18. Sheep Production in Semi-arid Rangelands

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Learning objectives

On completion of this topic you should be able to:

- describe the diverse nature of the rangelands utilised for sheep production
- analyse and discuss the impact of grazing pressure on botanical stability of rangeland communities
- justify the need to manage the total grazing pressure exerted by sheep and other competing herbivores within the rangelands environment
- explain the importance of maintaining the botanical stability of specific rangelands communities and the role of various management tools
- describe the differences that exist between various rangelands communities in their response to grazing pressure and other systems of manipulating botanical composition

Key terms and concepts

Major ecological influences operating in the rangelands include:

- irregular rainfall causes sporadic germination and growth (episodic summer or winter patterns)
- species composition changes markedly with the amount and intensity of rainfall, grazing numbers, animal species, and season
- long-lived species are often the main elements of stability; that is, perennial grasses
- plant growth is determined by the availability of water and nutrients;
- water is sparse and unevenly distributed
- fertility is low, yet there are important areas where nutrients are concentrated.

Introduction to the topic

Arid and semi-arid regions may be defined as areas where rainfall, relative to the level of evapo-transpiration, is inadequate to sustain reliable crop production (Meigs, 1953). Rainfall in these areas is generally low and/or erratic. Vegetation consists of grasslands, shrub lands, savanna or woodlands, but can also be covered by desert.

Kassas (1975) estimated that 43% of the world's surface is arid and Harrington (1981) suggested that 40% of the world's population of sheep, 30% of goats and 25% of cattle are found in the arid zone. Australian arid and semi-arid lands are remote, sparsely populated inland areas, defined by desert vegetation and landforms. The arid and semi-arid lands are the predominant form of rangelands and spread across about 70% of Australia, varying from under 60% of New South Wales, 85% of South and Western Australia, most of Queensland and all of the Northern Territory.

Rangelands are semi-natural ecosystems in which woolgrowers seek to obtain a productive output by simply adding sheep to a natural plant community in which native animal populations, although modified, intermingle with sheep. Management is therefore predominantly ecological in nature, of a low energy input and involves actions that seek to modify, rather than control, the natural forces operating on the system. Climatic forces exert a greater influence on productivity compared to management.

Rainfall in these zones ranges from about 250mm in the south, up to 800 mm in the north and about 500 mm in the east**.** They are divided into winter dominant (NSW and Victoria) and summer dominant rainfall areas, separated roughly along a line from Taree, Coonamble, Brewarrina, Hungerford, Thargomindah, Birdsville, NT/SA border and west through Exmouth WA. Only 16% of annual rain falls in winter at Julia Creek in Queensland compared with 53% for Cobar in New South Wales. Rainfall variability is also a characteristic of the semi-arid regions. For example, the coefficient of variation of rainfall in Longreach is 45%.

Climate change projections indicate a warming trend across Australia (Whetton, 2001). The projection for the semi-arid rangelands is for an increase of 2ºC by 2030 and 6ºC by 2070 compared with 1990. The outcome will be higher evaporation and a decline in water balance.

Selection of stocking rate is the most important rangeland management decision for the sheep enterprise. Managers can maintain or improve the condition of pastures by adjusting stocking rates at critical times although other remedies such as fire, or mechanical disturbance, may be available. The appropriateness of various management strategies depends on the rangeland community to be managed. This requires a specific knowledge of the species to be managed.

18.1 Types of rangeland and communities

The rangelands are broken up according to physical features such as soil type and climate, which in turn controls the vegetation classes by which the zones are named. The most productive areas are generally along rivers and drainage lines. Perennial species are aggressive, palatable, and constitute a desirable pasture climax. They not only provide a reliable source of good nutrition, but also help prevent land erosion and degradation. Conservative stocking rates generally promote perennial pastures.

The following discussion broadly describes the major vegetation types found in Australian rangelands.

Mitchell grasslands

The open tussock Mitchell grasslands cover approximately 320 000 km^2, being mainly distributed between the 250 and 550 mm annual rainfall isohyets where summer rainfall is dominant (Figure 18.1). It is dominated by Mitchell grass (*Astrebla spp*.), a perennial grass species, with a mixture of other annual and perennial plant species, both grasses and forbs (small non-woody annual plants of forage herbs). The period of most reliable rainfall in these regions coincides with highest temperature and evaporation, such that plant growth is strongly regulated by the incidence of rainfall. The overriding feature of the rainfall is high variability.

Mitchell grasslands constitute an important grazing resource for the pastoral industries of Western Queensland, Northern NSW and the Northern Territory. They colonise fertile grey cracking clay soils and have a high livestock carrying capacity compared to other pasture lands of comparable rainfall and are the most resilient of the Australian rangeland pastures. Management is directed primarily to improvement of animal production by attention to drought management, nutrition and alleviation of heat stress.

As well as Mitchell grass, Flinders Grass, Kangaroo Grass, Neverfail, Queensland Bluegrass, and Coolah grass are common. Highly palatable annual grasses and forbs appear after rain and can constitute up to 70% of the diet of livestock in season.

Semi-arid woodlands

The semi-arid woodlands are characterised by open woodlands of medium-sized or small trees, with a secondary shrub layer and a lower layer of perennial and annual grasses and forbs. Soils are typically loamy well drained red sodosols of low fertility and high in iron and aluminium. The tree layer is generally dominated by Poplar Box (*Eucalyptus populnea*), Mulga (*Acacia aneura*) or a Belah (*Casuarina cristata*) and Rosewood (*Heterodendrum oleifolium*) association. These woodlands lie between the 150 and 450 mm annual rainfall isohyets of eastern Australia, covering around 500 000 km^2 (Figure 18.2). Rainfall is extremely unreliable. Prior to pastoral use, fire contributed to maintaining the ecological balance. But the suppression of fire by pastoralists and the low resiliency of the grasses to grazing have generally left these woodlands in a degraded condition, being characterised by a high biomass of woody shrubs and trees and a sparsely covered soil surface.

Queensland's semi arid Mulga woodlands are spread from Morven to Quilpie and Augathella to Dirranbandi and achieve densities of up to 2000 stems/ha in the east. Mulga is used as a stock fodder tree in drought and like most Acacias can regenerate to its original dense stands of mature trees in about a 16 year cycle. It is dominated by spear and wire grasses *Aristida* and *Stipa* spp, and desirables like Mulga Oats and Mulga Mitchell grass.

In the Poplar Box woodlands, typical pasture species include Wiregrass, Woolybutt, Mulga Oats, Greybeard grass and Wallaby grass. Undesirable species such as Speargrass and Daisies are common in some areas while Crowsfoot and naturalized medics are desirable short lived plants that appear after cool season rain.

The Belah-Rosewood communities support desirable pasture species such as Speargrass, Bottlewashers and Copperburrs such as Spearfruit and Gray Copperburr.

Chenopod shrublands

The chenopod shrublands are restricted to the semi-arid areas of southern Australia, covering around 500 000 km^2 (Figure 18.3). The soils are frequently treeless heavy cracking fertile clays. They are dominated by low shrubs, mainly Saltbush (*Atriplex spp*.) and Bluebush (*Maireana spp*.) species, with a diverse understory of annual plant species. Commonly occurring grasses include White-top in winter rainfall areas and Mitchell grass in the summer rainfall areas. Other grasses and forbs (including Copperburrs and Poverty Bushes) grow between the Saltbushes and Bluebushes.

Summer rainfall may constitute up to 50% of the annual total, but the winter rainfall is the most effective and reliable for pastoral use. Compared to other rangeland types, the chenopod shrublands are ecologically simple systems due to the absence of trees and the minor involvement of fire as a disturbance force. But while recognised as being some of the most productive rangelands, they are still subject to degradation. This country is renowned for being highly productive for sheep, and for producing wool with low grass seed burden.

Mallee rangelands

The distribution of mallee rangelands covers around 300 000 km^2 across southern Australia, usually in winter rainfall areas. They lie chiefly between the 200 and 500 mm annual rainfall isohyets, where the former delimits the northern extremity of effective winter rainfall (Figure 18.4). These rangelands are dominated by populations of multi-stemmed mallee eucalypts. The soils are sandy and subject to wind erosion.

Mallee vegetation is often characterised by distinctive patterns relating to the occurrence of sand dunes. In the dunes where Whipstick Mallee occurs, Porcupine grass often comprises the most abundant pasture species, and may form a continuous sward, while in the more open areas, Bull Mallee is accompanied by Speargrass.

The large amount of litter fuel produced results in the mallee lands being some of the most inflammable.

Arid mulga woodlands

The arid mulga woodlands in Western Australia cover approximately 700 000 km^2 (Figure 18.5). The tree layer is dominated by Mulga shrubs (*Acacia aneura*), beneath which lies a diverse range of chenopod and spinifex shrubs. Annual rainfall varies between 200 and 275 mm, with woodland distribution delimited by the rarity of winter rainfall in the north and the rarity of summer rainfall in the south. Lack of moisture for pasture growth is a characteristic, rather than an exception, in Western Australia's mulga lands.

Desirable perennial grasses in Mulga country include Woolybutt, Mulga Oats and Mulga Mitchell. Short-lived species include Speargrasses, Wiregrasses, Bottlewashers and Copperburrs. Annuals appear as a response to rainfall.

Figure 18.1 Distribution of Mitchell grasslands. Source: Orr and Holmes (1984)

Figure 18.2 Distribution of semi-arid woodlands. Source: Harrington et al. (1984).

Figure 18.3 Distribution of chenopod shrublands. Source: Graetz and Wilson (1984).

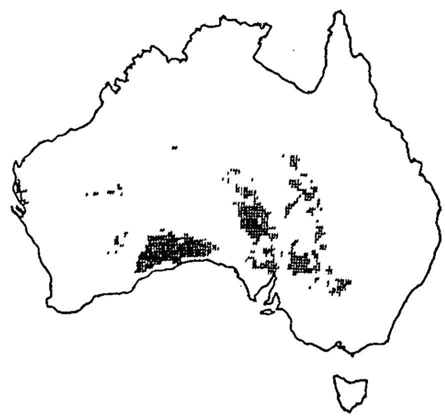
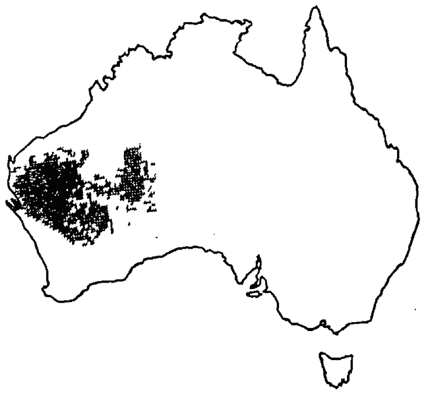


Figure 18.4 Distribution of mallee woodlands. Source: Noble (1984)

Figure 18.5 Distribution of arid mulga woodlands. Source: Morrisey (1984).



18.2 The impact of grazing pressure on rangeland communities

Species selection

Species selection reflects a hierarchy of dietary components in which grazing pressure is transferred gradually from one species or plant group to the next as the season progresses from wet to dry, or availability progresses from high to low. In the semi-arid rangelands, there is a wide range of species available to grazing sheep. In addition, as individual plants tend to be spatially separate, sheep can freely exercise their dietary preferences.

During the active growth period, dietary selectivity is at its greatest, with annual plant species supplementing perennial species and constituting the bulk of the diet. As these annuals die off or are grazed down, the more palatable perennial species increase in their contribution to the diet. As the availability of this second category is reduced, plants of low palatability increase as a dietary component. Many are shrub species and are considered as reserve species, supplying a maintenance diet during unfavorable times. There is a fourth group of plants that are rarely or never eaten, due to bitter or aromatic compounds or a fibrous, spiny structure.

The result of this hierarchy is that some species achieve longer periods of rest from grazing. This is to the advantage of low palatability species and to the detriment of high palatability species.

There are also differences between animal species in diet selectivity. Relative to sheep:

- *cattle* are less selective, eating more of the dominant species and less of the smaller grasses, medics and forbs
- *goats* consume more browse at heights up to two metres, allowing them access the more of the palatable trees and shrubs, but obtain most of their forage needs from the same herbage species as sheep, with similar selectivity
- *kangaroos* consume more grass and less browse and forbs
- *rabbits* select green feed and certain woody shrub and tree seedlings.

Spatial distribution

Many semi-arid rangeland communities are characterised by a non-uniform spatial distribution of plant species. Thus grazing pressure is generally non-uniform, creating areas of high to low grazing pressure. High grazing pressure by domestic, feral and native species on areas populated with palatable plant species and low tree and shrub densities can be undesirable. It is these areas that require monitoring to allow the use of electric fencing, rotational grazing and spelling as tools of reclamation.

The location of watering points has a critical influence on the spatial patterns of grazing pressure. Grazing pressure is most intense within 1-3 km of the watering point, declining with increasing distance from water supply and depending on the pasture species. For example, sheep grazing saltbush have a higher requirement for water due to the sodium content of their diet.

Impact of grazing on botanical composition

Changes in botanical composition inevitably result from the combined effects of grazing selectivity and total grazing pressure. The degree of change varies with the rangeland type (Table 18.1). In the more resilient rangelands (e.g. Mitchell grasslands), changes in major species are reversible or are limited to a decline only in minor species. In the less resilient rangelands (e.g. semi-arid woodlands), vegetation change is extensive, soil erosion increased and animal productivity reduced. The chenopod shrublands are of intermediate resilience, with the dominant species potentially being killed by intense grazing pressure in dry times, but other species remaining either unchanged or increasing to fill the space. Animal production may therefore change little, at least in the short term.

Although overgrazing has a critical effect on the whole landscape, it is the overgrazing of grasses that has the most significant effect on production. Grasses are the most likely to be changed by overgrazing (defoliation and subsequent death as they comprise many of the most palatable species for domestic livestock and because they form significant patches. Even moderate grazing pressure affects grass patches by reducing them by the amount consumed. With appropriate management of stocking rate, the patches will recover.

Table 18.1 The impact of grazing pressure on botanical composition and animal productivity for various rangeland communities. Source: Wilson and Harrington (1984).

Community	Nature of change	Effect
Saltbush (*Atriplex vesicaria*) shrubland, NSW	*A. vesicaria* replaced by *Sclerolaena spp*. or grasses	No change in animal production, increased susceptibility to erosion
Mitchell grassland, Qld	Reduction in *Aristida spp*., increase in annuals	Increased animal production, less seed in wool
Mulga woodland, WA	Increased component of *Aristida spp*.	Reduced animal production
Poplar box (*Eucalyptus populnea*) woodland, NSW	Replacement of perennial grasses by shrubs	Reduced animal production, increased susceptibility to erosion, reduced soil moisture status

Grasses might die, not only from overgrazing, but from grazing at the wrong time, even when stocking rates are apparently within reasonable bounds. This can occur rapidly with the onset of drought and the plants become stressed from the lack of water. Under these circumstances, ungrazed grasses might survive longer. That is, the combined effect of grazing and drought can have a devastating effect on the pasture. Overgrazing causes bare patches as palatable species die out.

Grazing is not uniform over a paddock. Adjacency to watering points, mentioned elsewhere is a case in point. Another example is presented by kangaroos which have a preference for areas near shade. Hence, stocking rate defined in terms of animals per unit area is misleading. Additionally, total stocking rate, which combines domestic and feral/native animals is difficult to estimate accurately.

Basing stocking rates on "average" years is doomed to fail. Average years are a part of a distribution of predominant rainfall conditions, many of which are better while the remainder are worse. There is a high risk in assuming that the rangelands can be maintained in below average rainfall years with average year stock numbers.

Useful guides to adjusting stock to available feed can be made by measuring dry matter yields at the end of the growing season. Stocking rates are estimated such that only 30-35% of annual total dry matter is consumed (Christie, 1975b). Another technique is to avoid grazing perennials below the third node in dry times.

18.3 Sustainable grazing pressure and production

Sustainability refers to the maintenance of a prescribed level and direction of productive capability over time. Long term maintenance depends upon a range of issues concerning the production environment, including the ecosystem and physical, legal, social, economic and personal constraints. But the prime objective should be maintenance of the ecosystem, for without that, the other concerns become meaningless.

Managing the rangelands

Managing rangelands effectively means matching grazing pressure to available biomass production. Grazing the rangelands is first and foremost a business and therefore maintaining the resource is critical, not only to ecological sustainability, but to the continuing economic health of the enterprise. Conservative stocking, or understocking has been the main conservationist call for rangelands. It aims to reduce the impact of grazing on the rangeland resource. The side benefit is that the risk associated with poor seasons can be mitigated through feed conservation.

The dilemma for rangeland systems is to resolve the needs for animal productivity and plant productivity. The issue for the community farmers and ecologists is whether they are in conflict or in balance or in mutual coexistence for ecological rangeland health.

In extreme cases of overgrazing, the more palatable and desirable perennial species may be eliminated, causing a succession to annual plants then to bare ground resulting in a loss of soil cover.

Cost benefit analyses will generally favour systems that promote biomass production and biodiversity when viewed in the long term.

Rangelands condition

Rangelands condition can be categorised according to the abundance of palatable perennial species combined with landscape processes (Burnside et al 1995). The following are characteristics of rangelands under different categories of condition.

Good condition

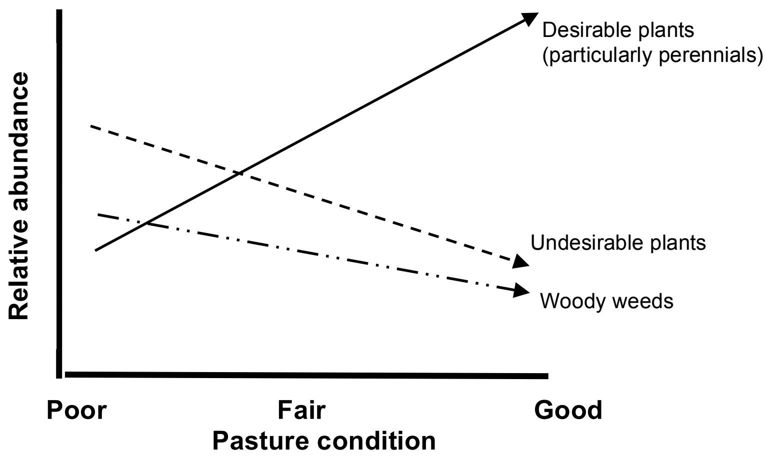
The rangelands can be defined as in good condition when there is a full inventory of expected species of perennial plants. Under good conditions, species composition is close to optimal. Soil, water and nutrient conservation levels are high and erosion is minimal or non-existent.

Fair condition
Most original perennial species are present, but there may have been some loss accompanied by an increase in shrubs and other grasses. Some soil, water and nutrients mat be lost, but most are conserved in the system and erosion is low. Rangeland in fair condition can be improved to good condition with careful management.

Poor condition
Rangelands in poor condition are characterised by decreased number of plants and some loss of species. Bare areas of land are common and other areas may be dominated` by woody shrub weeds. Because of the loss of plants and the open areas, water and soil erosion is common.

The change in plant species mix as rangelands progress from poor to good is summarised in Figure 18.6.

Figure 18.6 Pasture composition of rangelands pastures as they progress from poor to good. Source: Lewer (2005).



Rangeland condition is influenced by a range of factors including:

- Grazing pressure (time, species, numbers)
- Climate (temperature and rainfall, rainfall patterns)
- Fire
- Timber management.

Different pastures, in different environments, under different management are more or less resilient to these factors. For example, Mitchell grass may show little effect of long term grazing whereas mulga country may be less resilient under the same level of challenge.

Grazing systems
Grazing systems are designed to balance livestock production and sustainable forage production. Well executed, the grazing system should lead to a pasture that is high in the proportion of desirable plants, particularly perennials. Stocking rate and grazing systems must be considered as an integrated unit, although O'Reagain and Turner (1992) concluded that stocking rate has a greater influence on animal production than grazing system after reviewing 22 grazing trials. They also concluded that unsustainably high stocking rates are the main cause of pasture degradation and soil erosion.

Systems defined

Rangeland managers generally use continuous grazing, or set stocking, but rotational grazing or deferred grazing systems are also used. Rotational grazing involves on/off grazing of sheep at specified intervals and has its most intensive form as cell grazing. The rest periods enable pasture maintenance and regeneration. Deferred grazing is less systematic than rotational grazing, with longer and usually less frequent rest periods. It is most often used after or during the wet season, and more effectively managed at that time. The rest periods allow the setting and maturation of seed, and can be extended for the whole wet season in some regions.

Pastures can be spelled by adopting a flexible stocking policy within a set stocking system. The number of stock on a specific area can be reduced when there is a need to allow seed set or the establishment of seedlings. Very heavy stocking of particular paddocks might be used to encourage grazing of less palatable species. If carried out when the more desirable and palatable species are dormant, little damage will be done to them.

The following table describes various grazing systems and their impact on rangelands.

Table 18.2 Grazing systems practiced on rangelands and their impact.
Source: McCosker (1994).

Grazing system	Alternative names	Description	Impact
Continuous	Set stocking	Plants continuously grazed.	High stocking: overgrazing; drought and erosion susceptible; Low stocking: Undergrazed and overgrazed patches. Woody weed ingress. High animal performance.
Rotational resting	Deferred grazing	More paddocks than mobs. Rest period of weeks to years.	Potentially reduced overgrazing. Possible undergrazing
Rotational grazing		Sheep moved on fixed dates.	Rotations can be fast or slow with rests of 30-365 days. Frequently lower animal production than continuous grazing. Patch grazing with under and over grazing. Can slow degradation.
Crash grazing	a. High utilisation Multi-camp rotational grazing. Short duration grazing. Mob grazing Etc b. High performance	Paddocks heavily grazed before moving sheep to next paddock, generally on calendar basis Paddocks lightly grazed to utilise palatable species. Ungrazed plants eventually die out. Usually calendar based.	Will reverse land degradation. High utilisation and good animal impact. Low animal performance. Will reverse land degradation. Increase in palatable species. High animal performance.
Time control grazing	Savoury grazing method. Cell grazing. Wagon wheel. Controlled grazing. Management intensive grazing Etc	Commonly 20-40 paddocks per flock. Moves based on pasture growth and physiological need for rest. Not calendar based.	Paddock number and recovery period determine grazing period. High animal performance. Combines features of both types of crash grazing. In wagon wheel system, can leave eroded areas at centre.

Which is best?

In a review of 22 Southern African grazing experiments, O'Reagain and Turner (1992) found that, in terms of pasture composition, in 3 cases, continuous grazing was superior, while in 5 cases rotational grazing was superior and there was no difference in the remainder. However, the additional subdivision that is necessary for rotational grazing may lead to more even pasture grazing.

Many of the advocates of various forms of rotational grazing, such as cell grazing, claim that increased stocking rates can result if this practice is properly performed. This is not born out by research. Norton and Bartle (2002) argue that this enigma can be explained by better livestock dispersion with the more intensive fencing that accompanies rotational grazing and better pasture utilisation. Sheep that are newly introduced to a new paddock are stimulated to explore the whole area. In addition, the higher stocking rate forces sheep to graze regions that they might otherwise ignore. Smaller areas will generally be better served by watering points, placing most of the grazing opportunities within easy access. Further, even subdivision into relatively few extra paddocks will prove the benefits from better animal distribution. According to Norton and Bartle (2002) in research trials, defoliation frequency is usually the focus, with no consideration of the harvested foliage. In a South African experiment, O'Connor (1992) observed a decrease in species selection by sheep under cell grazing leading to more efficient use of available forage.

Graziers frequently provide anecdotal evidence that under intensive rotational grazing, problem weeds cease to be an issue. The only Australian evidence to support this contention comes from Earl and Jones (1996). They set up a control treatment (continuous grazing) and rotation treatments at the same stocking rate. During the 3 year experiment, the most desirable/palatable species increased or remained unchanged under cell grazing, but declined significantly under continuous grazing. The least desirable/palatable species declined significantly under cell grazing but changed little under continuous grazing regimes. Percentage ground cover was significantly higher under the cell grazing treatment than with continuous grazing. The suggestion was that the moderate utilisation of the palatable plants followed by rest allowed expression of their competitiveness and they were able to replace the undesirable species. Alternatively, the light grazing of the unpalatable plants, unused to defoliation, may have reduced their vigour in the plant community.

A case study

The impact of grazing pressure and diet selection in a Saltbush and Cottonbush community on the Riverina Plain of NSW. Source: Wilson et al. (1969).

A three-year study was undertaken on the impact of adult Merino wethers grazing a Bladder Saltbush (*Atriplex vesicaria*) - Cottonbush (*Kochia aphylla*) community on the Riverina Plain, NSW. Paddocks were grazed continuously at 0.6 (light), 1.2 (intermediate) or 2.5 (heavy) wethers per hectare, with the district-stocking rate being around 0.6 sheep per ha.

Table 18.3 shows the botanical composition (%) of the pasture and of the diet in each season of one year, when grazed at the lightest stocking rate. In spring, approx. 66% of the dry matter available came from Saltbush, whereas this species only comprised 9% of the diet. In contrast, around 35% of the diet came from medics, even though they only comprised 7% of the dry matter available. A similar pattern was evident for the perennial (*Danthonia spp.*) and annual (*Vulpia spp.*) grass species. From summer through to early winter, Saltbush represented an increasing component of the diet given its predominance and the low availability of the more preferred species.

Total forage availability declined rapidly under intermediate and heavy stocking rates. Within one year of grazing at 2.5 wethers per hectare, at least 85% of the Saltbush plants were dead (Figure 18.7). Continued grazing, with supplements of Lucerne being provided, resulted in zero survival of Saltbush, such that grazing of these plots ceased after year 2. At 1.2 wethers per hectare, Saltbush mortality was high, requiring cessation of grazing on these plots during year 3. At 0.6 wethers per hectare, survival of Saltbush was relatively high at around 94%.

Initially, wool production per hectare increased with increased stocking rate, but the higher stocking rates could not be sustained due to deterioration of pastures (Figure 18.8). Thus animal productivity declined rapidly. Seasonal fluctuations in body weight and wool growth rate were also more severe at the heavy stocking rate, with supplementary feeding being required by the second year. In the third year, even though the highest stocking rate was reduced by 50%, animal performance continued to decline.

This study demonstrates the large changes in botanical composition that can occur as a result of changes in stocking rate in a rangeland community generally considered to be intermediate in its resilience to grazing pressure. Increases in stocking rate can therefore have a very profound effect on the sustainability of sheep production in rangeland communities.

Table 18.3 Availability of pasture species (Avail%) and contribution of pasture species to the diet (Diet%) of Merino sheep grazing a Bladder Saltbush (A. vesicaria) – Cottonbush (Kochia aphylla) community at 0.6 sheep per hectare. Source: Wilson et al. (1969).

Species		Spring	Summer	Autumn	Winter
Atriplex vesicaria	Avail%	66	72	79	83
	Diet%	9	38	72	87
Kochia aphylla	Avail%	5	6	6	4
	Diet%	tr.	6	1	1
Danthonia spp.	Avail%	1	1	<1	<1
	Diet%	15	6	tr.	0
Vulpia spp.	Avail%	4	0	0	<1
	Diet%	11	0	0	0
Medicago spp.	Avail%	7	0	0	<1
	Diet%	35	0	0	0
Medicago burr	Avail%	-	3	3	2
	Diet%	6	4	14	1
Dead matter	Avail%	11	12	11	10
	Diet%	4	10	12	11
Other	Avail%	6	5	<1	<1
	Diet%	20	36	1	tr.
kg DM per hectare		1997	1686	1437	1273

Figure 18.7 Survival of Bladder Saltbush grazed at 0.6, 1.2 or 2.5 wethers per hectare, over a three-year period. Source: Wilson et al. (1969).

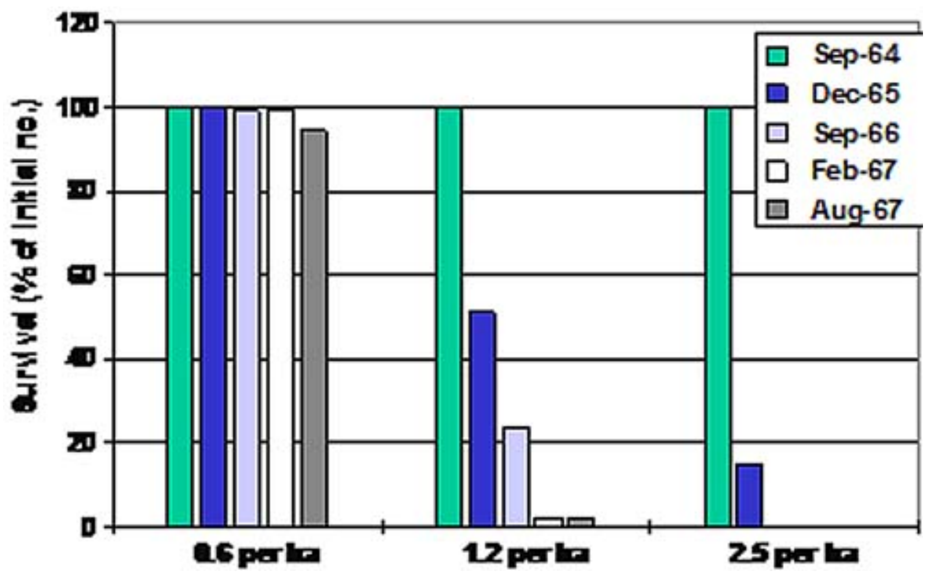
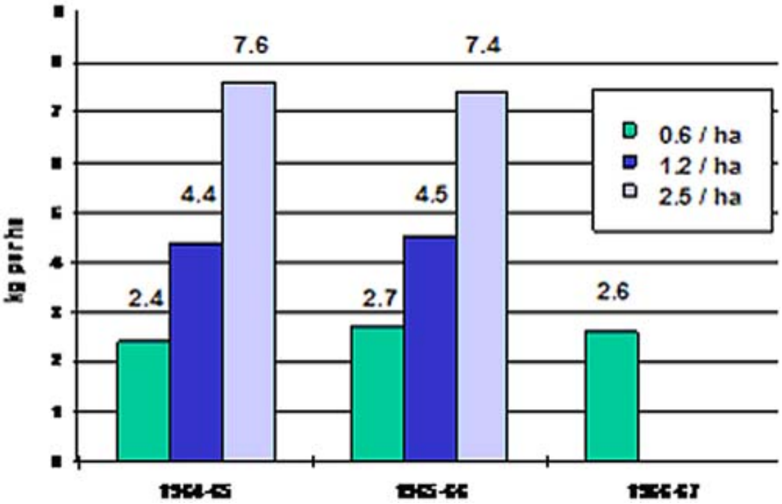


Figure 18.8 Clean wool production per hectare for wethers grazing on Saltbush and Cottonbush at 0.6, 1.2 and 2.5 sheep per hectare. Source: Wilson et al. (1969).



18.4 Total grazing pressure

Total grazing pressure is related to both animal demand and forage availability as shown in the following equation:

$$\text{Total grazing pressure (TGP)} = \frac{\text{Total animal demand for forage}}{\text{Total available forage}}$$

Domestic livestock do not represent the only source of grazing pressure exerted in rangeland communities. Native and feral fauna (e.g. rabbits, goats and kangaroos) also exert grazing pressure on the vegetation, each with a different impact. TGP is high when feed is limited, for example, during periods of low rainfall when the combined effect of livestock and feral animals exerts unsustainable pressure on the rangelands.

It is interesting to note, that on monitored sites in Western Australia, over a three year period, kangaroos consumed more of the available forage than did sheep and goats combined (Anon, 1993).

TGP refers to paddocks or farms. The effective grazing pressure on a smaller area (patch) within a paddock may be much higher than the estimated rate. Research studies have demonstrated a decline in the population of desirable species and an increase in less desirable species, including weeds (Willms et al. 1988; MacDonald, 1978) on these overgrazed patches.

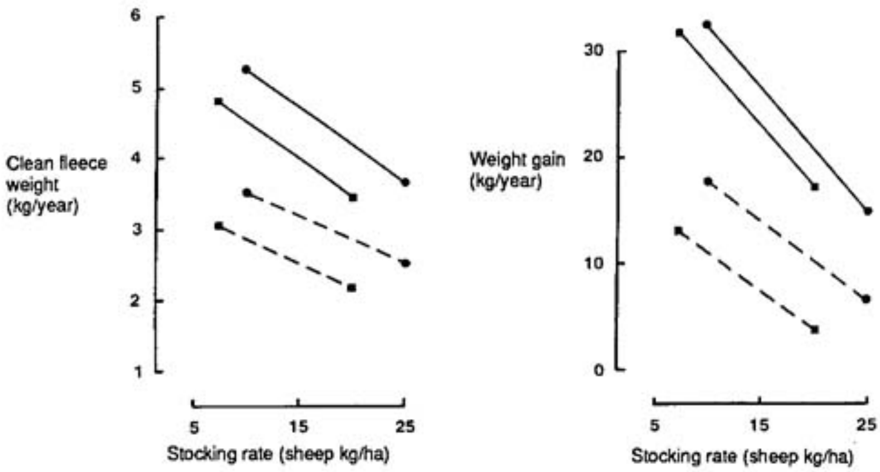
Long term success of the grazing system focuses on the ability of the manager to control both the frequency and the severity of defoliation of the edible plants. This is achieved by manipulating the number and class of livestock grazing an area under different environmental conditions. However, it is generally not possible to significantly influence the numbers of native and feral herbivores that are a part of TGP.

Thus manipulation of sheep grazing pressure to achieve a desired management goal, must also give consideration to the grazing pressure exerted by these other herbivores, that is, managing total grazing pressure. Because of differences in body weight, comparative grazing pressures are such that 1 head of cattle is equivalent to 8 sheep, 11 goats, 13 kangaroos and 133 rabbits.

During dry times, competing herbivores can have a direct influence on the productivity of sheep grazing in the same vicinity. This was shown in relation to kangaroos in a three year study undertaken in the semi-arid mulga woodlands of north west NSW (Wilson 1991). The experimental area was free from inedible shrubs and contained a wide variety of perennial grasses. After being suitably fenced, Merino hogget wethers of 6 months age and 20-25kg liveweight were introduced at stocking rates of 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8 sheep per hectare. A new group of sheep was used each year. A second series of paddocks stocked both sheep and kangaroos (mainly western greys) at equal numbers, to give stocking rates of 0.2, 0.27, 0.33, 0.4, 0.47 and 0.53 sheep per hectare. Sheep and kangaroo stocking rates were expressed as kilograms live animal per hectare to account for differences in animal size.

Stocking rate of both sheep and kangaroos significantly influenced clean fleece weight and weight gain per head during the first and third years, when rainfall was low. Figure 18.9 shows these relationships across a range of sheep stocking rates and for two representative kangaroo stocking rates, 0 and 15 kg per hectare. These results show that (1) increased sheep stocking rate resulted in reduced wool production and weight gain per head, and (2) the inclusion of kangaroos in the grazing area noticeably reduced wool production and weight gain of sheep.

Figure 18.9 Clean fleece weight and weight gain per head per year achieved across a range of sheep stocking rates with (■) and without (•) the equivalent of 15kg per hectare of kangaroo grazing pressure. Two years are shown: 1987 (dashed line) and 1989 (solid line). Source: Wilson (1991).



It was therefore demonstrated that kangaroos impacted directly on forage availability to sheep grazing the same area and therefore also on sheep productivity. Each additional kangaroo had the same effect on forage availability as up to 0.75 sheep of the same weight and on sheep production as 0.6 sheep of the same weight. The effect was greatly diminished when feed was abundant. A response in sheep productivity would therefore be expected from controlling kangaroo numbers during dry periods.

18.5 Predicting sustainable stocking capacity

Carrying capacity is the total number of stock that can be safely carried in a paddock or on a property in the long term. Carrying capacity is a measure of productivity and may be used by lending institutions to assess ability to service debt. Over or underestimating stocking capacity can have major implications for profitability.

In South Africa, carrying capacities are controlled by Government agencies, but in Australia, responsibility lies with the lease holder or owner, who is expected to exercise a duty of care over the holding. However, State Governments may intervene where significant degradation is apparent.

In contrast, stocking rate is the number of animals or a specific class per unit area during a specific time period and can vary according to season or for other management reasons. Stocking rate is a management decision made according to seasonal or other conditions.

To calculate the number of ewes that can be run on a farm, let us make the following assumptions:

Dry matter production is 100 kg/ha when rain reaches the second decile (the second lowest, expected in one out of ten years).
In the year described, a dry ewe will eat 600 kg of dry matter.
The farm comprises 200 000 hectares.
Maximum take off is 30% of annual dry matter available.

Then,

Farm size = 200 000
Total DM available =200 000 x 30 = 6 000 000 kg / annum
Ewes that can be maintained = 6 000 000/600 = 10 000

To calculate sustainable carrying capacity, it is therefore necessary to have good information on long term rainfall, and be able to estimate intake for different classes of sheep.

18.6 Impact of water quality and availability

General considerations

Sheep move around the available pasture between grazing areas, watering points and shade and hence the supply of water and its location within the paddock are important (Squires, 1984). If the watering points are very widely spaced, especially when stocking rates are high, then the grazing pressure can be extremely variable. The best use of forage, and the best pastures will result where there are more watering opportunities (Squires, 1981).

The distribution, quality and quantity of stock water all have an effect on not only the performance of grazing animals but also on the long-term performance of natural pastures. The overall availability and the methods of distribution of water impact on the variable grazing pressure placed on the pastures by the animal and under constant pressure lead to the eventual change of composition of the plant species.

Sheep are willing to walk long distances to water, but excessive differences will effect both feed and water intakes (Squires and Wilson, 1971). At a distance of up to 3.2 km did not affect intake of either feed or water, but when the separation was increased to 4 km, Merino sheep drank three times each two days, and at 4.8 kms, this dropped to once per day. Feed intake decreased above 3.2 km and this adversely affected production.

Abundant amounts of permanent water encourage stock to develop regular grazing habits that place constant pressure on the pasture. However, with the development of piped artesian water, reticulation outlets can be strategically shifted and grazing pressure is not constant across the paddock and pressure on desirable species is lifted near to watering points.

In country that is made up of lighter soils, the preference for sheep is to drink bore water because of the mineral content. Even if surface water is available in dams or creeks elevated grazing pressure is going to remain in those areas closer to the bore water. Conversely on the heavier soils, the tendency is for sheep to have less craving for minerals and subsequently they will graze those areas closer to the surface water.

In saltbush country, not only do sheep prefer surface water, but they will also require more of it to balance the high salt diet. Also, in the more tropical parts of Australia, the combination of both high fibre diets and high temperatures will equate to higher water consumption when compared to the sheep grazing areas of the more temperate zone.

Recent anecdotal evidence suggests certain practices can improve the quality and increase the subsequent intake of stock water. The addition of anti-bacterial agents is said to improve consumption rates because of the improved quality of the water and the use of magnets on the inlet pipes of containers is said to de-mineralise the bore water that results in better performance of livestock. Any increase in water intake is going to have a beneficial effect on metabolism and pasture utilisation.

Intake variables

Provision of good quality water in sufficient quality is critical to achieving optimum sheep production. Luke (1987) has considered a number of important issues in his research review, and the principles are summarised below.

The water consumption model is based on a dry sheep equivalent (DSE), defined as a sheep that is:

- Non-lactating
- 45 kg liveweight
- Condition score 3
- Has a maintenance diet available
- Has access to good quality water (<1000 mg/litre total suspended solids).

The basic model relates drinking rate (DR, litres/day) to average daily temperature (T, °C).

$$DR = 0.191183 \times T - 2.88245$$

As the temperature rises, so does water consumption. However, the predicted drinking rate will be modified by different environmental and physiological conditions.

Saline water

Although sheep vary in their tolerance of saline water, their intake generally increases by about 20% for each 3500 mg/litre of extra salt in the drinking water.

Feed quantity and quality

Water consumption is affected by dry matter intake (DMI) according to the following relationship:

$$TWI = 3.86 \times DMI - 0.99$$

Total water intake includes that in the feed, and higher DM concentration in the feed, the greater will be water demand. Sheep being fed dry summer pasture will require more water than those consuming green forage.

Saltbush

The higher the concentration of salt in the diet, the lower will be the sheep's tolerance to salt in the drinking water. Sheep will drink up to twice as much water when grazing saltbush than when they graze salt-free pastures.

Liveweight

Water intake is related to metabolic liveweight ($\text{liveweight}^{0.82}$). Water for heavier or lighter sheep is related to the defined DSE according to the ratio of their metabolic weights. That is,

$$\text{Water intake} = (\text{liveweight}^{0.82}) \times (45^{0.82})^{-1}$$

A 70 kg sheep will therefore drink 44% more water per day than one DSE.

Pregnancy and lactation

Water demand increases to double DSE requirements by the fifth month of pregnancy for a single bearing ewe and is more for twin bearers. Lactating ewes require twice as much water as non-lactating ewes.

Productivity

Heavier wool cutters require up to 25% more water than average wool cutters.

Many of these factors are additive. For example, a 65 kg ewe in late pregnancy, carrying twins, grazing saltbush in 30°C weather might have the following daily requirements:

Base drinking rate = (0.191183 x 30) – 2.88245 = 2.85 litres

Allowance for size = $65^{0.82}$ x $(45^{0.82})^{-1}$ = 1.35

Allowance for twins = 2

Allowance for saltbush = 2

Total = 2.85 x 1.35 x 2 x 2 = 15 litres per day

18.7 Vegetation management

The characteristic of greatest importance to pastoralists in the semi-arid woodlands is the proportional biomass of trees, shrubs and pasture. In the adult stage, trees limit the growth of shrubs and together they limit the growth of perennial grass. Trees and shrubs eventually come to dominate as they grow taller and live longer. However, the grass component can indirectly influence the tree and shrub component by providing fuel for bush fires, thereby reducing the density of shrubs and trees. In addition, adult grasses compete strongly with tree and shrub seedlings for soil moisture and can reduce their establishment.

But the combined effects of grazing pressure, diet selectivity and reduced fuel loads for fire has resulted in a competitive advantage for many of the shrub and tree species. Many have little or no forage value, allowing them to increase in predominance as the more favoured grass species are preferentially grazed out. This subsequently reduces the fuel load available for controlling shrub densities, as at least 80g/m^2 of grass mass is required for a successful burn.

Tree pulling

Mechanical clearing often involves two large tractors, between which is dragged a heavy chain that flattens the trees. The operation causes considerable soil disturbance that can form a bed for perennial grasses. Woody weeds and juvenile trees below 1m height (generally in a ratio of at least 4:1 pulled trees), whip under the chain and without competition, create the woody weed problem in the next phase of the attempted climax reversal. On areas where pasture seeds can be sown the established pastures might reduce the shrub infestation providing up to 4000kg/ha dry matter can be grown as fuel for a 'hot' fire. Buffel grass is often sown to obtain a strong pasture sward.

Severe restrictions on tree pulling are now in place across Australia with Commonwealth Vegetation Management Plans enacted by the States. There remain, however, certain permits for re-growth control generally of non-endangered species.

Chemical control

Herbicides can be used to thin trees and treat shrubs, thus opening up the environment to pasture plant establishment. Unfortunately, it also allows further shrub development, which might then only be controlled by burning. The costs of herbicide application are generally too high to justify their use.

Woody weed control

There are two common techniques for woody weed control, mechanical and fire.

Mechanical

Stick raking aims to pull woody weeds from the ground thus allowing them to die on the surface. Blade or disk ploughing chops and buries the woody weeds. These techniques may be economical in the higher rainfall areas, but are expensive.

Fire

The planned outcome is to maintain the vegetation within the bounds of its resilience to grazing and thereby in a form that will achieve the highest long-term productivity from animal production. The authors favour ‘cold fires’ ignited in winter and preferably late noon which will go out at night. The only exception is a ‘hot’ regrowth control fire in which a heavy fuel burden of about 4000 kg/ha of grass has been grown. These fires are quite destructive but can be followed by periods of rest and rehabilitation for the grass communities. Frequent annual burning of pastures as practiced in some cattle country has encouraged monocultures of black spear grass with it obvious shortcomings of nitrogen and carbon depletion of soils and loss of dry matter and biodiversity.

The application of fire in rangeland management is likely to have one of the following objectives:

- To reduce the risk of wildfires by strategic fuel reduction during the early part of the dry season. Feed reserves need to be carefully husbanded during the burning operations
- To increase the area over which the sheep are distributed by encouraging palatable species growth. In this context fire should be used infrequently due to the destructive nature of each burn
- To rid pastures of rank growth and encourage young, more palatable growth. However, some argue that moribund pasture is a much more desirable climax than bare soil after a burn
- To control woody weeds and increase the productivity of the rangelands. This remains the only justifiable use of fire when attempting to reverse a climax to trees to a climax of pastures and improve ground cover.

Each rangeland community in a specific location has its own potential fire regime, defined by frequency, season and intensity of fire. The potential fire frequency depends on the quantity and reliability of rainfall and the accumulation of fuel from year to year. Fire was historically a major natural selection tool of rangeland communities, with populations of plant species being screened to accommodate certain fire regimes (e.g. heat-promoted germination; fire-related reproductive cycles).

Fire can be a two edged sword - a tool for destruction and monocultures (potentially with erosion) or one for improving condition and trend of pastures.

18.8 Breeding sheep for the rangelands

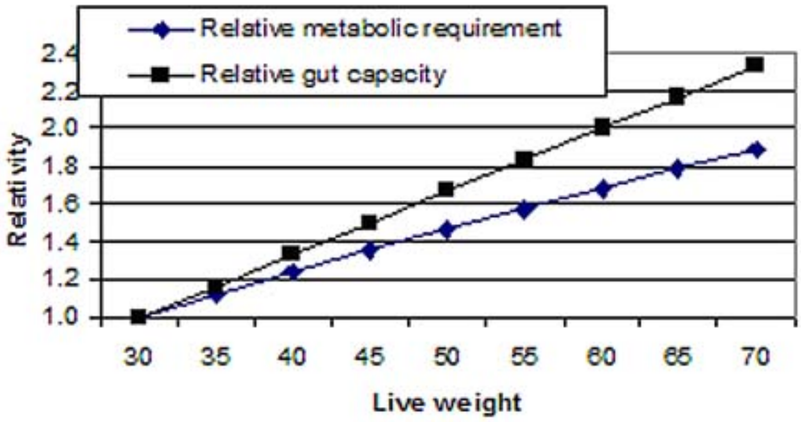
Most of the sheep on rangelands are Merinos with the Peppin and South Australian strains predominating. Peppin and Collinsville strains are similar in production of meat and wool, being of similar liveweight, and producing wool of similar quantity and quality. The South Australian Bungaree is larger framed than the other two strains mentioned, but has coarser wool (Lewer et al., 1992).

Many pastoralists believe that large framed sheep are best suited to the rangelands because they are better able to travel the large distances between forage and water. However, an important reason to aim for larger animals is related to metabolic demand as shown in Figure 18.10, adapted from Freudenberger and Noble (1997).

Gut capacity is in direct proportion to liveweight whereas metabolic requirements are proportional to $(\text{liveweight})^{0.75}$. Larger sheep may therefore have a greater ability to digest poor quality forage as their gut is larger relative to their energy needs. With recent strong trends towards meat production and weak wool prices, larger sheep provide a greater potential to exploit market conditions.

Parent Merino studs are, in the main, either located outside the rangelands environment or run under conditions that do not reflect rangeland conditions and it has therefore not been possible to efficiently breed sheep that are adapted to this harsh environment. The few Australian studs that are located in the rangelands, principally in Queensland, frequently buy-in rams from interstate, negating any opportunity to produce genetically adapted sheep possible in closed-flock breeding in the target area.

Figure 18.10. Relativity between metabolic requirements, gut capacity and liveweight. Source: Lewer (2005).



Rams identified as superior in a specific environment are those that are carrying and expressing the appropriate genes for that environment. Such rams may not express or may not carry genes for a diverse environment. Rams transferred from elsewhere might suffer a short or even long term difficulty with adapting to the new environment. However, their progeny should be better able to withstand the trauma because they were born under the changed conditions. However, this does not demonstrate whether the right rams were transferred in the first place.

There may be scope for improvement of productivity for both wool and meat, by selecting over a long period, specific genotypes that are bred in, and therefore genetically adapted to, the semi-arid rangelands. A second option maybe to cross the Merino to more hardy breeds of meat sheep and then select for wool traits within the interbred crosses.

The term "pastoral draft" is used to describe the rams that are sent to the rangelands, frequently at the end of the selling season, after selection of those for the more productive areas. Because large numbers of rams are required in the extensive areas of the rangelands, the buyers are usually satisfied to have less selection potential in exchange for a lower price.

A recent development has been the introduction of meat breed sheep from South Africa and the Middle East. The first of these was the Awassi, one of the main Middle Eastern breeds, that was sourced from Cyprus. Later, other breeds such as the Damara, South African Mutton Merino and Dorper were obtained from South Africa along with others. These breeds are suited to the semi-arid areas as this is the environment for which they were developed or from which they originated.

Readings

The following readings are available on CD

1. Luke, G.J. 1987, *Consumption of water by livestock*, Technical Report 60, Division of Resource Management, Western Australian Department of Agriculture.
2. Norton, B.E. and Bartle, R. 2002, 'An assessment of rotational grazing systems in rangelands', Conference Australian Rangelands Society (unpublished).

Activities

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Assignment Questions

Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCT

Summary

Summary Slides are available on CD

Arid and semi-arid rangelands make up a large proportion of the earths surface with these regions supporting almost half of the world's sheep population. Rangelands are characterised by low and/or erratic rainfall and vegetation ranges from grasslands, shrublands, savannah or woodlands through to desert. Successful sheep production in rangeland areas requires careful grazing management such that the condition of the rangeland is maintained for successful production in future years. Key factors to consider in rangeland management are stocking rates and carrying capacity, other herbivores apart from livestock, watering points, species selection and weed control.

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Glossary of terms

Source: http://wfrec.ifas.ufl.edu/range/rangelands/glossary.htm

Biomass	the total amount of living plants and animals above and below ground in an area at a given time
Browse	that part of leaf and twig growth of shrubs, woody vines and trees available for animal consumption
Carrying Capacity	the maximum *stocking rate* possible which is consistent with maintaining or improving vegetation or related resources. It may vary from year to year on the same area due to fluctuating forage production
Defoliation	the removal of plant leaves, i.e., by grazing or browsing, cutting, chemical defoliant, or natural phenomena such as hail, fire, or frost
Forbs	any broad-leafed herbaceous plant other than those in the *Gramineae* (or *Poaceae*), *Cyperaceae* and *Juncacea* families
Palatability	the relish with which a particular species or plant part is consumed by an animal
Rangeland Condition	the present state of vegetation of a range site in relation to the climax (natural potential) plant community for that site