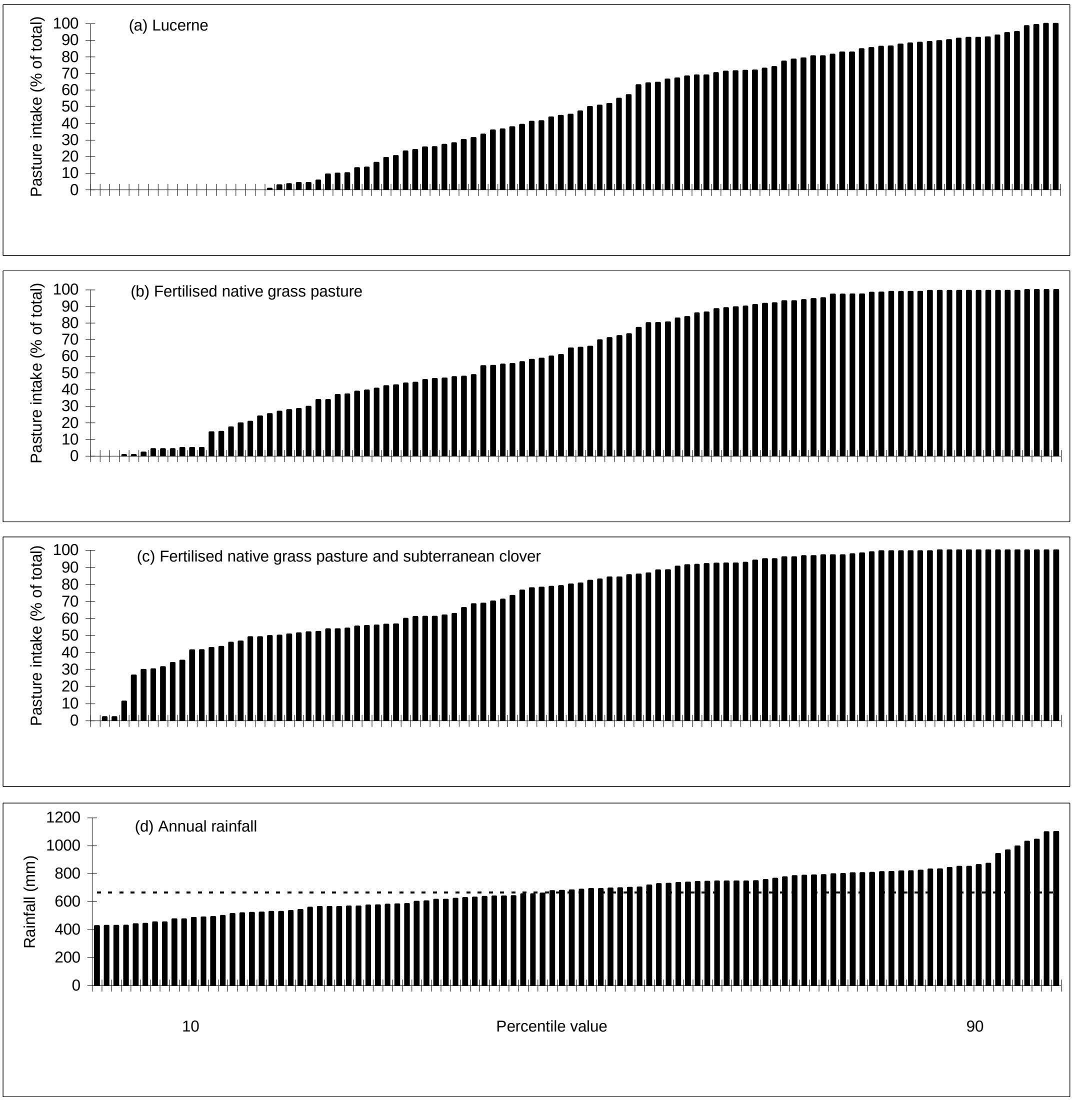

Figure 1. Distribution of percentile values (0–100) for predicted pasture intake (expressed as a percentage of total intake) for pastures of (*a*) lucerne, (*b*) fertilised native perennial grasses, and (*c*) fertilised native perennial grasses oversown with subterranean clover, together with (*d*) the distribution of annual rainfall (mm) and the mean (dotted line) for the period 1906–2005 at Gowrie, NSW.

December 2005, being of interest and the preceding 5 years allowing nutrient cycling to stabilise.

Results and discussion

Mean annual rainfall at Gowrie (1906–2005) was 667 mm (Fig. 1*d*) and as reported by Lodge and McCormick (2010) for other centres on the North-West Slopes of NSW, rainfall for 1900–99 was lower in the first 50 years of the last century compared with the second 50 years (618 *v.*711 mm). Inter-annual rainfall variation was also high (Lodge & Brennan 2008; Lodge & McCormick 2010), with 40% of years having 50 mm more rainfall than the mean and 40% having 50 mm less rainfall than the mean.

The relationship between total annual rainfall and predicted pasture intake, expressed as a proportion of total intake, was positively correlated and significant (*P* =0.05) for each of the pasture types examined. While these data were correlated, the relationship was not strong (*r*-values <0.57), but this was not unexpected since total annual rainfall does not reflect the distribution of rainfall events throughout the year. The exact nature of the relationship between annual rainfall and pasture intake was variable. For example, all of the years in which the fertilised native pasture (with or without subterranean clover) did not provide any predicted intake, were the lower rainfall years (i.e. those years <10th percentile for annual rainfall). However, in the 18 years that predicted intake from the lucerne pasture was zero, only one occurred in the <10th percentile rainfall years and 15 were in rainfall years between the 10th and 50th percentile. Similarly, in the wetter years (i.e. those years with >80th percentile for total annual rainfall), predicted pasture intake values were generally greater than the 60th percentile, but the lowest predicted pasture intake values corresponded to the 16th, 16th and 18th percentile values for the fertilised native pasture, fertilised native pasture oversown with subterranean clover and lucerne pasture, respectively.

The three pasture types had markedly different distributions for the proportion of the total predicted intake (Fig. 1*a*-*c*). This was related to the different growth habits of the species in each pasture, *viz*, a perennial species monoculture (lucerne), a mixture of perennial species with different growth habits (native pasture with C_3 and C_4 grass species) or a mixture of perennial and annual species (native pasture with subterranean clover). Also, of interest was the relationship between the distributions for each pasture type (Fig. 1*a*-*c*) and the distribution for total annual rainfall (Fig. 1*d*), although some caution is required in interpreting these patterns, since summing daily values can mask important seasonal differences that occur throughout a year.

Overall, mean predicted intake provided by the lucerne pasture was only 47% of total intake (Fig. 1*a*), while for the fertilised native pasture it was 61% (Fig. 1*b*), and for the fertilised native pasture oversown with subterranean clover it was 73% (Fig. 1*c*). The corresponding median values were 46, 65 and 80%, respectively. The lucerne pasture provided >80% of the total intake in 25% of years, compared with 42% of years for the fertilised native pasture and 50% of years for the fertilised native pasture oversown with subterranean clover (Fig. 1*a*-*c*). In the lowest 25% of rainfall years, lucerne pastures contributed least (<10% of total intake), compared with <34% and <53% of total intake in the fertilised native and oversown native pastures, respectively.

The pasture that best met the predicted intake requirements of Merino ewes rotationally grazing at 3.75 head/ha over a 100-year period of variable climate (Fig. 1) was the fertilised native pasture containing a mixture of C_3 and C_4 perennial native grasses, oversown with the winter-growing annual legume, subterranean clover. With a variable climate, this broad mix of seasonal growth habits and perennial and annual species probably allowed different environmental niches to be exploited in different years.

The lucerne monoculture least met predicted animal intake requirements, although lucerne is reputed to be a productive perennial legume in this environment. Its poor predicted performance was associated with a high proportion of years of below average rainfall (50 years in the 100-year record) and a high proportion of very dry years, with rainfall in over 30% of all years being more than 100 mm below average annual rainfall. Although lucerne is relatively drought tolerant because of its deep root system, most of these dry years tended to occur consecutively, exacerbating effects on soil moisture, as also shown by Lodge & Johnson (2008). Also, the soil profile depth in the model was restricted to 2 m, potentially underestimating water uptake by deep rooted species. However, most soils in the region may have restricted root depth because of either shallow bedrock or high bulk density in the B horizon (e.g. Lodge *et al.* 2010). Also, it is acknowledged that these simulations were at a conservative stocking rate (<8 dry sheep equivalents/ha) for fertilised pastures, but this rate was determined by a local producer focus group (McCormick *et al.* 2009) and so was relevant to on-farm practices.

The next phase of these investigations will involve simulations that represent the situation on 'real farms', where a range of different pasture types and forages are often grown to take advantage of climate variability in good seasons and minimise its impact in poor seasons. However, previous modelling (e.g. Lodge & Johnson 2008) and preliminary simulations of farms with multiple paddocks and pastures/forages have indicated that in dry years and seasons, which unfortunately occur with regular frequency on the North-West Slopes of NSW, some supplementation will be needed to maintain required ME intake, even at relatively low stocking rates.

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