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RUMEN ECOLOGY DRIVING PRODUCTIVITY AND LANDSCAPE ECOLOGY IN THE SHRUBLANDS OF THE WEST AUSTRALIAN RANGELANDS

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ABSTRACT
The halophytic shrubs of the West Australian (WA) semi-arid shrublands provide the microbes in the rumen of livestock with a relatively constant source of salt and rumen degradable nitrogen (RDN), but the supply of digestible organic matter (DOM) is often low. When the salt content of the drinking water is also high, the dietary preference of livestock is likely to be driven towards plant species with low salt content and adequate DOM. Perennial grasses are an important component of these species in shrublands as they can improve livestock productivity, especially in dry seasons. This dietary preference has important implications for livestock management when these species are in short supply. After decades of continuous and sometimes high grazing pressure, the perennial grasses of the WA shrublands are now restricted to protected niches under shrubs and fallen branches. The task of regenerating sustainable livestock production may require changes to grazing management that will regenerate and maintain perennial grasses. Kangaroos must also be controlled, as de-stocking alone has been found to lead to a six-fold increase in kangaroo numbers.

INTRODUCTION
Understanding the principles of ruminant nutrition is essential for designing sustainable production systems in shrublands. The WA shrublands have a highly variable climate. The annual rainfall is 200-250mm with winter rain generating most of the forage. The region has many halophytic shrubs such as the *Atriplex* and *Maireana* species, and seasonally driven perennial and annual grasses and forbs (Watson 2003). The challenge to achieve good growth and lactation from livestock is to ensure good rumen function by providing the microbes in the rumen with an appropriate balance of RDN, DOM and other essential nutrients (Standing Committee of Agriculture 1990). The salts from the halophytic shrubs are likely to reduce the amount of food eaten (Masters *et al.* 2005). Thus it is important to provide adequate DOM of low salt content to dilute the salt and complement the high RDN in halophytes.

HISTORICAL CONTEXT OF THE WA SHRUBLAND ECOLOGY
Prior to European settlement about one hundred years ago, kangaroo populations in the region were much lower than today (Watson 2003) as a result of few permanent water points and predation by dingoes. Prior to settlement, in prolonged dry seasons, the kangaroo population probably declined to numbers that could survive around the limited permanent water. With the return to good seasons, plants would have ample time to grow and set seed before kangaroo numbers built up. Under this grazing regime the perennial grasses and other low-salt species would not have developed an ability to tolerate heavy and continuous grazing.

Pastoralism brought multiple stock water points to the region, constructed on shallow sources of ground water with varying concentrations of salt. The pastoral community in the region often reminisce about the large numbers of stock that were carried on stations during good seasons over 70 years ago (Watson 2003). It is likely that this pastoral system reduced the population of low salt, high DOM (LSDOM) species. The numbers of domestic stock would build up in good seasons and during poor seasons there would be heavy and continuous grazing of the LSDOM plant species. During this era, the absence of modern road transport meant that de-stocking in dry seasons was difficult and there has always been a strong temptation for pastoralists to postpone de-stocking in the hope that it would rain.

These circumstances would have set a lethal 'death trap' for perennial grasses (Hodgkinson 1995) and possibly other LSDOM species. Loss of perennial grass cover has also occurred as a result of pastoralism in semi-arid woodlands of eastern Australia (Freudenberger *et al.* 1999) and in arid shrublands of New Mexico (Gibbens *et al.* 2005). Perennial grasses are important for livestock production in rangelands, particularly for sheep in dry years, as they are a valuable source of highly digestible green leaf (Freudenberger *et al.* 1999). The present vegetative cover on exclosures constructed during the 1970s in the WA shrublands, provides evidence that perennial grasses and other LSDOM species could support the large numbers of stock in the past. It is clear that we need to develop a suite of management practices to enable the previous productive capacity to be restored, while at the same time maintaining profitable pastoral enterprises.

CHALLENGES FOR MANAGEMENT OF THE WA SHRUBLANDS

In shrubland environments, the rewards for providing livestock with a diet balanced in RDN, DOM and salts have important implications for pastoral businesses and natural resource management. In grass dominant pastures, the limiting factor for livestock production is often RDN. Rumen microbes are capable of synthesising protein from non-protein RDN. This enables producers in the grasslands of northern Australian to use urea as a source of RDN to balance the adequate supply of DOM. Coincidentally salt is often used to limit the intake of urea. The opposite scenario prevails in the shrublands where DOM is often limiting (Lefroy 2002). Halophyte shrubs, of high RDN content, can act as a 'standing urea lick'. Providing a diet balanced with DOM poses major challenges for both livestock productivity and land management practices in semi-arid shrublands. DOM is expensive to import and because shrub vegetation is high in RDN and salt but low in DOM, grazing pressure is directed strongly to the LSDOM plant species. Sheep production is severely depressed when halophytic shrubs make up more than 25-30% of the total diet since they are unlikely to be able to consume enough DOM to grow or lactate (Masters *et al.* 2005). The resultant diet preference towards LSDOM species, played out over decades of pastoralism, may have driven the demise of these species in the region. The loss of perennial grasses alone could largely explain the reductions in carrying capacity. This loss or reduction in the number of LSDOM species has probably also contributed to soil erosion in the region (Pringle *et al.* in press).

Since importing DOM as grain or hay is usually uneconomic, management practices to restore the LSDOM species need to be introduced. Some of these practices include carrying less stock, and/or introducing paddock rests and adjusting stock numbers according to feed on offer. Ensuring that stock numbers remain within carrying capacity avoids three important issues: production losses, animal welfare issues associated with starvation and overgrazing of perennial grasses and the LSDOM species. The management challenge to keep stock numbers within carrying capacity is exacerbated by the highly variable climate of the region (Watson 2003). There is a need to avoid overgrazing the relatively low populations of perennial grasses in the shrublands, especially when they are recovering after rainfall. At low stocking rates (10-20 ha per sheep), the patch grazing habits of stock needs to be managed. The mobile population of kangaroos poses yet another challenge. Norbury and Norbury (1993) showed that when sheep were removed, the number of kangaroos increased six-fold in the paddock. The need to control kangaroos must be addressed by pastoralists and governments, if sustainable pastoralism is to be achieved.

STRATEGIES TO REGENERATE PRODUCTIVE CAPACITY

The recent large-scale installation of self-mustering yards on water points throughout the region enables timely and cost-effective de-stocking of domestic animals and feral goats when there is no surface water. In response to requests from pastoralists during recent dry seasons, the Department of Agriculture and Food WA, financially supported by Commonwealth and industry funding bodies, has commenced working with pastoralists to develop methods to manage climate risk and to regenerate the productive capacity of the region. These methods include the introduction of rotational grazing, assessing food on offer (FOO) and adjusting stock numbers accordingly to achieve targeted body condition scores (Oldham *et al.* 2005) and rangeland regeneration objectives. In the short term, Merino sheep and cattle generally lose body condition before they damage range condition. Thus good livestock production, at least in part, reflects good range condition. Conversely, WA 'rangeland goats' have achieved 130% kidding rates at stocking rates that damaged the rangeland (Fletcher 1991). Little is known about the grazing impact of the recently introduced Damara sheep breed, but anecdotal evidence suggests they graze like goats. The fat reserves in their tails may enable them to continue grazing when FOO is low, thus applying extreme pressure to LSDOM plants. Alternatively, because goats and possibly Damaras are browsers, they may be useful for taking the pressure off regenerating grasses and other LSDOM plants. This subject is worthy of investigation.

On most management units there are remnant seed banks of perennial grass species where they are protected by shrub canopies and fallen branches. *Stipa elegantissima* is a noteworthy species as it is highly productive, palatable and it has the favourable attribute of wind borne seed panicles. It still exists on most land systems in the WA shrublands through a nurse-plant relationship with shrubs (Armas and Pugnaire 2005). The good rains received over most of the region in 2006 have produced widespread germinations of perennial grass and LSDOM species. The challenge is to manage future grazing pressures to optimise the establishment and survival of these species and regenerate carrying capacities.

The challenge of achieving effective regeneration poses important questions for pastoralists, researchers and policy makers. At what point is de-stocking necessary to avoid excessive grazing of the regenerating grass and LSDOM species? Can goats and Damara sheep be used to take grazing pressure off grasses? Can surface water be harvested to dilute the dietary salt load from halophytes and ground water? At low stocking rates can patch grazing be alleviated? What resting regimes and grazing management systems are required to allow perennial grass species to germinate, establish and then survive through dry seasons? Will regeneration of grasses and other LSDOM species improve biodiversity? What methods can be developed to ensure kangaroo numbers do not jeopardise rangeland regeneration? What rate of rangeland regeneration is commercially viable and/or what financial support is required to encourage this endeavour? The answers to these questions have important implications for sustainable management of shrubland communities in the rangelands across Australia and other continents.

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