A Report on the Viability of Pastoral Leases in the Northern Rangelands Region Based on Biophysical Assessment

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EXECUTIVE SUMMARY

The Kimberley and Pilbara comprise Western Australia's Northern Rangelands. The pastoral industry of both regions is becoming increasingly similar, with most formerly sheep producing properties in the Pilbara moving to cattle, more control and manipulation of herds, and enterprises with a higher proportion of breeders.

The projected viability (based on a capacity to carry a minimum number of stock in an ecologically sustainable manner) of pastoral leases in this region was analysed through assessment of biophysical parameters, in particular the inherent landscape productivity and its capacity to be managed in an ecologically sustainable manner, and the impact of current rangeland condition on grazing capacity. Analysis was conducted on individual pastoral leases The effect of leases being run in combination with other leases in one business, or access to substantial non-pastoral income was ignored.

Of the 154 pastoral leases assessed, applying a threshold viability level of a potential carrying capacity of 4,000 cattle units, but ignoring reduced carrying capacity caused by degraded rangeland condition:

- 16 leases in the Kimberley and 37 leases in the Pilbara do not reach the viability threshold when all land systems within the lease area are considered;
- 18 Kimberley leases and 40 Pilbara leases do not meet the viability threshold when land systems whose pastoral potential is so low that investment in management and infrastructure is considered non-viable are excluded.

The background and arguments behind this assessment are discussed.

When lease carrying capacity was further reduced by discounting potential productivity to reflect rangeland degradation, the number of leases attaining financial viability declined substantially. Again considering a viability threshold of 4,000 cattle units, excluding low productivity landscapes, and accounting for carrying capacity decline as a consequence of rangeland degradation, 60 of the 92 Kimberley leases and only 12 of the 62 leases in the Pilbara were rated as viable. Leases not meeting this threshold are distributed throughout the region, although in some Land Conservation Districts (the district basis for much of the analysis) only a low percentage of pastoral leases reach the threshold.

Given the magnitude and level of rangeland degradation, the analysis examined to what extent viability could be improved by applying a period of virtually complete destocking to restore rangeland productivity. The conclusion was that the outcome would be minimal in the Pilbara. The effect of rangeland restoration was only substantial in the Kimberly when extremely optimistic scenarios of range condition improvement were considered.

It would appear that a significant proportion of pastoral leases in the Northern Rangelands are non-viable based on the inherent productivity of the landscape and the condition of the rangeland resources, while range condition decline continues on many leases. This conclusion is supported by other studies also reporting substantial financial constraints. It is difficult to envisage a future for these pastoral leases, assuming operation as stand alone pastoral enterprises, if the legislative requirements of ecological sustainability are to be met.

1 INTRODUCTION

Western Australia's rangelands comprise 87% of the state and occur outside the South West Land Division. Pastoral leases, used for grazing livestock predominantly on native vegetation, cover 35% (874,000 km^2) of the rangelands, with the balance consisting of Unallocated Crown Land (UCL) and land vested for conservation and Indigenous purposes. Pastoral land is held under a leasehold arrangement, and legislation is quite prescriptive as to the manner in which land must be managed.

The Northern Rangelands have affinities with both the semi arid and monsoonal high rainfall areas elsewhere in northern Australia. Winter rainfall is neither regular or expected, although is more common in the southern Pilbara than the Kimberley. Rangeland plant species vary with soils, rainfall and grazing pressure, but the amount of rainfall and its effectiveness (essentially the duration of the wet season or, more importantly the duration of the dry season) is the major factor that determines both the quantity and the quality of available forage.

The inherent productivity of the soils and vegetation of the region (described in the land system approach) drives the capacity of the rangelands for pastoral production. Land systems were first described by CSIRO in the 1970s, with further studies being conducted in the 1990s by the Department of Agriculture & Food Western Australia (DAFWA) on areas, such as the Broome coastal strip, not covered by the CSIRO surveys. These surveys and the individual lease assessments by DAFWA demonstrate that the Northern Rangelands cattle industry is strongly dependent on relatively small areas of higher productivity land systems, with most of the land over which leases are granted being of only moderate or lower carrying capacity. Such areas of higher value grazing country are often widely dispersed, surrounded by much larger areas of lower productivity. Many leases, particularly in the Kimberley, also have significant areas where the land systems are classified as unsuitable for grazing, with a zero carrying capacity. This has a major consequence for rangeland condition, in that it is these small areas that receive the majority of the grazing pressure and so often exhibit a declining range trend.

The primary indicators of financial performance in the northern cattle industry are the number of cattle turned off annually and the costs of achieving that turn-off. In enterprises with adequate infrastructure and managerial control, production indices and turn-off rates can be quite high. Conversely, if infrastructure and managerial input is low, turnoff rates could be low as the production unit is essentially an unmanaged cattle harvesting operation.

The objectives of this report are as follows:

- Review the biophysical condition of pastoral land in the Northern Rangelands.
- Investigate appropriate criteria and define the viability of pastoral activities from a biophysical viewpoint.
- Report on the current state of the rangelands at both a lease and district level, identifying those leases in the Northern Rangelands with:
    1. Little prospect of stand-alone viability from pastoral production under any management regime,
    2. The potential to sustain a viable pastoral grazing enterprise following a period of rehabilitative management (essentially long-term destocking);
    3. Existing capacity to sustain a viable pastoral grazing enterprise.

The region was assessed as to its viability for pastoralism at the individual lease and district level. For this analysis, joint management of leases and income derived from alternative diversified activities such as tourism, and its effect on business viability, is ignored (see discussion below). This is despite the income generated by these activities potentially being a substantial, if not the major, source of income for the business.

2 THE ANALYSIS PROCESS

2.1 Process

The analysis carried out used biophysical parameters of pastoral grazing land potential to support domestic stock while maintaining the required rangeland condition state. Leases could be classified as being in one of three categories. These were:

Category **A** Lease viable as a stand-alone pastoral enterprise in 2011, with a capacity to remain so under appropriate management.

Category **B** Lease not viable in 2011, but able to become viability following five years of rehabilitative management (essentially destocking) and recovery of rangeland condition.

Category **C** Lease not viable as a stand-alone pastoral enterprise in 2011, with insufficient biophysical land capability to become viable within five years.

2.2 Viability

Information on pastoral lease viability in the Northern Rangelands is limited. Each situation has unique circumstances, and general rules are difficult to determine. However, a fundamental principle is that enterprises must have sufficient production scale to amortise costs across the business, and the lease must possess sufficient productivity to sustain this.

Therefore, this assessment defined viable pastoralism as an enterprise that must simultaneously:

1) Maintain or improve the condition of the rangeland as required by legislation;
2) Generate a sufficient financial income to meet:
    a. Fixed costs (overheads)
    b. Variable costs (operating)
    c. Provision for depreciation of capital items
    d. Generate an acceptable return on investment;
3) Sustain both 1 & 2 over time and during periods of seasonal and market variability.

Fixed costs remain largely constant irrespective of the intensity of the enterprise, and include items such as personal drawings, interest, rents and rates, insurance, capital items and consumables that are independent of operations (e.g. generator fuel, education, phone, etc). To cover fixed costs a pastoral enterprise must possess a certain scale*,* and it is likely that the minimum scale will vary within and between districts, e.g. the West Kimberley versus the East Pilbara. Variable costs are those that arise directly from the operations of the enterprise and include mustering, fuel, animal husbandry, repairs and maintenance and staff wages. The capacity to cover variable costs is determined by enterprise productivity and the sales this generates.

The determination of a viability threshold is difficult, as it is likely to vary within and between districts, enterprises and individual leases. The financial performance of a pastoral business is difficult to estimate due to the paucity of data and the degree of aggregation in existing data (e.g. ABARE surveys). At the lease level, financial performance will be influenced by the variability in the climate, the constituent land systems that influence carrying capacity, the level of infrastructure development, the overall cost structure of the business, the level of managerial skill and the amount of debt carried.

In defining a viability threshold, an assessment by DAFWA of Kimberley leases in 2002 suggested that in excess of 4,000 cattle units would be realistic, and that this figure may currently be as high as 6,000 cattle units (Bright, *pers comm.*). Stockdale (*pers comm.*), using data from the Pilbara benchmarking survey, suggested a figure for the Pilbara of around 4,500 cattle units. This contrasts with the figure identified in the final report of the Kimberley Pastoral Industry Inquiry (Dept. Regional Development and Lands, 1985) which stated (page 250) “the ability to generate surplus income at significant levels, year–in, year–out (YIYO) requires at least 10,000 to 12,000 head of cattle (LSU)”.

For initial analysis, this assessment adopted the figure of 4,000 cattle units. However, as with the assumptions related to the effect of spelling on improvement in range condition (outlined below), a capacity was introduced into the analysis to permit a modification of this number to reflect a range of viability thresholds, so that its sensitivity could be tested. Moreover, the apparent inexorable decline in the terms of trade for pastoral production will undoubtedly result in this viability threshold steadily increasing over time simply to allow to Northern Rangelands pastoral businesses to remain static but ecologically sustainable.

In comparison to a similar analysis conducted for the Southern Rangelands, discussions within DAFWA staff and information available elsewhere

(McCosker *et al.,* 2009; Holmes *et al.,* 2010) suggested that the viability threshold for Northern Rangelands cattle properties was significantly higher than that used for an assessment of the Southern Rangelands because of higher overall costs.

Two points should be noted in regard to the assessment of viability in this analysis. Firstly, each lease was individually assessed, irrespective of whether or not it was operated as part of an amalgamated business running several leases together. This decision was based on the ability under current legislation for each lease to be sold individually, such that its forming part of an amalgamated operation in 2011 was no guarantee that this would always be the case. Secondly, non-pastoral income in whatever form was not considered. It is acknowledged that a significant number of pastoral businesses in the Northern Rangelands have some form of non-pastoral income. However, as with the situation of multiple leases being combined in the one business, there was no guarantee that either the current or the future lessees would continue to have access to this additional income, and that at some point the lease may be required to be fully viable as a sustainable, stand alone pastoral enterprise.

The amount of debt carried by pastoral enterprises in the Northern Rangelands has increased dramatically during the last decade (McCosker *et al.,* 2009, Holmes *et al.,* 2010). While primarily a consequence of rapid escalation in the costs of land purchaes, it also reflects a more general willingness on the part of pastoral business managers to accept debt as part of their operating business structure. Debt servicing commitments can have a profound influence on the capacity of a business to generate a positive net financial return. However, this analysis considered that debt servicing commitments should not be a variable in the determination of biophysical viability. Rather, debt service costs should be considered as part of an investment decision in the context of providing a rate of return that would be acceptable to the investor.

2.3 Lease Level Potential Carrying Capacity

The pastoral rangeland in Western Australia is described in terms of land systems, identified on the basis of distinctive combinations of soil, topography and vegetation. The potential of a land system to carry stock is derived from those characteristics, the perennial vegetation in particular. The Potential Carrying Capacity (Potential CC) of each pastoral lease has been determined by the Department of Agriculture and Food Western Australia (DAFWA) based on assessment and estimation of the productivity of the land systems and their individual units comprising each lease. The lease Potential and Present Carrying Capacities (Present CC – the Potential CC discounted for a decline in range condition) were estimated from recommended carrying capacities for each land system, and for different range condition status. The Potential CC assumes relatively even grazing distribution (this requires an adequate number and distribution of water points and appropriate fencing) and good range condition. The Present CC is discounted for present range condition status of the rangeland but importantly, continues to assume sufficient development such that domestic stock can access the entire lease. However, this situation is rarely the case. Therefore, in most situations, the sustainable carrying capacity will be less than the Present CC.

The estimated carrying capacities for each land unit/system (both Potential and Present) are intended as a guide to both the productive potential of the land and as an indicator of carrying capacities appropriate for ecologically sustainable management of vegetation and soils. As such, they could be considered conservative estimates. However, the Potential CC is not a mandated stock level, and is not meant to be used as a rigid stocking rate guideline for any particular season or year, in acknowledgement of the seasonal variation in pasture growth and short-term carrying capacity that occurs in rangeland environments. The same is true of the Present CC. Rather, they are an average (over a decadal timescale or more) number of cattle units that a lease could carry, if fully developed (livestock can access the entire lease), and still maintain the ecological integrity of the rangeland. The actual grazing value and appropriate stocking level of a particular paddock or lease at any time will vary with seasonal conditions, rangeland condition and degree of recent use. In periods of above average seasons, it would be expected that the lease could run above its Potential CC, while in poorer seasons stock numbers would be reduced to below the Present CC.

Comprehensive information and mapping exists on the land systems of each pastoral lease, based usually on rangeland survey data. These published data have a high level of integrity, consistency, reproducibility and spatial detail. Information for the Pilbara is available in a series of recent publications (Payne *et al.,* 1988; van Vreeswyk *et al.,* 2004 a & b; Payne and Mitchell, 2002). In the Kimberley, the Potential CC of each lease was re-assessed in 2003 following the method of Novelly & Baird (2001). The areas of each land system on each lease are known, and for each land system a Potential CC (cattle units/unit area – generally a square kilometre) has been determined. Therefore, for each lease, the sum of the Potential CC for each of the constituent land systems provides the lease level Potential CC.

2.4 Costs of managing pastoral country

There are significant costs associated with managing cattle operations, particularly associated with mustering and general cattle management, and these costs vary considerably between the various country types. Costs are as much associated with the spatial extent of the country managed as with the number of cattle.

Mustering costs per cattle unit are particularly high in very low carrying capacity country because of its characteristics. Small patches of more favourable country types interspersed within much larger areas of low potential, often inaccessible country. This result in small mobs of cattle being widely scattered over the larger area. The opportunity for trap mustering is generally limited because of permanent waterholes. Therefore, extended and costly aerial mustering is often necessary to bring in essentially very few cattle. For this reason, the majority of Pilbara stations only conduct one round of cattle processing and this lack of control of the herd is a critical constraint to productivity and profits. The other issue is that the mustering efficiency in these situations is unlikely to be above 80%, further reducing the return on mustering and management costs.

Given the high management costs per cattle unit in low productivity country, not all pastoral rangeland on an individual lease necessarily has sufficient productivity to warrant its use in pastoral activities. There may be insufficient financial return to warrant investment in management activities or infrastructure on the poorer country. Such insufficient productivity may be a consequence of either inherent low rangeland productivity, the degraded condition of the small areas of productive landscapes, or both. In such situations, the only option to increase the financial return from the landscape is to run a stock number in excess of the carrying capacity year in and year out. This is not ecologically sustainable, and creates an unacceptable risk of rangeland degradation.

Therefore, in this assessment of lease viability, land whose productivity does not warrant investment or use under current financial conditions was excluded.

The descriptors used to define pastoral potential in the Kimberley and Pilbara regions relate to different carrying capacities (Table 1). In the Kimberley, land systems classified as “very low” potential include all land systems rated with a carrying capacity of less than 2.5 cu/sq km. The equivalent figure for the Pilbara is land systems rated at less than 0.8 cu/sq km. In order to utilise a common relationship equivalent between the Kimberley and Pilbara, for Kimberley leases it was assumed that 33% (one third) of the “very low” potential country had a carrying capacity of 1 cu/sq km or less. Therefore, for the purposes of determining Potential CC in the absence of these land systems, the Potential CC of Kimberley leases was reduced for each square kilometre so rated by 1 cattle unit. For Pilbara leases, the Potential CC was reduced by the area of “very low” potential land systems, generally classed, for calculation purposes as 0.6 cattle units/ sq km. In defining these levels, the productivity of a cattle herd in various country types using data derived from the 2010 Pilbara Benchmarking study was used, and discussions held with DAFWA staff with significant experience in both the Kimberley and Pilbara regions.

Table 1. Pastoral potential distribution, Northern Rangelands

Production potential classifications	Kimberley Potential Stocking Rate (cattle units /sq km)	Pilbara Potential Stocking Rate (cattle units /sq km)
Very high		6.5-20
High	>8.0	3.5-6.5
Moderately high		2.0-3.5
Moderate	4.0 - 8.0	1.5-2.0
Low	2.5 - 4.0	0.8-1.5
Very low	<2.5	<0.8
Unsuitable	0	0

[Source: Pilbara, Van Vreeswyk, 2004b; Kimberley; RMB, 1985; Novelly and Baird, 2001].

2.5 Legislative Imperative

Land tenure in the pastoral rangelands of Western Australia is predominantly leasehold with leases issued under the *Land Administration Act 1997* (LAA). The statutory authority for management of the pastoral estate rests with the Pastoral Lands Board and the Department of Regional Development and Lands (RDL). DAFWA provides technical assistance to RDL to support their activities. In addition, the Commissioner of Soil and Land Conservation under the *Soil and Land Conservation Act 1945* (SLCA) has the duty and powers to prevent or mitigate land degradation. If warranted, the Commissioner can make orders to destock and/or rehabilitate degraded land.

The specific provisions in both legislative Acts that relate to the rangelands are as follows:

Section 95 of the *Land Administration Act* stipulates the specific functions (among others) of the Pastoral Lands Board (PLB):

> 95 (c): "*to ensure that pastoral leases are managed on an ecologically sustainable basis";*
>
> 95 (e): "*to develop policies to rehabilitate degraded or eroded rangelands and to restore their pastoral potential".*

Section 108 of the LAA refers to the management of land under a pastoral lease:

> (4) "*The lessee must maintain the indigenous pasture and other vegetation on the land under the lease to the satisfaction of the Board."*

Section 101 Minister may grant pastoral lease over Crown lands:

(5) A pastoral lease must not be granted unless:

(a) the Board is satisfied that the land under the lease will be capable, when fully developed, of carrying sufficient authorised stock to enable it to be worked as an economically viable and ecologically sustainable pastoral business unit;

Section 108 Management of land under a pastoral lease:

(2) The lessee must use methods of best pastoral and environmental management practice, appropriate to the area where the land is situated, for the management of stock and for the management, conservation and regeneration of pasture for grazing.

(4) The lessee must maintain the indigenous pasture and other vegetation on the land under the lease to the satisfaction of the Board.

Section 13 of the *Soil and Land Conservation Act (1945)* stipulates the function of the Commissioner of Soil Conservation to be:

> "the prevention and mitigation of land degradation."

Furthermore, the WA Environmental Protection Agency has stated in its Position Statement No 5 that (page 22) "current landholders and managers should assume responsibility for the managed land that has lost environmental values due to previous poor practices", while under the *Environmental Protection Act (1986)* it is an offence to allow "substantial damage to some or all of native vegetation in an area and includes …the grazing of stock".

Consequently, good range condition and ecologically sustainable management should not be seen as some aspirational goal that may or may not be achieved depending on the vagaries of seasons or the markets. Rather, it is a clear legal requirement of a pastoral lessee under legislation, irrespective of seasons and markets, and carrying stock numbers in excess of the capacity of the landscape to be ecologically sustainable should not be considered an acceptable response under any circumstances, including the preservation of an operating cash surplus.

2.6 Impact of range condition on viability assessment

The condition of the rangeland is critically important in determining the current productivity of a given lease, and in determining what limits of grazing pressure are required to satisfy the legislative requirements of pastoral land in Western Australia.

The Potential CC calculation assumes that all the rangeland is in "good" range condition, and that cattle are distributed homogeneously across the landscape depending on its carrying capacity. But, this is rarely the case, with cattle distribution in the large management units in the Northern Rangelands as much defined by cattle behaviour as by the manager. This is because in many country types fencing is difficult, while wet season conditions often lead to loss of managerial control through the destruction of floodgates.

As range condition declines from "good", to "fair" and then to "poor", carrying capacity and drought resilience (the capacity of the rangeland to provide fodder during rainfall deficit) can decline. This is because both the quantity and seasonal availability of perennial forage declines as range condition declines (Condon *et al.,* 1969; Heady, 1975). While animal productivity may be maintained in average or better seasons as range condition declines (Holm *et al.,* 2005), this is not so as seasons fail (Hacker and Tunbridge, 1991). This is evidenced by the downgrading of carrying capacity as a consequence of declining range condition in the range survey reports (see Payne and Mitchell, 2002; van Vreeswyk *et al.,* 2004b) and is the general case for rangelands (Cook *et al.,* 1962; Condon *et al.,* 1969; Christie and Hughes, 1981, Powell *et al.,* 1982 among others). Moreover, while rangeland in "poor" condition may be productive in average seasons at stocking rates close to those suitable for "good" condition rangeland, the requirements of legislation require a return of "poor to "good" condition rangeland, and this can only be achieved at stocking rates below those required for peak animal production.

Therefore, discount factors have been developed by DAFWA to permit the calculation of reductions in stock carrying capacity as a consequence of decline in range condition. These discount factors are published in the Pilbara range survey reports (van Vreeswyk *et al.,* 2004b) and have been determined for Kimberley rangelands (Craig, *pers comm*). Discount factors used in this analysis are listed in Appendix 1.

The discount rates reflect the current capacity of the rangelands to carry stock while improving range condition, not simply a carrying capacity that the rangeland can sustain in its current condition. If an improvement in range condition is required (as per the legislation noted above), then even lower stock numbers are warranted. Given the requirements for the management of pastoral land under the legislation, it is likely that the discount rates are, in fact, optimistic, and that when a rate applicable to improve the rangeland is used, then a discount in Potential CC greater than that used in this analysis would be required.

In the grasslands, "fair" condition rangeland retains a reasonable capacity to support stock when grazed at levels sufficient to allow improvement. Because of the more dynamic nature of the grasslands compared with the shrubland areas, and the more favourable climatic conditions in the Northern Rangelands compared with the Southern Rangelands, rangeland assessed as "fair" has a significant capacity to improve in condition under benign management. However, "poor" condition rangeland is considered to have been significantly degraded, and has a limited grazing potential and animal production capacity except in years of very much above average rainfall when a substantial, annual species forage bank may be available. While the carrying capacity of rangeland assessed as in "poor" condition varies between land systems, in all cases the assessment of condition as "poor" implies virtual complete loss of drought resilience and, in many instances, a requirement for complete destocking to allow rehabilitation.

Information exists on pastoral rangeland at a lease level from the assessments carried out by DAFWA's Rangeland Program until 2008. These assessments incorporate the proportion of rangeland in "good", "fair" and "poor" condition on each lease. Therefore for those land systems on each lease included in the calculation of the lease carrying capacity above, the reductions in carrying capacity as a consequence of range condition being either "fair" or "poor" rather than "good" were determined, such that a carrying capacity reflective of the most recent assessment of range condition of the lease was determined.

2.7 Impact of subsequent management (achieving Category B) on viability

Range condition can improve, but it is not a short-term process. Often transitions (Westoby *et al.,* 1989; Bestelmeyer, 2006) are recorded, where the ecology of an area changes virtually permanently, and removal of the major driver of change, total grazing pressure, the impact of domestic, feral and native herbivores, will not achieve a return to "good" condition, even in the long term. Such transitions have been recorded in the Northern Rangelands (Watson and Novelly, 2010), particularly with rangeland now classified as "poor" condition. This is not to suggest that "poor" condition rangeland has no grazing capacity, rather that the opportunity for regeneration of "poor" condition rangeland by grazing management alone is limited during a reasonable management timeframe. This recovery is very much a function of the episodic nature of available soil moisture (Watson *et al.,* 1997) and the impact of total grazing pressure.

This analysis considered that the more dynamic climatic and vegetative environment of the Northern Rangelands would enable some level of recovery of "poor" condition rangeland to occur under favourable or rehabilitative management settings, but that the capacity of rangelands to recover was greater in the Kimberley than the Pilbara. This was because of the more reliable seasonal conditions (interannual) and the generally higher annual rainfall amounts in the Kimberley. This is reflected in the data from the Western Australian Rangeland Monitoring System (WARMS).

The impact of a notional period of rehabilitative management would be applied for five years has been tested here. This would take the form of:

- Complete shut down of artificial stock water points;
- Fencing off natural water points from use by domestic and feral animals, allowing access to water only by native herbivores;
- o Active removal of all (to the extent possible) domestic and feral grazing animals.

However, given that it is difficult to be confident about the possible improvement in range condition, sensitivity analysis was inserted to allow various scenarios of range improvement (and hence increase in carrying capacity following destocking) to be assessed for each region. Therefore, for each lease, the current discounted carrying capacity and the carrying capacity possible following five years of destocking under various improvement scenarios was determined.

2.7 Other factors

This analysis does not account for several variables that would impact on the viability of enterprises based on pastoral leases and viability thresholds. These include:

- Consideration of the variation in the viability threshold for different pastoral enterprises. There is no doubt that possible enterprises, or mix of enterprises (live export, live export plus some sale to the agricultural areas, bullocks etc.), are likely to have differing cost structures, and therefore different viability thresholds.
- Differences in fixed and variable costs, e.g. through proximity to towns and major roads, or the impact on distances to market or service centres.
- How heterogeneity and distribution of land systems within leases and land units within land systems would affect the financial return to infrastructure development.
- Variation in management innovation and managerial expertise among businesses and lessees/managers.

It is appreciated that these factors will be important in a regional context (the viability threshold will vary between LCDs), and in identifying individual leases that may, or may not, fall into a given category.

3 SITUATIONAL ANALYSIS

3.1 The Regional Grazing Resource

The viability of pastoralism in the Northern Rangelands is a function of the inherent variability and limited productivity of the region's natural resources. The purpose of this section of the report is to describe the biophysical context of the Northern Rangelands, to provide an understanding of the sustainable pastoral potential of the region, what has caused soil and pasture degradation, and what characteristics and criteria should be considered in assessing potential viability from a biophysical viewpoint.

The Northern Rangelands consist of two discrete areas, the Kimberley and Pilbara regions. The Kimberley Region is the most northern, and encompasses approximately 421,500 sq.kms, one-sixth of the state's total land area. The Kimberley is bordered by the Great Sandy Desert and the Pilbara to the south and the Northern Territory to the east. The bio-geography of the Kimberley is varied, ranging from arid deserts, gorges and sandy beaches, through to river valleys and rainforests.

The Pilbara is bordered the Kimberley to the north, the Great Sandy Desert to the north and east, and the Little Sandy Desert to the east. It covers over 505,000 sq kms, or approximately one-fifth of Western Australia. Most habitation in the Pilbara occurs in the western third, the eastern third being largely desert with few inhabitants.

The Kimberley and Pilbara pastoral industries are becoming increasingly similar, with greater control and manipulation of herds, and enterprises with a higher proportion of breeders turning off cattle at a younger age. While pastoral Kimberley has been exclusively cattle for some time, the Pilbara saw a steady decline in sheep enterprises over the past two decades to the point where only a few stations in the south west still produce wool. The developing strength of the live-export markets and their preference for *Bos indicus* type cattle, along with recognised productivity gains, has seen the Pilbara following the lead of the Kimberley in adopting more tropically adapted cattle. This higher *Bos indicus* content makes the Northern Rangeland cattle less attractive to some southern buyers, and several Pilbara producers have opted to produce quality *Bos taurus* cattle for the southern markets.

Turn-off patterns have changed with the increasing status of live export. The preferred age range for live export turn-off is at 18-30 months. This change has encouraged an increase in the breeder herd and turn-off numbers without an increase in total herd numbers. Improved management, lower annual mortality rates and an increase in spaying has seen an increase in both heifer and cull cow turnoff.

Growth in demand for live feeder cattle since the early to mid-1990s has helped further improve breeding and management systems in the Kimberley and Pilbara. Significant changes in management started during the Brucellosis and Tuberculosis Eradication Campaign (BTEC), begun in the 1980s, including increased fencing and consequently improved livestock control, as well as increased use of *Bos indicus* cattle. The live export market itself has induced a transformation from traditional breeding and fattening systems that turned off bullocks at around 4-5 years of age, to enterprises with a higher proportion of breeders turning off cattle at a younger age.

In the Kimberley, direct sale to live export is essentially the only current viable market for cattle. Local processing works have been closed since the end of BTEC, as they were unable to compete with prices offered to producers supplying live export. The Pilbara is somewhat better placed to service both live export, through northern and southern ports, and processing markets. Approximately 50% of Pilbara cattle are turned off for direct live export through the ports of Broome and Port Hedland and the balance are trucked south for finishing prior to live export (Clarke *et al.,* 2007). Most of the Kimberley and Pilbara cattle are unsuitable for domestic markets (age and breed) and those that are processed in Australia are exported as lower value manufacturing beef.

In recent years, nearly all classes of northern Western Australian cattle had found a market in live export. However, more recently larger, older beasts have not been accepted for live export, as Indonesian importers enforced a requirement for younger stock not exceeding 350kg liveweight. Additionally, problems are being encountered with finding northern markets for Shorthorn (*Bos taurus*) cattle from the North Kimberley.

The supply of cattle to livestock export markets remains seasonal, and governed by the summer wet season. Historically stock have only been accessible during the dry season and turnoff peaked initially in May (early dry season sales) and then again in September (to capitalise on final boat loadings). The viability of a more intensive production system funded through live exports and featuring smaller more manageable paddocks, improved watering points and access roads, has helped even out the supply pattern.

3.2 Regional Description

The Northern Rangelands encompasses the Land Conservation Districts (LCDs) of Ashburton, De Grey, East Pilbara and Roebourne in the Pilbara, and Broome, Derby-West Kimberley, Halls Creek-East Kimberley and North Kimberley in the Kimberley. The Pilbara LCDs generally have a reasonably uniform number of leases in each LCD, but, in the Kimberley, the two major catchments of the Ord and the Fitzroy Rivers contain the majority of the pastoral leases (Figure 1 and Table 2).

In the Northern Rangelands (Kimberley and Pilbara) as at 2011, there are 154 pastoral leases, with 92 in the Kimberley and the remainder in the Pilbara. Ownership is variable, ranging from large corporate conglomerates, private companies, and indigenous organizations and, particularly in the Pilbara, mining companies (Figure 2).

Information from rangeland surveys indicates that the condition of perennial vegetation varies considerably across the region. Overgrazing had resulted in reduced rangeland productivity over a significant proportion of the survey area, and effectively permanent degradation of some areas (Payne, 1979; 1988; Payne *et al.,* 1988; van Vreeswyk *et al.*, 2004a; Craig, *pers comm.).* For example, the Pilbara survey conducted in 1995 (van Vreeswyk *et al.,* 2004a) identified that, of the 181 736 sq kms assessed, 322 sq kms were severely degraded, 12% of the area was assessed as being in “poor” condition, and only 46% of the area assessed as “good” condition.

Table 2. LCDs and lease number per LCD considered for this report, Northern Rangelands Region.

LCD	Number of Leases
Pilbara LCDs	
Ashburton	16
DeGrey	15
East Pilbara	13
Roebourne	18
Total	**62**
Kimberley	
Broome	9
Derby West Kimberley	31
Halls Creek-East Kimberley	36
North Kimberley	16
Total	**92**
Total – Northern Rangelands	**154**

3.3 Climatic Conditions

The Kimberley region has a tropical monsoon climate with two dominant seasons separated by short transitional periods. Hot and humid conditions characterise a tropical summer season from November to April. The region receives about 90% of its rainfall during this period, when low pressure systems and unstable air characterise much of the weather pattern. From May to October the Kimberley is influenced by high pressure systems and a predominantly south easterly airflow from the continent's interior. This brings the dry season. The vegetation is tropical savannah in the north and arid desert grassland in southern parts.

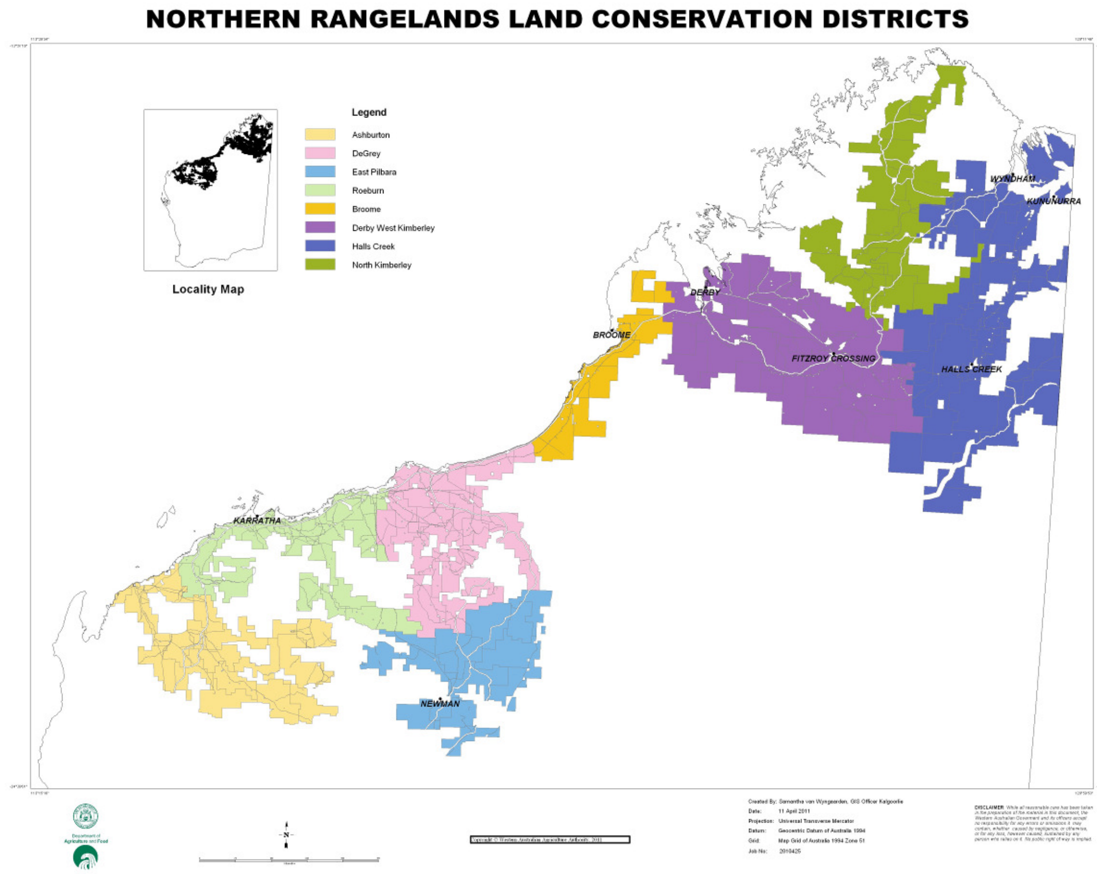

Figure 1.Western Australian Pastoral Land Conservation Districts, Northern Rangelands region.

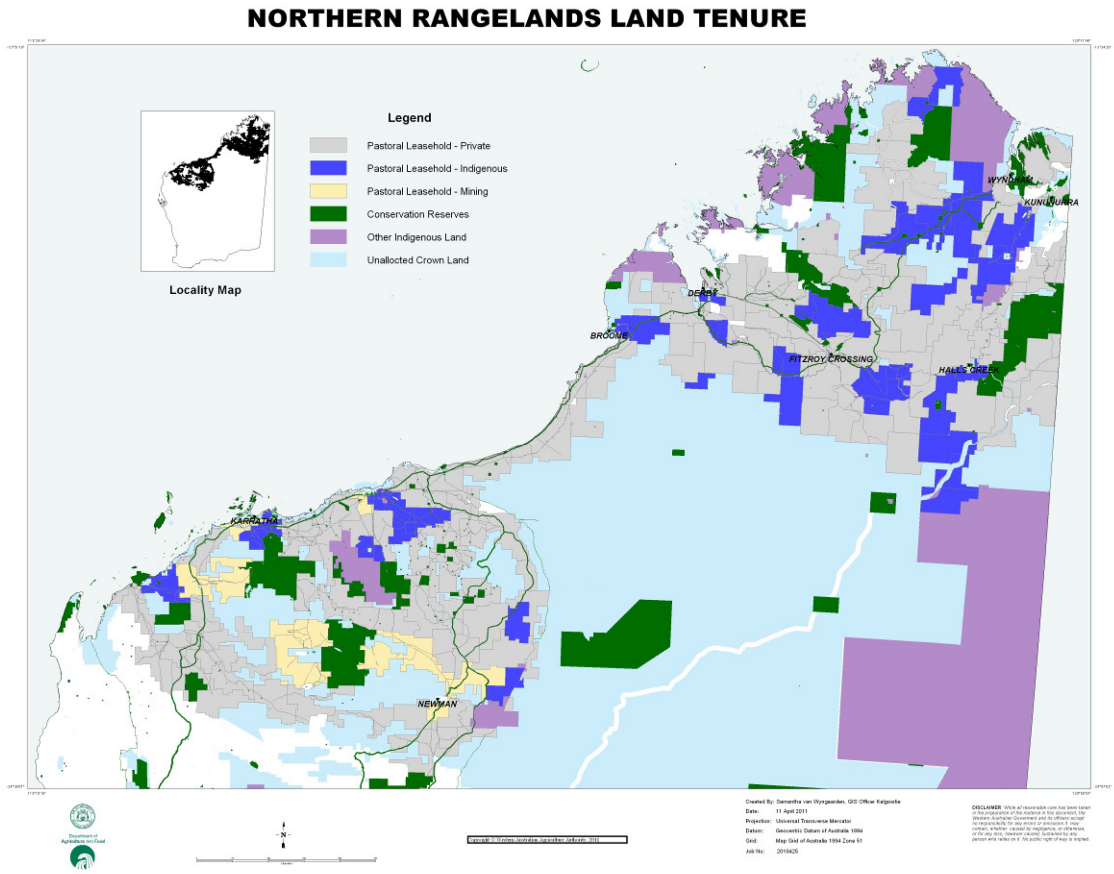

Figure 2. Western Australian Pastoral Land Tenure, Northern Rangelands region

The Pilbara region occurs roughly on the boundary between the summer dominant and winter / uniform rainfall zones. Poor or even failed wet seasons are more frequent in the Pilbara compared with the Kimberley. For example, the west Pilbara (Yarraloola, 100 year data) can on average expect a failed wet season every 4th year and the east Pilbara (Warrawagine, 100 year data) every 6th year (Holmes *et al.,* 2010). The critical issue here is the productivity and financial recovery time from such an event, because if its duration exceeds the frequency of recurrence, recovering from failed seasons is a permanent constraint.

In the Pilbara, there is a gradual change from hummock (mainly spinifex) or tussock grasses in the north to shrub-dominated understoreys in southern parts.

To illustrate this climatic variability, a seasonal quality index was estimated for each WARMS site in the Northern Rangelands.

Seasonal quality was assessed for the Kimberley region for each of the epochs (an epoch is a 3 year sampling cycle, the first being 1994 to 1996, the last 2006 to 2008) since current WARMS data have been collected (Table 3). In general, seasonal quality has been above average in the Kimberley over the past 15 years, with the majority of WARMS sites classified as "above average" (Table 3), and no sites assessed as experiencing a "below average" epoch during this period.

Seasonal conditions in the Pilbara and Gascoyne grasslands were variable across LCDs (Table 4), with the most favourable conditions being recorded in the 1990s, and a greater prevalence of "average" or "below average" years recorded since 2000. Data suggest the East Pilbara has received good seasons over the last six years, while there was a substantial occurrence of "below average" seasons in the Ashburton and Roebourne LCDs.

Rangeland climate varies between years and over longer timeframes. Major changes in the climate that affect grazing enterprises have been recorded since the 1970s, and rainfall trends are particularly important (McKeon *et al.,* 2009). The extent to which these trends can be attributed to longer term climate change is debatable. Nevertheless, changes in landscape processes in response to anomalous rainfall / drought episodes provide examples of likely impacts. The increased summer and autumn rainfall in most rangeland regions of western Australia is associated with, or causing, substantial changes in landscape hydrology, vegetation and Potential CC.

Climate change projections, including changes in rainfall, temperature, and other climatic variables, are likely to affect forage and cattle production Heat stress is a significant issue for livestock grazing in tropical areas of Australia because it reduces productivity and reproductive success. The incidence of heat stress may increase with the prospect of global warming. Therefore, it is anticipated that there will be decreases in carrying capacity given that the best prediction of climate change impacts across the rangelands is for a decline (or little change) in rainfall and an increase in temperature.

Table 3. Percentage of WARMS sites assessed as receiving above average, average or below average seasonal conditions, Kimberley LCDs

LCD	**Seasonal quality**	**Cycle 1 (E1 to E2)**	**Cycle 2 (E2 to E3)**	**Cycle 3 (E3 to E4)**	**Cycle 4 (E4 to E5)**
Broome	Above average	78%	100%	76%	41%
Broome	Average	22%	0%	24%	59%
Derby West Kimberley	Above average	97%	100%	25%	92%
Derby West Kimberley	Average	3%	0%	75%	8%
Halls Creek East Kimberley	Above average	68%	100%	75%	78%
Halls Creek East Kimberley	Average	32%	0%	25%	22%
North Kimberley	Above average	74%	100%	74%	82%
North Kimberley	Average	26%	0%	26%	18%

Table 4. Percentage of WARMS sites assessed as receiving above average, average or below average seasonal conditions, Pilbara and Gascoyne LCDs.

LCD	**Seasonal quality**	**Cycle 1 (E1 to E2)**	**Cycle 2 (E2 to E3)**	**Cycle 3 (E3 to E4)**	**Cycle 4 (E4 to E5)**
Ashburton	Above average	59%	14%	na*	12%
Ashburton	Average	41%	86%	na	26%
Ashburton	Below average	0%	0%	na	62%
DeGrey	Above average	na	100%	11%	80%
DeGrey	Average	na	0%	44%	20%
DeGrey	Below average	na	0%	44%	0%
East Pilbara	Above average	na	na	70%	100%
East Pilbara	Average	na	na	30%	0%
East Pilbara	Below average	na	na	0%	0%
Roebourne	Above average	na	100%	20%	18%
Roebourne	Average	na	0%	17%	48%
Roebourne	Below average	na	0%	63%	34%

*na implies no WARMS sites assessed in the LCD during that epoch.

3.4 Range Condition, Trend and Viability

Grazing pressure is the major driver influencing rangeland condition and trend and, consequently, carrying capacity. However, lessees" stocking rates decisions are often based on short-term economic benefits. This, plus a combination of limited knowledge, optimism or myopic management, and inadequate regulatory control, has led to overstocking. Legislation mandates ecologically sustainable, not economically sustainable, management. However, on a given area of rangeland, an ecologically sustainable stocking rate may not be economically viable because the return per stock unit at the ecologically sustainable rate may be insufficient to yield a profit. In dry years in particular, even the most conservative stocking rate may be detrimental to range condition. Yet, it is at these times that the capacity of a manager to modify stock numbers is often limited by market constraints and livestock condition. Therefore, deciding how to make an optimal decision on stocking rate given the rangelands environment is difficult. This is exacerbated by the fact that stocking rates above ecologically optimum stocking rates are financially most attractive at anything other than a zero discount rate (Wang and Hacker, 1997). Such economic factors require pastoralists to focus on short-term profitability, and often require an increase in stocking rates and consequently forage utilisation to levels well above long-term sustainable levels. The propensity to adopt this approach is enhanced by the time lag in the obvious impacts of overgrazing. This lag suggests, in the short term at least, that there is no long term loss to rangeland productivity.

The presence of palatable, perennial species defines range condition. In other words, they are a proxy for range condition, with range condition synonymous with the density of desirable species relative to the potential of the particular vegetation type in question. Perennial species confer a degree of stability on the animal production system in the face of varying seasonal conditions. In grasslands, overgrazing causes a decline in desirable (and previously dominant) perennial species (shrubs and grasses), with these species often reduced to isolated plants or scattered patches, particularly close to waterpoints. Less palatable species replace desirable plants, or perennial vegetation disappears almost entirely. In many instances, ground cover is completely lost, with soil erosion and almost total deterioration of the soil's hydrological properties (Holm *et al.,* 2003). Rain, when it does fall, is often ineffective in generating vegetative growth, owing to reduced infiltration and increased run-off.

Year-to-year (i.e. continuous) variation in rainfall as well as episodic events (Watson *et al.,* 1996) is the major constraints and opportunities driving both rangeland degradation and the likelihood of recovery (Watson *et al.,* 1997). However, it is perhaps simplistic to focus on rainfall and its variability as the major cause of rangeland degradation. Many units within the landscape possess inherently low productive potential and hence attractiveness to cattle, so that more productive areas take the brunt of the grazing pressure and are often severely degraded as a result. A primary driver of degradation has been overstocking, not only when the rangeland was under stress during the frequent periods when rainfall was below mean values, but also during periods of average seasons (the effect of continuous processes (Watson *et al.,* 1996)). This highlights that a major challenge is to optimise economic performance, yet at the same time maintain stocking rate within carrying capacity and reduce the degradation risk. That this must be done within a highly variable and unpredictable climate and financial returns, and within the context of total grazing pressure from not only domestic stock but also native (such as kangaroos) and feral (such as camels and goats) herbivores merely adds to the complexity of the problem.

Cattle production and management characteristics are highly variable across the Northern Rangelands regions. Based on Western Australian Pastoral Lands Board (PLB) *Annual Return of Livestock and Improvements* for the five years to 2004-2005, the Kimberley region carried, on average, over 576,000 cattle units. This is roughly equivalent to the Present CC calculated for each lease, and about 70% of the Potential CC for the region. However, this was by no means consistent across the region. Company-operated properties were generally stocked up to 30% above their respective Present CC, and owner-manager properties, on average, carried numbers close to their Present CC. Indigenous-managed leases (which now account for approximately one third of the 92 Kimberley pastoral leases) were stocked, on average, about 40% below the Present CC.

Over the same 5-year period, and also based on the *Annual Return of Livestock and Improvements* to the PLB, the Pilbara region carried an average over 230,000 cattle units, which was almost 30% above the Present CC of the region and close to 100% of its Potential CC. Properties owned by mining companies carried numbers close to their Present CC (and 80% of Potential CC) while Indigenous-managed properties were at about 80% and 65% of their Present and Potential CC respectively. Owner-manager properties were stocked, on average, 20% above their Present CC while corporate/aggregation properties were 75% above their Present CC.

These data suggest that the Pilbara, as a whole, is being stocked above its capacity, and that this is most common on properties operated as part of an aggregation or as part of a corporate entity. As in the Kimberley, most areas in the Pilbara recorded average or above-average rainfall and associated pasture growth, for many of the 12 years to 2005 and especially from 1993 to 2001. This may have inflated expectations of property carrying capacities. Indeed, the current Pilbara cattle numbers are a reflection of the sharp increase in regional numbers that occurred from 1997 and plateaued from about 2002.

DAFWA reports trends in regional and district land condition in pastoral rangelands annually to the PLB. These are based on data collected in the Western Australian Rangeland Monitoring System (WARMS; Novelly *et al*., 2008). WARMS is designed to report on the rangeland condition at the district or regional level, not at the individual pastoral lease level.

In the Kimberley, monitoring sites were established between 1994 and 1996, and were assessed five times to 2008. Recorded perennial grass frequency increased up until 2002 but since then has remained relatively steady. As noted above (Table 3), much of the region has had a run of above-average seasons over this period. This implies that stocking levels and stocking management in the Kimberley over the 5 years to 2008 were generally sustainable within the prevailing climatic conditions.

In the Pilbara, monitoring sites were established between 1994 and 2001 and, have been assessed five times. Perennial grass frequencies at WARMS grassland sites in the Pilbara were generally lower during the fifth assessment cycle compared to the fourth, although in the Roebourne LCD recorded perennial grass frequencies increased. Van Vreeswyk *et al.,* (2004b) reported on assessments of range condition across the Pilbara from 1995 to 1999. This report provides clear evidence of grazing-induced changes in vegetation throughout the survey area such as fence line effects between paddocks, piosphere effects around watering points and decline of key plants in preferred communities. The less preferred land types, such as spinifex grasslands on stony plains and low hills, typically experience little impact of grazing and were assessed as being in “good” condition. While only 12% of the Pilbara region as a whole was assessed as being in “poor” condition, 30% or more of the area of more productive, and preferred, land types was assessed as in “poor” condition. Another 20% or so of these land types was assessed as “fair” condition (Van Vreeswyk *et al.,* 2004b).

The consequence of these stock numbers on the resource over the 3 years 2006 to 2008 in the Northern Rangelands and the relative stocking levels are illustrated in Figure 3. Changes in recorded grass frequencies from WARMS sites are represented horizontally, either increasing (to the right of the figure) or decreasing (to the left) compared with the previous WARMS sampling cycle. Reported animal numbers relative to the assessed Present CC of leases within each LCD are represented vertically. LCDs with average reported stock numbers above the average Present CC are in the upper half, and those with average stock numbers below the average Present CC in the lower half of the figure. Ideally, the place to be is on the right hand side of Figure 3.

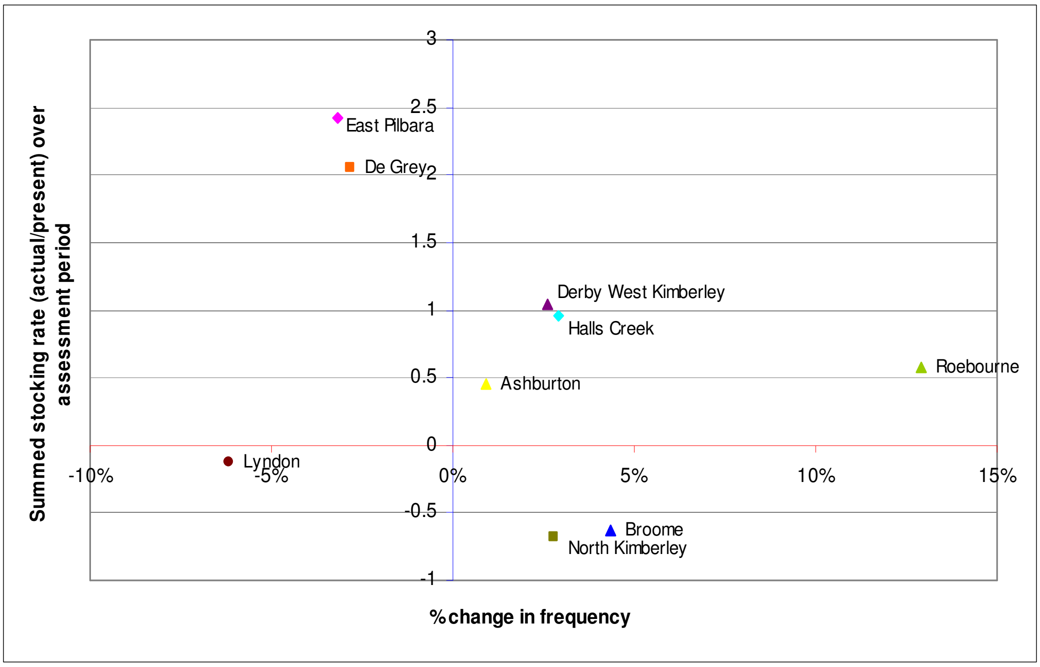

Figure 3. Changes in recorded frequency of desirable perennial grasses in relation to grazing pressure, Northern Rangelands LCDs.

In considering this information, the antecedent status of grass frequency should be considered. For example, while Figure 3 indicates grass frequency in the Roebourne LCD had improved substantially over the previous three years (despite a slightly above capacity stock level across the district and 34% of WARMS sites in the district having a seasonal quality rated as “below average” and only 18% “above average”), this increase is on the back of the previous three year period in which the frequency of desirable perennial grasses in the Roebourne LCD declined by 27%. Therefore, the increase is from a low base, with the recovery significantly less than the decline in the previous sampling cycle. Conversely, positive changes recorded during the 2006-2008 assessment in Kimberley LCDs all surpassed the declines recorded at the previous assessment.

4 RESULTS

4.1 Regional Analysis

A total of 154 leases in the Northern Rangelands were assessed using the analysis process described above, and their carrying capacity defined for a range of land potential scenarios (Tables 6 and 7). Data on land potential were derived from rangeland survey reports. In particular, as outlined in the analysis process, the impact of allocating a zero Potential CC rating to land system types in which a positive return to investment in development and management would not be possible was assessed.

Table 6. The number of leases in Pilbara in relation to Potential Carrying Capacity classifications (assumes all rangeland in "good" range condition) meeting a range of viability thresholds.

Number of Pilbara Leases Reaching Viability Thresholds (62 pastoral leases in total)			
Viability threshold (cu)	**All land systems included**	**Land systems with low pastoral potential excluded**	**Land systems discounted to current range condition with low pastoral potential excluded**
3000	35 (56%)	30 (48%)	22 (35%)
4000	25 (40%)	22 (35%)	12 (19%)
5000	17 (27%)	13 (21%)	7 (11%)
6000	12 (19%)	11 (18%)	4 (6%)

The number of leases reaching the various viability thresholds declined as the viability threshold increased, as land systems with low pastoral potential were excluded, and as the carrying capacity reduction due to rangeland condition decline was incorporated. Only 35 of 62 (56%) pastoral leases in the Pilbara reached the lowest viability threshold of 3000 cu when all land systems within the lease were included. The similar figure for the Kimberley was 79 of 92 leases (86%). Discounting the Potential CC for current range condition and removing low pastoral potential country significantly reduced the number of lease reaching viability thresholds in the Pilbara. The impact was less in the Kimberley.

Table 7. The number of leases in Kimberley in relation to Potential Carrying Capacity classifications (assumes all rangeland in "good" range condition) meeting a range of viability threshold.

Number of Kimberley Leases Reaching Viability Thresholds (92 pastoral leases in total)			
Viability threshold (cu)	**All land systems included**	**Land systems with low pastoral potential excluded**	**Land systems discounted to current range condition with low pastoral potential excluded**
3000	79 (86%)	78 (85%)	71 (77%)
4000	76 (83%)	74 (80%)	60 (65%)
5000	67 (73%)	64 (70%)	49 (53%)
6000	59 (64%)	57 (62%)	39 (42%)

4.2 The Impact of Range Condition and Rehabilitative Management

Potential CC assumes good range condition. However, widespread range deterioration has occurred in the Northern Rangelands since settlement, and this has had a significant impact on the carrying capacity (Jennings, 1979; Payne 1979, 1988; House *et al.,* 1991), and hence viability of pastoral businesses at an individual and regional level. That rangeland condition has declined across the Northern Rangelands therefore reflects a lower expectation of rangeland carrying capacity compared with its non-degraded state. Discount factors to account for this were used to reduce the carrying capacity of each lease according to the most recent assessment of lease-level range condition by DAFWA. This, in turn, reduced the number of leases that met the viability threshold (Tables 6 and 7).

Rangeland plant species exhibit differing growth responses to different rainfall events. This response to rain is confounded by the presence or absence of grazing pressure (Gardiner, 1986a; 1986b). Nevertheless, given adequate seasons, strict grazing management is an effective option for rehabilitation in rangeland assessed as being in "fair" condition. Optimal grazing management is, in many instances, complete destocking for an extended period. Under these conditions, some degree of rehabilitation is achievable. However, management strategies based on the reduction in livestock numbers or complete removal of domestic stock are often insufficient to guarantee an improvement in range condition if populations of kangaroos and feral herbivores are not similarly controlled. Moreover, it is really only during extended periods of favourable soil moisture that substantial improvement in range condition is possible, independent of stock numbers (Watson *et al.,* 1997; Watson *et al.,* 2007). Mechanical intervention has a very low probability of delivering a cost-effective rehabilitation outcome.

Based on the above assessment, it was assumed that a substantial period (say 5 years) of rehabilitative management (essentially total destocking) could improve current range condition. The choice of five years was related to the assumed capacity of an individual business to tolerate a period during which possibly substantial proportions of the lease would not be available for grazing. While it is appreciated that longer time periods (decades or more) of destocking may achieve substantial improvements in range condition, the capacity of a business to consider this a financially feasible option is doubtful.

Consequently, a range of scenarios of improvement in range condition were explored. These scenarios were defined from assessment of the WARMS rangeland monitoring data. Essentially, these scenarios consisted of an improvement of the areas of rangeland assessed as being in "fair" and "poor" range condition by various percentages over the five years of destocking, hence increasing the carrying capacity of the individual leases. These scenarios for the Kimberley were:

1. Improvement in the overall condition of the rangeland such that 25% of the reduction in carrying capacity is recovered over the period;
2. Improvement in the overall condition of the rangeland such that 50% of the reduction in carrying capacity is recovered over the period;
3. Improvement in the overall condition of the rangeland such that 75% of the reduction in carrying capacity is recovered over the period.

Because of the more arid conditions and greater rainfall variability, a less optimistic set of assumptions were defined for the Pilbara. These were:

1. Improvement in the overall condition of the rangeland such that 15% of the reduction in carrying capacity is recovered over the period;
2. Improvement in the overall condition of the rangeland such that 25% of the reduction in carrying capacity is recovered over the period;
3. Improvement in the overall condition of the rangeland such that 40% of the reduction in carrying capacity is recovered over the period.

Assessment was also conducted at each of the four threshold level carrying capacities assessed.

This process differs somewhat from that used in the Southern Rangelands (where rangeland assessed as "fair" condition was the focus of improvement. This is based on the grasslands being far more dynamic than the shrublands, with even grassland assessed as "poor" exhibiting a capacity to improve over the defined timeframe (and given seasons)).

Using these scenarios, leases were then ranked into three groups (Tables 8 and 9, and Figure 4). These groups were:

Category A Lease viable as a stand-alone pastoral enterprise in 2011 given current range condition and with the capacity to remain so under appropriate management.

Category B Lease not viable as a stand-alone pastoral enterprise in 2011, but considered able to attain viability following five years of rehabilitative management (essentially destocking) through improvement in range condition.

Category C Lease not viable as a stand-alone pastoral enterprise in 2011, and having insufficient biophysical capacity to become so within a 5-year time scale through improvement in range condition.

The data in the "0%" column in Tables 8 and 9 reflect the distribution of lease categories at the various threshold levels where there has been no improvement in range condition (i.e. reflect viability levels based on Present CC.

Table 8. Effect of recovery of range condition on the number of financially viable Pilbara pastoral leases, considering land systems with a pastoral potential of "low" or better and a range condition status as per the latest DAFWA assessment.

Threshold (cu)		**% Recovery of Discounted Range Condition**			
		0%	**15%**	**25%**	**40%**
3000	A	22 (35%)	22 (35%)	22 (35%)	22 (35%)
	B		1 (2%)	3 (5%)	4 (6%)
	C	40 (65%)	39 (63%)	37 (60%)	36 (58%)
4000	A	12 (19%)	12 (19%)	12 (19%)	12 (19%)
	B		1 (2%)	4 (6%)	4 (6%)
	C	50 (81%)	49 (79%)	46 (74%)	46 (74%)
5000	A	7 (11%)	7 (11%)	7 (11%)	7 (11%)
	B		1 (2%)	2 (3%)	4 (6%)
	C	55 (89%)	54 (87%)	53 (85%)	51 (82%)
6000	A	4 (6%)	4 (6%)	4 (6%)	4 (6%)
	B		0 (0%)	0 (0%)	2 (3%)
	C	58 (94%)	58 (94%)	58 (94%)	56 (90%)

* See text for definition of Categories A, B and C.

The greater improvement in range condition of Kimberley leases compared with Pilbara leases is based on the more favourable seasons that generally occur in the Kimberley, and because of the greater concentration of stock on the smaller proportion of preferred (by cattle) land systems in the Pilbara. Also, the potential of Kimberley land systems is generally higher than those land systems in the Pilbara (Table 1), with a greater capacity to respond to management. The lower potential land systems are generally in far better condition than the higher potential land systems (excluding "very high"). This is because the lower potential land systems are generally substantially more stable and resistant to grazing (dominated by spinifex and other resilient perennial grasses in many instances), and often are inaccessible and unattractive to stock. Subsequently, these land systems generally receive an actual grazing pressure below that applied by the manager. In contrast, the higher potential land systems generally experience an actual grazing pressure greater than that applied by the manager as they are often favoured by stock and tend to be comprised of vegetation types that are preferred by stock. Consequently, favoured land systems in the Pilbara are commonly overgrazed. This substantially compromises their capacity to improve.

Table 9. Effect of recovery of range condition on the number of financially viable Kimberley pastoral leases, considering land systems with a pastoral potential of "low" or better and a range condition status as per the latest DAFWA assessment.

Threshold (cu)		**% Recovery of Discounted Range Condition**			
		0%	**25%**	**50%**	**75%**
3000	A	71 (77%)	71 (77%)	71 (77%)	71 (77%)
	B		3 (3%)	5 (5%)	5 (5%)
	C	21 (23%)	18 (20%)	16 (17%)	16 (17%)
4000	A	60 (65%)	60 (65%)	60 (65%)	60 (65%)
	B		5 (5%0	7 (8%)	11 (12%)
	C	32 (35%)	27 (29%)	25 (27%)	21 (23%)
5000	A	49 (53%)	49 (53%)	49 (53%)	49 (53%)
	B		3 (3%)	9 (10%)	13 (14%)
	C	43 (47%)	40 (43%)	34 (37%)	30 (33%)
6000	A	39 (42%)	39 (42%)	39 (42%)	39 (42%)
	B		2 (2%)	7 (8%)	10 (11%)
	C	53 (58%)	51 (55%)	46 (50%)	43 (47%)

* See text for definition of Categories A, B and C.

Northern Rangelands Pastoral Lease Viability
Modelled on 4,000 cu using 'Low' Pastoral Potential Land Systems or Better

Figure 4. Distribution of Northern Rangelands pastoral leases rated as Classification A, B or C based on viability threshold of 4 000 cu, excluding low productivity landscapes, and including recovery of 50% (Kimberley) and 25% (Pilbara) of discounted carrying capacity due to improvement in range condition.

4.2 Analysis at the LCD Level

While the key attributes determining lease viability (lease size, land system potential and range condition) are evident across the Northern Rangelands region, their impact is not consistent across LCDs. While direct comparisons are complicated by the different number of leases in each LCD, the assessment of viability indicated that the proportion of viable leases in LCDs varies, and that some LCDs are dominated by leases classified as Category C (Table 10). Moreover, the viability of the Kimberley region as a whole appears greater than that of the Pilbara.

Table 10. Lease classification by LCD, at Potential Carrying Capacity excluding low productivity landscapes, 50% or 25% recovery of discounted range condition in the Kimberley and Pilbara respectively and a viability threshold of 4,000 cu.

LCD	Total	Lease Classification					
		A		B		C	
PILBARA							
		No.	%	No.	%	No.	%
ASH	16	5	31%	2	13%	9	56%
DEG	15	3	20%	0	0%	12	80%
EAP	13	1	8%	1	8%	11	85%
ROE	18	3	17%	1	6%	14	78%
Total	62	12	19%	4	6%	46	74%
KIMBERLEY							
		No.	%	No.	%	No.	%
BRM	9	7	78%	1	11%	1	11%
DWK	31	21	68%	2	6%	8	26%
HAL	36	19	53%	4	11%	13	36%
NTK	16	13	81%	0	0%	3	19%
Total	92	60	65%	7	8%	25	27%

4.3 Analysis at the Individual Lease Level

A listing of individual leases and their classifications (A, B or C) is provided in Appendix 2.

Leases in the Northern Rangelands have a Potential CC ranging from above 15 600 cattle units to around 110 cattle units, and lease areas ranging from around 81 sq km to around 15 600 sq km. The impact of the reduction in Potential CC through the removal of land systems of limited productivity varies between leases and within and between LCDs (Appendix 2).

5 DISCUSSION

This analysis concludes that a proportion of pastoral leases within the Northern Rangelands are non-viable based on a biophysical assessment of their capacity to be ecologically sustainable. However, a higher proportion of Kimberley leases appear to be viable compared with Pilbara leases, and the restriction to exclude low potential land systems has a greater impact on lease viability in the Pilbara compared with the Kimberley. This more positive situation in the Kimberley reflects the general characteristic of Kimberley leases having a lower proportion of low pastoral potential rangeland, and highlights the greater issues in the Pilbara associated with cattle congregating on more favourable land systems.

The impact of an improvement in range condition is relatively uniform across the Northern Rangelands. Comparing the common figure (25% improvement), the percentage of leases classified as B (able to become viable within five years) sits in a range of around zero to 9%. It is only with the very optimistic 75% range condition improvement in the Kimberley analysis that figures of around 20% are achieved. In a hierarchy of drivers towards viability, the inherent potential of the land systems is far more significant than the current range condition. In other words, an extended period of destocking will not return the majority of non-viable leases to viability.

Despite a more favourable situation in the Kimberley compared with the Pilbara, this assessment of lease viability is generally consistent with previous and recent assessments. The 1985 Kimberley Pastoral Industry Inquiry stated (Dept. Regional Development and the North West, 1985 - page 26):

> "*The Kimberley industry has been profitable in the past and still is where cattle are run close to "steady state" conditions, with herd sizes of at least 10 000 – 12 000 head*".

Far more recently, McCosker *et al.,* (2009) stated (page 4):

> "*In 2009, the northern beef industry is in its worst state since the beef slump of the 1970s with average return on assets (ROA) of 0.3% to 2.0%. Average beef producers tend to be spending more than they have earned in 6 of the last 7 years, indicating the northern beef industry is generally in a very unprofitable and unsustainable state*".

And again on page 63:

> "*Overall, the extensive rangelands of northern Australia have beef production systems and businesses that are poorly productive and have poor or non-existent profitability. The majority of beef production businesses in northern Australia are not economically sustainable*".

Some northern pastoral businesses struggle with poor returns and inadequate capital performance despite significant changes to production systems (in particular the move to *Bos indicus* cattle). There has been limited productivity improvement through innovation over the past decades. Many businesses have very little enterprise capacity to adopt change, while current lease conditions lessen the incentive of the lessee to make capital investment in diversified activities. The declining terms of trade evident elsewhere are also evident in the northern pastoral industry, and many businesses struggle to generate sufficient capital for financial survival. Consequently, as reported in the *Annual Return of Livestock and Improvements,* a not-insignificant number of pastoral leases increasingly rely on a non-pastoral enterprise for business viability.

Viability is not static, the viability threshold is rising, and will continue to rise. Scale has been shown to be a major contributor towards profitability and its effects are amplifying. Data from Queensland (McCosker *et al.,* 2009) indicates that at the beginning of the decade, 1,123 LSU (large stock units) were needed to maintain overheads at $80/LSU. At the end of the decade, the corresponding number was 2,405 LSU.

There appears to have been (and probably still is) a general over-estimation of the carrying capacity of the rangeland resources in the Northern Rangelands by managers and lessees, particularly in the Pilbara. Annual return data reveal that reported cattle numbers more than doubled in the East Pilbara and DeGrey LCDs between 1993 and 2008, with negative consequences recorded on range trend. Although variable, stock densities rose in the Kimberley over the same period, with the exception of the Halls Creek / East Kimberley LCD. Stock densities doubled in the Derby West Kimberley and North Kimberley LCDs. These are regional figures, with considerable heterogeneity among leases within the region and within LCDs. The higher than average proportion of Halls Creek / East Kimberley leases currently managed by indigenous interests (which are either virtually destocked or which run stock numbers very much below the Present CC) lowers the overall LCD average.

Stock numbers generally increase during periods of above-average rainfall. These higher numbers often become considered the norm, with continuation of elevated stocking rates with a return to average seasons. Stock numbers may even continue to rise during below average seasons. This is evident in the Pilbara. The continuing increase in reported Pilbara stock density has not been accompanied by recent good seasonal conditions. In the period of the fifth WARMS assessment cycle, 62% of WARMS sites in the Ashburton LCD were assessed as receiving a “below average” season. However, stock densities rose during this period.

The adverse business outcomes overgrazing is reduced livestock performance and marketability, diminution of lessees’ equity (primarily through livestock feeding costs), and risks to animal welfare. The extremely poor performance of the extensive breeder herd is an alarming contributor to poor business performance (McCosker *et al.,* 2009).

An obvious consequence is also rangeland degradation. In the Ashburton LCD, the frequency of perennial grasses assessed within the WARMS program declined slightly to 79% in the 2006-2009 cycle as cattle numbers continued to rise. In particular, the damage caused to the rangeland by retention of livestock during below average rainfall years degrades its drought resilience – its capacity to sustain livestock at the onset of periods of rainfall significantly below the median. This exacerbates the adverse effects of subsequent below average rainfall years on financial performance, initiates calls for government assistance, and delays or even precludes rangeland recovery.

This analysis identified that, although there are differences between the Kimberley and Pilbara, the current situation in the Northern Rangelands is one in which many pastoral leases have a varying, and sometimes significant, portion of their lease area comprised of inherently low pastoral productivity rangeland, and are subsequently of doubtful viability. Some Pilbara leases have in excess of 85% of their land systems classified as being of “very low” pastoral potential. This figure is as high as 100% in the Kimberley, albeit on leases substantially smaller than the average. Of the 92 Kimberley leases, 31 have greater than 50% of their area classified as being of “very low” potential, with the corresponding figure for the Pilbara being 12 of 62 leases.

Of those leases potentially viable, a significant proportion fail to reach the viability threshold when their carrying capacity is discounted according to their most recently assessed range condition. At the same time, information from the *Annual Return of Livestock and Improvements* submitted by lessees indicates that many Pilbara leases have continued to increase their current stock numbers to levels inappropriate to the current condition and potential of the rangeland on the lease, and continue to survive financially by further degrading rangeland condition. Of particular note is the limited effect of extended destocking on improving productivity. This is due to the major impact that “poor” condition rangeland is having, and the near impossibility of returning such rangeland to any form of productivity approaching pristine conditions because of soil loss and the breakdown of soil hydrological cycles.

Primary production in arid and semi arid rangelands is pre-determined by precipitation, the soils and topographic position of an area, ahead of species composition (Chew and Chew, 1965; Fischer and Turner, 1978; Friedel, 1981). Consequently, increases in the grass component of the vegetation do not necessarily imply an increase from the original Potential CC (which assumes all the rangeland is in “good” condition), although it may substantially increase the carrying capacity of the degraded landscape (i.e. increase the Present CC). This is because areas previously rated as “poor” condition prior to grass invasion can be rated as in “fair” or even “good” condition if the density and coverage of the grass component is significant, and if the grass species itself is a desirable species with respect to pastoral production. Therefore, such changes should not necessarily be considered as evidence of some grazing capacity significantly in excess of the pristine state and hence an argument as to viability.

The conclusions as to lease viability drawn from this analysis, particularly for the Pilbara, run counter to the fact that there remain 154 pastoral leases in the Northern Rangelands, the majority of which are currently running livestock and supporting pastoral businesses. How can this contradiction be explained? Obviously, the initial assumptions made for the analysis (jointly run leases and non-pastoral income have been ignored) goes some way to explaining this. Some leases owned by either mining companies or indigenous groups, or occasionally private interests, are effectively destocked and are not functioning as a pastoral business. Additionally, that different thresholds exist for different pastoral enterprises is acknowledged, as is the role of differing levels of managerial expertise, and the revenue from opportunistic harvesting/sale of feral animals from virtually zero managerial input. However, the explanation can also be found in the data reported by lessees in their *Annual Return of Livestock and Improvements* to the Pastoral Lands Board, and the Rangeland Condition Assessments conducted by DAFWA. Many leases are being run with reported stock numbers (as per the *Annual Return of Livestock and Improvements*) in excess of the rangeland’s inherent potential, the current condition of the rangeland on the lease, and without due regard to the limitations imposed by seasonal conditions or legislative requirements. Therefore, such leases appear to have continued to survive financially by degrading rangeland condition, an activity for which there is no short term financial cost. Consequently, when unfavourable seasonal conditions occur, there is no capacity in the system to absorb the impact.

Without significant technological advances (unlikely), reversal in the terms of trade (also unlikely) or significant restructuring, it is difficult to conceive a viable future as ecologically sustainably managed pastoral businesses for a substantial proportion of leases. Certainly, for these leases, it is not logical to foresee a viable future without further, potentially irreparable exploitation of already degraded rangelands.

Pastoralism is the largest spatial land user in the Northern Rangelands. Ecological sustainable management of grazing enterprises is complex. Ongoing pasture utilisation beyond species tolerance leads to plant mortalities and vegetation and range condition decline. The difficulties in making correct management decisions when faced with a range of uncertainties including climate and finances are obvious. These difficulties are exacerbated if the inherent productivity of the resource is not well understood by the land manager, with unrealistic expectations leading to overgrazing. The inability to accurately assess carrying capacities and grazing pressure, which form the basis of forage budgeting, militates against the adoption of ecologically sustainable grazing practices. The adoption of conservative stocking rates and a stock management policy responsive to climatic variability (and subsequent pasture availability) are clearly the required strategies to prevent degradation and promote pasture recovery. However, it appears that some pastoral lessees, particularly in the Pilbara, feel either compelled (presumably by a combination of insufficient carrying capacity and financial imperatives) to stock the rangeland resource to (or beyond) its limit (Wang and Hacker 1997), or are unable to correctly assess the potential of the rangeland resources such that they manage livestock numbers within the capability of the rangeland. Therefore, in many situations, the current status of rangeland condition suggests that degradation processes were already in train whenever drought occurred, and that drought hastened the inevitable decline in range condition.

6 CONCLUSIONS

A significant proportion of pastoral leases in the Northern Rangelands (dependent on the assumptions used, particularly the viability threshold) are non-viable based on the potential carrying capacity and the condition of the rangeland resources. The situation is far less favourable in the Pilbara than the Kimberley. In some LCDs in the Pilbara, well over 50% of pastoral leases are identified as non-viable in this assessment, based on the assumptions used. This conclusion is consistent with previous reviews and analyses (see, for example, Department of Regional Development and the North West, 1985; McCosker *et al.,* 2009).

For those leases defined as non-viable, lease size is too small, the land systems comprising the leases are too often of limited productive potential, and the rangeland condition, particularly the more productive areas of many leases, has been degraded.

Many leases are overstocked in terms of forage availability, itself a function of season and range condition. Range condition decline is on-going. However, at the same time, many leases require a level of investment in some form of ongoing remedial action towards long term sustainability.

Therefore, while on average these businesses need to be running substantially more cattle to be financially viable, this situation is in direct conflict with the legislative imperative to maintain, or in some instances regain, ecological sustainability.

Current stock numbers in excess of the Present CC would suggest that a continuation of the status quo will witness a continued decline in both business viability and range condition, particularly when unfavourable seasonal conditions occur.

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APPENDIX 1.

Discount factors

The discount factors listed below for each survey (and which were used in this analysis) are those from the published rangeland survey reports and reflect the decisions made at that time.

		KIMBERLEY	
		cu/sq km	
	Good	Fair	Poor
High	10.0	5.0	1.0
Moderate	6.0	3.0	0.5
Low	3.0	1.5	0.5
Very Low	1.0	0.5	0.0
Unsuitable	0.0	0.0	0.0

		PILBARA	
		cu/sq km	
	Good	Fair	Poor
Very High	16	8	5
High	8	4	3
Moderate	4	2	2
Low	2	1	1
Very Low	1.0	0.8	0.7
Unsuitable	0.6	0.6	0.6

APPENDIX 2.

Lease level assessment of pastoral leases: Pilbara

Name	LCD	Station Area (ha)	Lease Viability Category (A, B, C)
Ashburton Downs	ASH	311235	
Balfour Downs	EAP	431180	
Bonney Downs	DEG	373621	
Boodarie	ROE	77053	
Cheela Plains	ASH	187903	
Coolawanyah	ROE	177131	
Coongan	DEG	184671	
Corunna Downs	DEG	221161	
De Grey	DEG	379474	
Eginbah	DEG	224662	
Ethel Creek	EAP	373265	
Glen Florrie	ASH	197268	
Hamersley	ASH	299917	
Hillside	DEG	405800	
Hooley	ROE	171004	
Indee	ROE	160892	
Juna Downs	EAP	194745	
Kangan	ROE	122804	
Karratha	ROE	99951	
Kooline	ASH	209394	
Mallina	ROE	295527	
Mandora	DEG	91604	
Mardie	ROE	224740	
Marillana	EAP	357532	
Minderoo	ASH	226585	
Mininer	ASH	222291	
Mt Divide	EAP	199148	
Mt Florance	ROE	105317	
Mt Stuart	ASH	345508	
Mt Welcome	ROE	190951	
Muccan	DEG	176899	
Mulga Downs	ROE	354708	
Mundabullangana	ROE	197497	
Nanutarra	ASH	233664	
Noreena Downs	EAP	376207	
Panorama	DEG	248317	
Pardoo	DEG	198037	
Peedamulla	ASH	224328	
Pippingarra	ROE	62919	
Prairie Downs	EAP	227231	
Pyramid	ROE	108458	

Red Hill	ASH	188844	
Robertson Range	EAP	23969	
Rocklea	ASH	387637	
Roy Hill	EAP	396604	
Sherlock	ROE	98467	
Strelley	DEG	248936	
Sylvania	EAP	192922	
Uaroo	ASH	246286	
Ullawarra	ASH	268333	
Urala	ASH	55978	
Walagunya	EAP	180040	
Wallal Downs	DEG	232617	
Wallareenya	DEG	204969	
Wandanya	EAP	202824	
Warambie	ROE	69006	
Warrawagine	DEG	397303	
Weelarrana	EAP	172860	
Wyloo (west)	ASH	188709	
Yalleen	ROE	313921	
Yarraloola	ROE	222974	
Yarrie	DEG	257022	

Lease level assessment of pastoral leases: Kimberley

Name	LCD	Station Area (ha)	Lease Viability Category (A, B, C)
Alice Downs	HAL	136974	
Anna Plains	BRM	383037	
Bedford Downs	HAL	375262	
Beefwood Park	DWK	205555	
Billiliuna	HAL	162889	
Blina	DWK	254617	
Bohemia Downs	DWK	109463	
Bow River	HAL	300878	
Brooking Springs	DWK	193873	
Bulka	DWK	274709	
Burks Park	HAL	8145	
Carlton Hill	HAL	367405	
Carranya	HAL	357809	
Carson River	NTK	307701	
Charnley Springs	NTK	297903	
Cherrabun	DWK	272278	
Christmas Creek	DWK	138490	
Country Downs	BRM	150822	
Dampier Downs	DWK	260073	
Doon Doon	HAL	384970	
Doongan	NTK	309182	
Drysdale River	NTK	396760	
Durack River	HAL	379959	
El Questro	HAL	273435	
Ellenbrae	NTK	380965	
Elvire	HAL	63570	
Fairfield	DWK	80989	
Flora Valley	HAL	148222	
Fossil Downs	DWK	394028	
Frazier Downs	BRM	133149	
Gibb River	NTK	378755	
Glen Hill	HAL	14275	
Glenroy	NTK	107813	
Gogo	DWK	386691	
Gordon Downs	HAL	395365	
Home Valley	HAL	246753	
Ivanhoe	HAL	292211	
Jubilee Downs	DWK	91720	
Kachana	HAL	77513	
Kalyeeda	DWK	122519	
Karunjie	HAL	274244	
Kilto	BRM	26813	
Kimberley Downs	DWK	251198	
Koongie Park	HAL	38516	
Lake Gregory	HAL	271699	
Lamboo	HAL	360597	
Lansdowne	HAL	331271	
Larrawa	DWK	191596	
Leopold Downs	DWK	404647	

Lissadell	HAL	116984
Liveringa	DWK	260290
Louisa Downs	DWK	199434
Madigan	HAL	339445
Margaret River	HAL	176148
Marion Downs	NTK	253533
Meda	DWK	369190
Millie Windie	NTK	18463
Millijidee	DWK	306799
Moola Bulla	HAL	394236
Mornington	NTK	312019
Mowanjum	DWK	51969
Mowla Bluff	DWK	71977
Mt Amhurst	HAL	259201
Mt Anderson	DWK	93696
Mt Barnett	NTK	124835
Mt Elizabeth	NTK	196723
Mt House	NTK	367312
Mt Jowlaenga	BRM	84950
Mt Pierre	DWK	216088
Myroodah	DWK	401944
Napier Downs	DWK	386679
Nerrima	DWK	202986
Nicholson	HAL	280942
Nita Downs	BRM	210714
Noonkanbah	DWK	169791
Osmond Valley	HAL	15584
Pantijan	NTK	174379
Quanbun Downs	DWK	129688
Roebuck Plains	BRM	280980
Rosewood	HAL	19073
Ruby Plains	HAL	480859
Shamrock	BRM	178141
Sophie Downs	HAL	138623
Spring Creek	HAL	97151
Springvale	HAL	134335
Sturt Creek	HAL	315275
Tableland	NTK	311243
Texas Downs	HAL	312773
Thangoo	BRM	172056
Theda	NTK	303107
Yakka Munga	DWK	189437
Yeeda	DWK	386645

A Report on the Viability of Pastoral Leases in the Southern Rangelands Pastoral Region Based on Biophysical Assessment

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7 September 2012

EXECUTIVE SUMMARY

The Southern Rangelands region of Western Australia has low and variable rainfall (mean values of 250 mm per annum and coefficients of variation of 50% or more), land systems of limited pastoral potential, and a history of rangeland degradation which reduces livestock carrying capacity. Cattle, wool sheep and meat sheep are the dominant pastoral industries, although the capacity of the landscape to support domestic livestock is low.

An analysis was carried out on the viability of individual pastoral leases in this region, utilizing an assessment of the biophysical parameters associated with pastoralism, in particular the inherent productivity of the land systems, and the impact of a decline in rangeland condition on that potential. This analysis was based on assessment of the pastoral leases and not on any particular industry sector. Additionally, the fact that some leases are run in combination with other leases in the one business, and that many businesses have substantial non-pastoral income was ignored.

Of the 292 pastoral leases in the Southern Rangelands assessed in this analysis, ignoring the reduced productivity due to rangeland degradation, but excluding from consideration land systems whose pastoral potential is so low such that investment in infrastructure is non-viable, and applying a threshold viability level of a potential carrying capacity of 10,000 dse:

- 131 do not meet the viability threshold when all available land area is considered
- 181 do not meet the viability threshold when only land with a potential carrying capacity of ≥ 5.5 dse/sq km is considered
- 219 do not meet the viability threshold when only land with a potential carrying capacity of ≥ 7.5 dse/sq km is considered.

The background and arguments behind this assessment are discussed.

As lease carrying capacity was further reduced by discounting potential productivity as a consequence of rangeland degradation, the number of leases attaining financial viability declined substantially. At a viability threshold of 10 000 dse, excluding land systems whose potential carrying capacity was < 7.5 dse/ha, and accounting for carrying capacity decline as a consequence of rangeland degradation, only 46 of the 292 leases were rated as being viable. Leases not meeting this threshold are distributed throughout the region, although some Land Conservation Districts (the district basis for much of the analysis) contain no pastoral leases that reach the threshold.

Given the magnitude and level of rangeland degradation, the analysis examined to what extent viability could be improved by applying a period of virtually complete destocking to restore rangeland productivity. The conclusion was that the outcome would be minimal.

It would appear that a significant proportion of pastoral leases in the Southern Rangelands (greater than half and dependent on the assumptions used) are non-viable based on their inherent productivity and the capacity of the rangeland resources to be managed in an ecologically sustainable manner. Range condition decline continues on many leases, and it is difficult to envisage a future for a substantial proportion of individual Southern Rangelands pastoral leases without further, potentially irreparable exploitation of already degraded rangelands.

1 INTRODUCTION

The Southern Rangelands region has made a significant contribution to the Western Australian economy. In 1985 the region supported more than 2,000,000 sheep, producing almost 10,000 tonnes of wool. The current outlook for wool production in the region is far less favourable. This, together with other factors including a decline in rangeland carrying capacity has greatly reduced the size of the wool industry. By 2008, sheep numbers had fallen by 75% to 500,000 sheep and wool produced fallen by more than 80% to 1,500 tonnes. The current deterioration in the terms of trade is expected to continue, and it is unlikely that returns from wool production can sustain the necessary investment in infrastructure required.

There is evidence that alternative small stock production (meat sheep or goats) is potentially more profitable than Merino sheep, while numbers of cattle in the Southern Rangelands increased substantially as sheep numbers fell. However, like Merino sheep, these industries are still extremely susceptible to deteriorating terms of trade.

Earlier reviews have highlighted the challenging circumstances of the Southern Rangelands. However, most of the previous reviews of the Southern Rangelands (see, for example, Jennings *et al* (1979) and Holm *et al* (1995)) have focused on the pastoral wool industry (as opposed to pastoralism). Given the changing nature of pastoralism in the Southern Rangelands and the move to both cattle and meat sheep, this report focuses on the pastoral lands themselves, and their capacity (under the current situation and condition) for ecologically sustainable pastoral production, rather than review one, or all industries *per se.* Consequently, this review has started from the potential of the basic resource to produce forage for domestic stock and the impact of the decline in the range condition on that potential. Obviously, any ultimate consideration of the capacity of the rangelands for pastoralism requires an assessment of those economic/financial benchmarks to allow classification of areas either exhibiting, or not, capacity to sustain pastoralism. However, for the purposes of this report these benchmarks will be generic, and the terms of trade, current prices etc of individual enterprises will alter the final classifications generated. A comparison analysis dealing with the financial aspects of the Southern Rangelands pastoral industry has being conducted (Allan Herbert, *pers com*).

The objectives of this report are as follows:

- Review the biophysical condition of pastoral land in the Southern Rangelands.
- Investigate appropriate criteria and define the viability of pastoral activities from a biophysical viewpoint.
- Report on the current state of the rangelands at both a lease and district level, identifying those leases in the Southern Rangelands with:
    1. Little prospect of stand-alone viability from pastoral production under any management regime,
    2. The potential to sustain a viable pastoral grazing enterprise following a period of rehabilitative management (essentially long-term destocking);
    3. Existing capacity to sustain a viable pastoral grazing enterprise.

The region has been assessed as to its viability for continuing pastoralism, across existing pastoral industries at the individual lease and district level. Income derived from any alternative diversified activity, common particularly over the last decade or more, and its effect on business viability, is ignored (see discussion below). This is despite the income generated by these activities often being a substantial, if not the major, source of income for the business. Some of these activities such as tourism use pastoral resources of the lease (land, water, ecological amenities) and require a permit from the Pastoral Lands Board (PLB). Alternatively, activities are conducted independently of the pastoral lease (off-property income generation), such as another occupation held by the lessee or his/her spouse, or businesses such as contracting to mining companies.

2 THE ANALYSIS PROCESS

2.1 Output

The process carried out for the purposes of this report was to determine, using biophysical parameters of pastoral grazing land potential, the rangeland's capacity to support domestic stock, and current rangeland condition if a lease fell into one of three categories. These categories were:

Category **A** Lease viable as a stand alone pastoral enterprise in 2011, with a capacity to remain so under appropriate management.

Category **B** Lease not viable as a stand alone pastoral enterprise in 2011, but able to attain viability following five years of rehabilitative management (essentially destocking).

Category **C** Lease not viable as a stand-alone pastoral enterprise in 2011 and having insufficient biophysical land capability for pastoralism to become so within a decadal time scale.

2.2 Viability

Information on pastoral lease viability in the Southern Rangelands is limited. Each situation is unique, and general rules difficult to determine. However, a fundamental principle is that enterprises must have sufficient scale to amortise costs across the business, and the lease must possess sufficient productivity to sustain this scale.

Therefore, this assessment considered viable pastoralism as an enterprise that must simultaneously:

1) Maintain or improve the condition of the rangeland as required by legislation;
2) Generate a sufficient financial income to meet:
    a. Fixed costs (overheads)
    b. Variable costs (operating)
    c. Provision for depreciation of capital items
    d. Generate an acceptable return on investment;
3) Sustain both 1 & 2 over time and during periods of seasonal and market variability.

Fixed costs remain largely constant irrespective of the intensity of the enterprise and include items such as personal drawings, interest, rents and rates, insurance, capital items and consumables that are independent of operations (e.g. generator fuel, vehicle running costs, education, phone, etc). To cover fixed costs a pastoral enterprise must possess a certain scale*,* and it is very likely that the minimum scale will vary between districts, e.g. Wiluna versus Yalgoo.

Variable costs are those that arise directly from the operations of the enterprise and include mustering, fuel, animal husbandry, repairs and maintenance and staff wages. The capacity to cover variable costs is determined by enterprise productivity.

The determination of a viability threshold is difficult, as individual situations vary, as does the threshold as enterprises and districts change. Various figures have been used in the past, and the range is significant. Recent assessment by Department of Agriculture & Food Western Australia (DAFWA) (Herbert, *pers comm.*) has suggested that a figure in excess of 10 000 dse would be realistic, and that this figure may be as high as 15 000 dse. Therefore, for initial analysis, this biophysical assessment adopted the figure of 10 000 dse. This figure is the same as that used by Holm *et al* (1995) as the cut off below which a lease would be classified as non-viable. However, as with the assumptions on the effect of spelling on improvement in range condition (outlined below), a capacity was introduced into the analysis to permit a modification of this number (to reflect the range indicated by Herbert's analysis) so that its sensitivity could be tested. Moreover, the on-going decline in the terms of trade for pastoral production in the Southern Rangelands will undoubtedly result in a steady requirement to increase the viability threshold to merely remain static.

Two points should be noted in the viability assessments. Firstly, each lease was individually assessed, irrespective of whether or not it formed part of an amalgamated lease business. This decision was based on the ability under current legislation for each lease to be individually sold, such that its forming part of an amalgamated operation in 2011 was no guarantee that such would always be the case. Secondly, non-pastoral income in whatever form was not considered. It is acknowledged that a significant number of pastoral businesses in the Southern Rangelands have some form of non-pastoral income. However, as with the situation of multiple leases being combined in the one business, there was no guarantee that either the current or the future lessees would continue to have access to this additional income, and that at some point the lease may be required to be fully viable as a stand alone pastoral enterprise.

2.3 Lease Level Potential Carrying Capacity

The Potential Carrying Capacity (Potential CC) of each pastoral lease has been determined by the Department of Agriculture & Food Western Australia (DAFWA) based on assessment and estimation of the productivity of the land systems comprising each lease. The Potential CC is not a mandated stock level. Rather, it is an average (over a decadal timescale or more) number of stock that a lease could carry, if fully developed, and still satisfy the legislative requirement for ecologically sustainable management. In periods of above average seasons, it would be expected that the lease could run above its Potential CC, while in poorer seasons stock numbers would be reduced to well below the Potential CC.

Information exists on the land systems of each pastoral lease in the Southern Rangelands, based usually on rangeland survey data. The published data (see Table 1) have a high level of integrity, consistency, reproducibility and spatial detail. Alternatively, Beard's vegetation mapping (Beard, 1975) is used for those few areas yet to be surveyed (areas east of Wiluna and the southern Goldfields). This latter information is less useful, and experience is that carrying capacity estimations for rangeland derived from Beard's survey tend to be more optimistic than those from rangeland surveys. This will have an impact on classification of land productivity in determining biophysical viability. The areas of each land system on each lease are known, and for each land system a Potential CC (dse/unit area – generally a square kilometre) has been determined, usually in consultation with pastoral lessees in the survey area. Therefore, for each lease, the sum of the Potential CC for each of the constituent land systems provides the lease level Potential CC.

Absolute values of Potential CC, not descriptors ("low", "moderate", "moderately high" etc) were used in this assessment. This was necessary because, although the Potential CC for each land system on each lease was determined from the relevant rangeland survey report, for some leases, land systems were defined from two rangeland survey reports. Generally, this had no impact because Potential CC estimations in the southern surveys are directly comparable. However, some leases in the north were surveyed, in whole or in part, during the Ashburton survey which is more reflective of higher productivity northern land systems. To account for this, land systems defined in the Ashburton survey were included in calculations based on their absolute Potential CC estimate rather than their qualitative descriptor.

Table 1. DAFWA Rangeland Survey Technical Bulletins.

Technical Bulletin No. 62: *An inventory and condition survey of the rangelands in the Ashburton River catchment, Western Australia.* Published in 1988 - revised edition.
Technical Bulletin No. 73: *An inventory and condition survey of rangelands in the Carnarvon Basin, Western Australia,* (WA Department of Agriculture). Published in 1987.
Technical Bulletin No. 84: *An inventory and condition survey of the Murchison River catchment and surrounds, Western Australia.* Published in 1994.
Technical Bulletin No. 87: *An inventory and condition survey of the north-eastern Goldfields, Western Australia.* Published in 1994.
Technical Bulletin No. 90: *An inventory and condition survey of the Sandstone-Yalgoo-Payne's Find area, Western Australia.* Published in 1998.
Technical Bulletin No. 92: *An inventory and condition survey of the Pilbara region, Western Australia.* Published in 2004.
Technical Bulletin No. 93: *An inventory of rangelands in part of the Broome Shire, Western Australia.* Published in 2005.
Technical Bulletin No. 96: *An inventory and condition survey of the lower Murchison River area, Western Australia.* Published in 2009.
Technical Bulletin No. 97: *An inventory and condition survey of the Western Australian part of the Nullarbor region* (***in press***).
Miscellaneous Publication 16/2003, *Re-assessment of carrying capacities in the Ashburton River catchment.* Published in 2004 – revised edition.

2.4 Impact of available water

Potential CC assumes two characteristics. Firstly, it assumes that all the potential grazing area can be accessed by stock. In the rangelands, this is predicated on water being available to livestock. In the Southern Rangelands, there is a paucity of reliable natural surface waters. Consequently, within this region the capacity to graze much of the rangeland requires investment in water point infrastructure. Viability demands that such investment provide a positive financial return under current terms of trade while making full provision for maintenance and depreciation of the asset.

As the density of waterpoints increases (the distance between them declines) then greater cost is incurred. Therefore, defining an optimal distance is important in both ensuring adequate grazing of forage resources (stock will only graze a certain distance out from water) and minimizing investment. While estimates vary, stock generally graze anywhere between 4 to 5 out to 10 kilometres from water (Burnside *et al.,* 1990; Brook *et al.,* 2004; Fensham and Fairfax, 2008) in a grazing radius, though the actual distance may be modified (either up or down) by the salinity of the water and/or the forage, the climate, topography or other factors. Therefore, it follows that a waterpoint potentially commands an area of up to 78 sq kms for a 5 km grazing radius and 314 sq kms for a 10 kilometre grazing radius. Using the average figure for the Southern Rangelands of 6.5 kms (Burnside *et al.,* 1990) and based on the potential carrying capacity of the land system(s) in which the waterpoint is situated, this area calculation allows determination of the number of stock that can be sustainably run in the 6.5 km grazing radius (133 sq km) surrounding the waterpoint. If, for example, the land system in which the waterpoint is located has a Potential CC of 5 dse/sq km (on a year-in, year-out basis), this implies that the grazing radius around that waterpoint can support approximately 665 dse. This is not to suggest that such numbers could be run at one waterpoint without the creation of substantial piosphere and overgrazing close to water, but is provided as an example of the calculation used. On the assumption that a waterpoint has an effective life of 25 to 30 years, and that there is an annual maintenance cost, then the costs associated with provision of that waterpoint can be determined. Equally, applying the known general parameters of livestock productivity, stock/wool prices and input costs, the maximum long-term financial return from the stock potentially able to be run on the area surrounding a waterpoint can be estimated. This provides a capacity to assess the financial viability of installing a waterpoint in a land system(s) of particular productive potential, and therefore whether or not it is financially viable to develop a given area on a pastoral lease.

It is appreciated that rangeland is heterogeneous, and that often the area surrounding a waterpoint will be a mosaic of pasture types within the grazing radius. However, for the purposes of this assessment the landscape surrounding waterpoints was considered uniform.

Given the current terms of trade, in determining viability not all pastoral rangeland on an individual lease necessarily has sufficient productivity to warrant investment in pastoral infrastructure. This may manifest as insufficient financial return to warrant investment in infrastructure in areas currently undeveloped, or insufficient cash flow to support upgrading and/or maintenance of existing infrastructure. Insufficient productivity may be a consequence of either inherent low rangeland productivity, the degraded condition of the landscape, or both. In such situations, the only option to increase the financial return from a waterpoint is to run a stock number in excess of the sustainable carrying capacity year in and year out. This creates an unacceptable risk of rangeland degradation, and is contrary to legislative requirements. Therefore, in assessing viability, land systems whose productivity does not warrant investment in pastoral infrastructure should be excluded.

In determining what land systems should be included in assessing viability, the decision was taken to include land with a Potential CC of either >5.5 dse/sq km or >7.5 dse/sq km. In defining these two alternatives, the productivity of a cattle herd using data derived from the 2010 Pilbara Benchmarking study was modelled. Harburg (*pers comm*) indicated that it was financially non-viable to invest in artificial waterpoints for land systems whose carrying capacity was below either of these figures, as their inherent productivity was too low to allow a sufficient number of stock to be sustainably run within the grazing radius to provide a viable financial return on the investment. Certainly, any land system with a carrying capacity below 5.5 dse/sq km was non-viable, and calculations suggested that only land systems with a carrying capacity of 7.5 dse/sq km or greater had sufficient productivity to be financially viable. Therefore, in this analysis, the lease level Potential CC was reduced by that component of the Potential CC derived from land systems with a carrying capacity of less than 7.5 dse/sq km potential. For means of sensitivity analysis, lease level Potential CC was also separately determined by excluding that component of derived from land systems with a carrying capacity below 5.5 dse/sq km. This provided two levels of land system potential for consideration in this report, > 5.5 dse/sq km and >7.5 dse/sq km.

The definition of these levels (5.5 and 7.5 dse/sq km) was constrained by the manner in which land systems are rated, and that a uniform grazing radius of 6.5 kilometres without any overgrazing close to water is optimistic. Moreover, it is appreciated that land systems are composed of land units of varying productivity, that the land system carrying capacity is a computation of the component land units, and land unit composition on individual leases is unavailable (only land systems are mapped). While this may have some implications for individual leases, it should not detract from the conclusions of this report.

2.5 Legislative Imperative

Land tenure in the pastoral rangelands of Western Australia is predominantly leasehold, with leases issued under the *Land Administration Act 1997* (LAA). The statutory authority for management of the pastoral estate rests with the Pastoral Lands Board and the Department of Regional Development and Lands (RDL). DAFWA provides technical assistance to RDL to support their activities. In addition, the Commissioner of Soil and Land Conservation under the *Soil and Land Conservation Act 1945* (SLCA) has the duty and powers to prevent or mitigate land degradation. If warranted, the Commissioner can make orders to destock and/or rehabilitate degraded land.

The specific provisions in both legislative Acts that relate to the rangelands are as follows:

Section 95 of the *Land Administration Act* stipulates the specific functions (among others) of the Pastoral Lands Board (PLB):

> 95 (c): "*to ensure that pastoral leases are managed on an ecologically sustainable basis";*
>
> 95 (e): "*to develop policies to rehabilitate degraded or eroded rangelands and to restore their pastoral potential".*

Section 108 of the LAA refers to the management of land under a pastoral lease:

> (4) "*The lessee must maintain the indigenous pasture and other vegetation on the land under the lease to the satisfaction of the Board."*

Section 101 Minister may grant pastoral lease over Crown lands:

(5) A pastoral lease must not be granted unless:

(a) the Board is satisfied that the land under the lease will be capable, when fully developed, of carrying sufficient authorised stock to enable it to be worked as an economically viable and ecologically sustainable pastoral business unit;

Section 108 Management of land under a pastoral lease:

(2) The lessee must use methods of best pastoral and environmental management practice, appropriate to the area where the land is situated, for the management of stock and for the management, conservation and regeneration of pasture for grazing.

(4) The lessee must maintain the indigenous pasture and other vegetation on the land under the lease to the satisfaction of the Board.

Section 13 of the *Soil and Land Conservation Act (1945)* stipulates the function of the Commissioner of Soil Conservation to be:

> "the prevention and mitigation of land degradation."

Furthermore, the WA Environmental Protection Agency has stated in its Position Statement No 5 that (page 22) "current landholders and managers should assume responsibility for the managed land that has lost environmental values due to previous poor practices", while under the *Environmental Protection Act (1986)* it is an offence to allow "substantial damage to some or all of native vegetation in an area and includes …the grazing of stock".

Consequently, good range condition and ecologically sustainable management should not be seen as some aspirational goal that may or may not be achieved depending on the vagaries of seasons or the markets. Rather, it is a clear legal requirement of a pastoral lessee under legislation, irrespective of seasons and markets, and carrying stock numbers in excess of the capacity of the landscape to be ecologically sustainable should not be considered an acceptable response under any circumstances, including the preservation of an operating cash surplus.

2.6 Impact of range condition

Rangeland condition determines the current productivity of a lease, and what level of stocking is required to satisfy the legislative requirements. Potential CC assumes all rangeland is in "good" range condition. However, as range condition declines, carrying capacity and drought resilience (the capacity of the rangeland to provide fodder during rainfall deficit) decline, since both the quantity and seasonal availability of forage decline (Condon *et al.,* 1969; Heady, 1975). This is evidenced by the downgrading of carrying capacity as a consequence of declining range condition in range survey reports (Table 1), and is the general case for rangelands (Cook *et al.,* 1962; Condon *et al.,* 1969; Christie and Hughes, 1981, Powell *et al.,* 1982 among others). Therefore, discount factors were developed during most rangeland surveys to permit calculation of reductions in carrying capacity due to declining range condition. These discount factors are published in the range survey reports (Table 1), and are listed in Appendix 1.

Discount factors to account for range condition decline were derived from carrying capacities obtained at stocking rate workshops held in conjunction with LCDs, during which the knowledge and experience of local managers was obtained. These results were compared with published research and the opinions of experienced DAFWA staff. There was general agreement between the three sources of information (van Vreeswyk, *pers com*). The discount rates reflect the current carrying capacity of the rangelands (i.e. maintain current condition). If range condition improvement is required (as per legislation), then even lower stock numbers are warranted. Given the requirements for the management of pastoral land under the legislation, it is likely that the discount rates are, in fact, optimistic, and that if a rate applicable to improve the rangeland was used, then a discount in Potential CC greater than that used in this analysis would be required.

Variation exists between surveys in the carrying capacity figures at different range condition classes (and hence discount rates) for some land systems. This occurred for three reasons (van Vreeswyk and Godden, 1998). Firstly, in some cases the proportion of land units comprising a land system varied in the description of that land system between surveys. Secondly, carrying capacity categories varied among surveys depending on the potential of the surveyed area. Finally, discussions with local LCD participants sometimes reflected different land system capabilities and land system components in different areas.

“Fair” condition rangeland retains a reasonable capacity to support stock when grazed at levels sufficient to allow improvement. However, “poor” condition rangeland is significantly degraded, to the point in some circumstances that it has virtually no residual capacity to exploit rainfall events except in exceptionally wet years, and has limited grazing potential and animal production capacity. While the carrying capacity of “poor” condition rangeland varies between land systems, in all cases “poor” condition implies virtual complete loss of drought resilience.

The stocking rate range used for the determination of animal numbers per unit area from land systems are reasonably uniform throughout the Southern Rangelands, and reflect a common assessment of rangeland potential. However, there is no consistent discount to account for range condition decline, and discount factors differ significantly between surveys. To deal with this and provide legitimacy for the assumptions, range condition discount factors in this analysis are those determined during rangeland surveys and published in relevant documentation. Discount factors defined during early rangeland surveys (Gascoyne, Carnarvon) were substantial. Later surveys (North East Goldfields, Nullarbor) applied less substantial discounts. This is not an issue for the Nullarbor survey, as virtually all of the rangeland was assessed as “good” condition. However, if discount factors consistent with the earlier surveys were applied, fewer leases in the Murchison and Goldfields would have met the viability threshold.

DAFWA assessments to 2008 provide information on pastoral rangeland at a lease level (percentage of “good”, “fair” and “poor”). Therefore, carrying capacity reductions as a consequence of range condition being other than “good” were determined, providing a lease carrying capacity reflective of the current range condition.

2.7 Impact of subsequent management (achieving Category B)

Rangeland in “poor” condition is in a stable degraded state, with rehabilitation unlikely within a practical timeframe (Wang and Hacker, 1997). This is not to say that “poor” condition rangeland has no grazing capacity, rather the opportunity for rehabilitation of “poor” condition rangeland is minimal at best. “Fair” condition rangeland has a far greater capacity to improve than “poor” condition rangeland, albeit slowly and not always back to the productivity level of the pristine state. This recovery is very much a function of the episodic nature of available soil moisture (Watson *et al.,* 1997).

For this analysis, it was assumed that, if destocking was total, around 50% of "fair" condition rangeland could revert to "good" condition within five years, allowing a proportion of the discounted carrying capacity to be reinstated.

Rehabilitative management would be applied for five years and would take the form of:

- Complete shut down of artificial stock water points;
- Fencing off natural water points from use by domestic and feral animals, allowing access to water only by native herbivores;
- Active removal of all (to the extent possible) domestic and feral grazing animals.

The figure of 50% was based on data from the Western Australian Rangeland Monitoring System (WARMS) (Watson *et al.,* 2007; Novelly *et al.,* 2008), and accounts for the fact that, given the climate of the Southern Rangelands, there was a reasonable likelihood that at least one, if not more, of the destocked years would receive below average rainfall. However, since it would be difficult to be certain about the possible range condition improvement, a sensitivity test was inserted into the analysis to allow various scenarios of range improvement (and hence carrying capacity increase following destocking) to be determined. Therefore, for each lease, the current discounted carrying capacity and the carrying capacity possible following five years of destocking under various improvement scenarios was determined.

Range condition can improve, but it is not a short-term process. Often transitions (Westoby *et al.,* 1989; Bestelmeyer, 2006) are recorded, where the ecology of an area changes virtually permanently, and removal of the major driver of change (grazing stock) will not achieve a return to "good" condition, even in the long term. Such transitions have been recorded in the Southern Rangelands (Watson and Novelly, 2010), particularly with "poor" condition rangeland. Through overgrazing, non-desirable species have replaced desirable species, and soils have become degraded, to the point that restoration actions are unable to recover the original state.

2.8 Other factors

This analysis does not account for several variables that would impact on the viability of enterprises based on pastoral leases and viability thresholds. These include:

- Variation in the viability threshold for different pastoral enterprises. There is no doubt that possible enterprises, or enterprise mix (live export, live export plus some sale to the agricultural areas, bullocks etc.), would have differing cost structures, and therefore different viability thresholds.
- Differences in fixed and variable costs, e.g. through proximity to towns and major roads, or the impact on distances to market or service centres.
- How heterogeneity and distribution of land systems within leases and land units within land systems would affect the financial return to infrastructure development.
- Variation in management innovation and managerial expertise among businesses and lessees/managers.

These factors will be important regionally (the viability threshold will vary between LCDs), and in identifying individual leases that may, or may not, fall into a given category.

3 SITUATIONAL ANALYSIS

3.1 Background

Pastoral viability in the Southern Rangelands is a function of inherent variability and limited productivity of the region's natural resources of soil, vegetation and rainfall. This section describes the biophysical context of the Southern Rangelands, and provides an understanding of the region's pastoral potential, the causes of rangeland degradation, and what criteria should be considered in assessing viability from a biophysical viewpoint.

3.2 Area

Western Australia's rangelands cover 87% of the state and include all but the south west. Pastoral leases, used for grazing livestock on native vegetation, cover 35% (874,000 km^2) of the rangelands, with the balance consisting of Unallocated Crown Land (UCL) and land vested for conservation and Indigenous purposes. There are currently 459 registered pastoral stations (comprised of 510 pastoral leases) in Western Australia.

This report considers the Southern Rangelands to be the southern pastoral zone (south of the Pilbara Region) between the South-West Agricultural Area and the arid interior, with a boundary delineated by Land Conservation District (LCD). It includes the Gascoyne, Murchison, Goldfields and Nullarbor Regions (Figure 1 and Table 2). These fall within the Local Government Areas (LGAs) of Meekatharra, Upper Gascoyne and Carnarvon. Depending on the delineation there are between 290 – 310 leases in the Southern Rangelands. Delineation may follow Local Government areas, DAFWA reporting regions, LCD boundaries, IBRA regions or other. This analysis uses a boundary delineated by LCD (includes Lyndon, Upper Gascoyne, Gascoyne/Ashburton Headwaters and Wiluna LCDs), a total of 292 leases.

The region is largely a mix of semi-arid mulga, spinifex and saltbush/bluebush vegetation communities supporting sheep, cattle and goats. In comparison to Northern Rangelands (essentially grasslands), productivity of the perennial vegetation communities (predominantly shrublands) in the Southern Rangelands is low. As a result of this and the unreliable seasons, perennial vegetation is more susceptible to degradation through overgrazing than northern grasslands.

The condition of perennial vegetation varies considerably across the region. Historic overgrazing has resulted in reduced rangeland productivity over a significant proportion of the area, and effectively permanent degradation of some areas of higher productivity rangeland, particularly in the Gascoyne and Murchison regions.

There is a diversity of land tenures in the Southern Rangelands (Figure 2), although private tenure (essentially a family or company owned pastoral business) predominates. Wool production was the major enterprise in the southern Gascoyne, Murchison and Goldfields areas. However, production from Merino sheep has and continues to experience deteriorating terms of trade. The contribution of Southern Rangelands sheep production continues to decline, and is currently less than 3% of the total value of the State's sheep production. This trend is expected to continue, although there is some evidence that alternative small stock production (meat sheep or goats) is potentially more profitable than Merino sheep. Over the past 20 years there has been a gradual expansion of the cattle industry (at the expense of the sheep industry) south through the Upper Gascoyne and Murchison areas. During the period that sheep numbers have been declining, cattle numbers increased by more than 300%, from 65,000 to over 200,000. Feral goat harvesting is common, with some leases also managing feral goats. Reported goat production currently accounts for around 33 000 dse, although this would underestimate the presence of unmanaged goats in the region (estimated to be 0.7 to 1 million; Johnson *pers comm.*).

Table 2. LCDs and lease number per LCD considered for this report, Southern Rangelands Region.

LCD		Number of Leases
Binnu*	BIN	4
Cue	CUE	9
Gascoyne Ashburton Headwaters	GAH	15
Gascoyne - Wooramel	GAW	16
Kalgoorlie	KAL	22
Lyndon	LYN	21
Meekatharra	MEK	20
Mt Marshall*	MML	2
Mount Magnet	MTM	17
Murchison	MUR	26
North Eastern Goldfields	NEG	29
Nullarbor - Eyre Highway	NUE	21
Perenjori*	PER	3
Sandstone	SAN	13
Shark Bay	SBY	13
Upper Gascoyne	UPG	19
Wiluna	WIL	18
Yalgoo	YAL	19
Yilgarn*	YLG	5
All LCDs		292

* Primarily an agricultural zone LCD, but does include pastoral leasehold country.

The move to cattle has come for reasons associated with perceived difficulties with small stock enterprises (producers consider cattle more resistant to wild dog predation, and require reduced infrastructure and lower labour inputs than sheep), as well as perceived superior financial returns from cattle production. The condition of small stock infrastructure has currently deteriorated to the point that many pastoral leases in the region have inadequate infrastructure to support a Merino sheep enterprise. Yet over a considerable period of time (more than 20 years), poor returns from sheep have diminished the capacity for pastoralists to either invest in necessary maintenance of sheep infrastructure or reinvest in the infrastructure required to support a cattle enterprise. This has implications for the productivity and sustainability of the resultant enterprise.

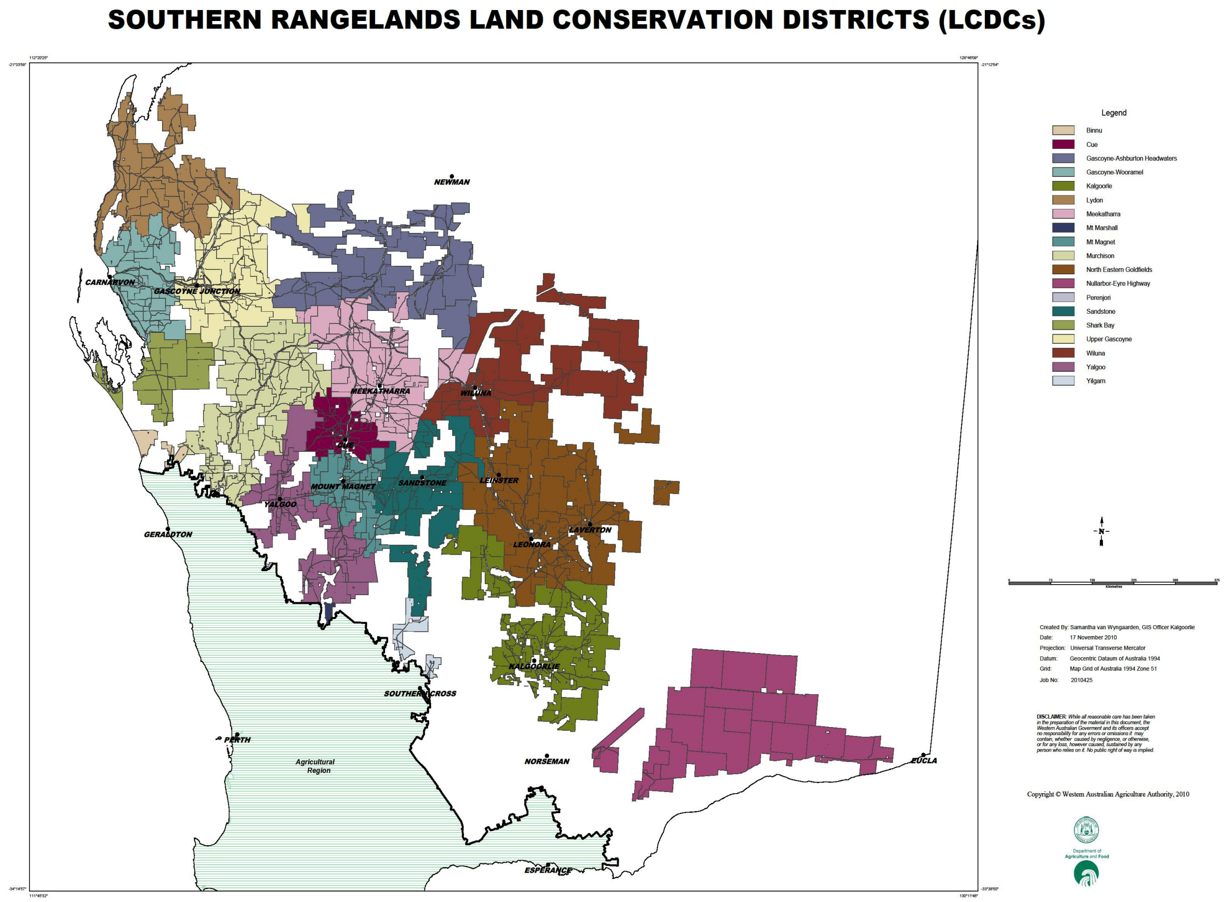

Figure 1.Western Australian Pastoral Land Conservation Districts, Southern Rangelands region.

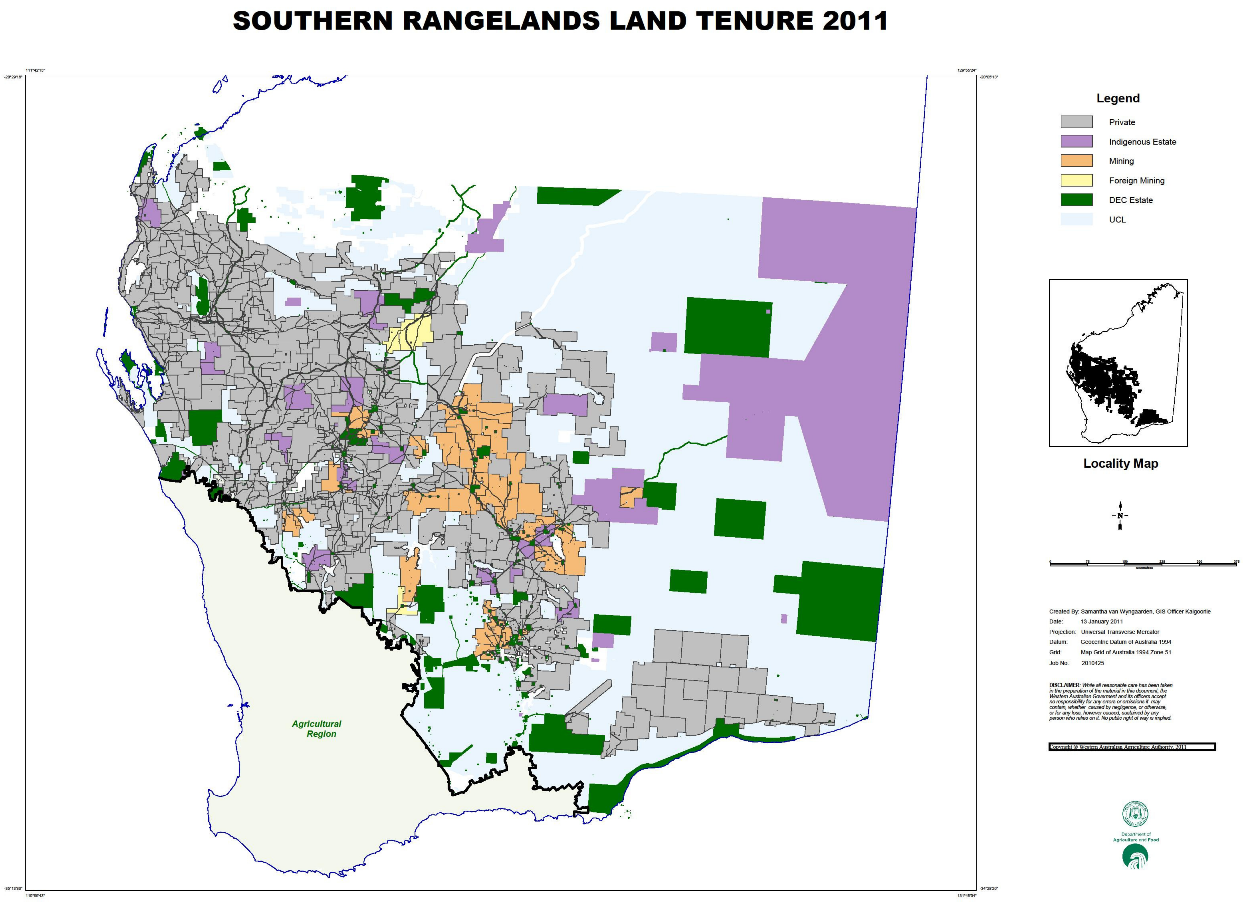

Figure 2. Western Australian Pastoral Land Tenure, Southern Rangelands region

3.3 Climatic Conditions

The natural driving force in the ecosystem of the Southern Rangelands is soil moisture from rainfall, which is stochastic. Rainfall drives vegetation dynamics. The winter rainfall pastoral zone of Western Australia has an average annual rainfall generally below 250 mm, most commonly around 200 mm (median rainfall around 50 mm per annum below the mean). Yearly variation in rainfall is high, with coefficients of variation from 50 to 60 per cent in many areas, the upper end of the scale compared to similar areas in Australia's pastoral zone (Novelly, *unpub data*). Nil rainfall can be recorded in any month. All this reflects an arid climate, with frequent dry years interspersed with occasional high rainfall events, and militates against sustainable management because maintaining forage demand (stocking rate) within supply (carrying capacity) is difficult in such a variable environment.

Holm *et al.* (1995), analysing the rainfall for the then sheep producing zone, defined that the most reliable winter rainfall in that zone in the Shark Bay LCD, where useful rains were recorded in 95% of years. In contrast, Wiluna LCD only receives a winter season in 45% of years (Holm *et al.,* 1995). Summer rainfall probabilities are low throughout the region. Substantial variation in rainfall also occurs at inter-decadal or longer timescales, in cycles that vary from 2.5 to 30 years or more (Gibbs and Maher, 1967; Allan, 2000), associated with either increased or decreased rainfall. These cycles provide either periods of sustained overgrazing risk or opportunities for rangeland recovery and financial stability.

To illustrate this variability, a seasonal quality index was estimated for each WARMS site in the Southern Rangelands. From 2000 to 2009, seasonal quality varied both temporally and spatially (Table 3). "Below average" seasons occurred in 49% of years, and only 22% were "above average". Moreover, the incidence of two, or even three, successive years when all sites within an LCD were" below average" was evident.

Management can do little to alter natural cycles of vegetation quality and quantity (Wilson and Harrington, 1984). Recent data and the longer term historical record reflect the seasonal risks affecting pastoralism in the Southern Rangelands, the significant spatial and temporal variation, and hence the difficulties in managing the balance between grazing domestic stock and critical forage levels. The impact of grazing pressure on the rangeland is most detrimental during "below average" seasons. However, "below average" seasonal conditions are not rare. Rather, with median rainfall only 80% to 90% of the mean and high coefficients of variation, "below average" is the norm for some LCDs for extended periods. Moreover, seasonal data reflect the risks associated with rehabilitative management. Minimal positive rangeland response can be recorded by one, two or even three successive years of destocking if seasonal conditions are adverse. From a district and regional viewpoint, these data also illustrate the variability in the region, and the difficulties of drawing general conclusions on seasonal conditions.

In summary, rainfall totals below the already low long-term mean are far more common in the Southern Rangelands than rainfall above the mean, rainfall is highly variable and successive below average seasons are common. Taken together, this defines an environment in which predicting available forage from one year to the next is extremely difficult, and suggests that if stock management is not flexible, overgrazing will be likely in most years.

Table 3. Average assessed seasonal quality of WARMS sites, Shrublands region, 1999 to 2009.

LCD	**Seasonal Quality**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Ashburton	Above	6			22	14	72	14	71	80	
	Average	68	42	48	72	4	28		29	20	4
	Below	26	58	52	6	82		86			96
Binnu	Above										
	Average				100		100			100	
	Below	100	100	100		100		100	100		100
Cue	Above	17			22	94		39		44	44
	Average	28		5	44	6	100	44	22	56	56
	Below	55	100	95	34			17	78		
Gascoyne Ashburton Headwaters	Above	12	28		63	60		80	63	68	
	Average	5	3	24	31	36	76	20	37	20	
	Below	83	69	76	6	4	24			12	100
Gascoyne Wooramel	Above					100				71	
	Average			16	31		100		100	29	
	Below	100	100	84	69			100			100
Kalgoorlie	Above		8		35	36	4			26	53
	Average		38		49	29	93		7	49	47
	Below	100	54	100	16	35	3	100	93	25	
Lyndon	Above				3	45	44		45	73	
	Average	45	6	53	51	10	56		55	24	
	Below	55	94	47	46	45		100		3	100
Meekatharra	Above	28	7		9	92		31	41	33	
	Average	33	2		83	8	72	24	36	34	24
	Below	39	91	100	8		28	45	23	33	76
Mt Magnet	Above				6	6	3	66		46	14
	Average		6	9	40	77	97	31		28	86
	Below	100	94	91	54	17		3	100	26	
Murchison	Above					33		27		91	3
	Average		6	3	66	61	100	20	42	9	3
	Below	100	94	97	34	6		53	58		94
North Eastern Goldfields	Above		56		30	89	7		6		27
	Average		32		37	11	45		8		63
	Below	100	12	100	33		48	100	86	100	10
Nullarbor Eyre Highway	Above		42		58	28	5		32		40
	Average	5	58	3	42	40	65	7	49	36	28
	Below	95		97		32	30	93	19	64	32
Sandstone	Above	11	20		7	40	7	16	9	9	38
	Average	11	51	22	38	42	93	38	11	22	58
	Below	78	29	78	55	18		46	80	69	4
Shark Bay	Above					24				82	
	Average				33	64	100		73	9	9
	Below	100	100	100	67	12		100	27	9	91
Upper Gascoyne	Above					89		19		93	
	Average			47	49	11	100	0	100	7	
	Below	100	100	53	51			81			100
Wiluna	Above	7	71		93	92		31	83		
	Average	3	29		7	8	75	20	9	43	30
	Below	90		100			26	49	7	57	70
Yalgoo	Above				8	4	35	29		88	63
	Average				69	48	65	6	14	12	33
	Below	100	100	100	23	48		65	86		4
Yilgarn	Above				100	33	50	50	50	83	50
	Average						50	17	17	17	17
	Below	100	100	100		67		33	33		33

Rangeland climate also varies between years and over longer timeframes. Major changes in the climate that affect grazing enterprises have been recorded since the 1970s, and rainfall trends are particularly important (McKeon *et al.,* 2009). The extent to which trends can be attributed to longer term climate change is debatable. Nevertheless, changes in landscape processes in response to anomalous rainfall / drought episodes provide evidence of likely impacts. The increased summer and autumn rainfall in most rangeland regions of western Australia is associated with, or causing, substantial changes in landscape hydrology, vegetation and Potential CC.

Climate change projections, including changes in rainfall, temperature, and other climatic variables, are likely to affect forage and animal production because it reduces animal production and reproductive rate. The incidence of heat stress may also increase with global warming. Therefore, it is anticipated that there will be decreases in carrying capacity given that the best prediction of climate change impacts across the rangelands is for a decline (or little change) in rainfall and an increase in temperature.

3.4 Rangeland Resources

Rangeland in Western Australia is described in terms of land systems, identified on the basis of distinctive combinations of soil, topography and vegetation. The potential of a land system to carry stock is based on those characteristics, the vegetation in particular. The land system is used as a guide to land capability and productive potential, in particular the number of stock (derived from dse estimates) that can be supported in a given area within natural resource limits, and without degrading the environment for present and future generations. The Potential CC provides a long term guide as to the potential productivity of the rangeland. The actual grazing value and appropriate stocking level of a particular paddock or lease at any particular time will vary with seasonal conditions, rangeland condition and degree of recent use.

The carrying capacity for any area or property is not fixed. It can be increased through development or technology. But mostly it is reduced by the pressures which accompany an increase in stock numbers. As rangeland is degraded, carrying capacity shrinks, leaving the rangeland (and hence the properties in that rangeland) unable to support the number of stock which could formerly been run in the area on a sustainable basis.

Rangeland is, in essence, a dynamic system operating in a stochastic environment, involving significant intertemporal variation over periods of varying length. Rangeland condition, expressed in terms of the availability of perennial, productive and palatable plants, is the fundamental determinant of productivity. The Potential carrying capacity implies all rangeland is in “good” condition. But rangeland productivity declines with decline in range condition, and this will fundamentally determine the long-run economic consequences of any management strategy.

The Southern Rangelands is dominated by “moderately high”, “moderate” or “low” pastoral potential land systems (Table 4), with approximately equal proportions of highly productive and low or unproductive land systems. However, significant variation exists in the distribution of productive potential between LCDs, between leases in an LCD and within the individual lease.

Table 4. Pastoral potential distribution, Southern Rangelands

Production potential classifications	Area (sq kms)	Percentage	Potential Stocking Rate (dse/sq km)
Very high	10 234	2	≥20
High	52 333	10	11-17
Moderately high	144 066	28	7-10
Moderate	132 757	25	5-7
Low	108 660	21	3-5
Very low	71 387	14	≤3
No description	3 135	1	
Total	522 571		

3.5 Range Condition, Trend and Viability

Grazing pressure is the major driver of rangeland condition and trend, and hence carrying capacity. But, lessees' decisions on stocking rates are often based on short-term benefits, and a combination of limited knowledge, optimism and myopic management by lessees, and inadequate legislative control has led to overstocking. Ecologically sustainable management is required by legislation, not economically sustainable management. At times, an ecologically optimal stocking rate may not be economically viable because the cost per stock unit at the ecologically sustainable stocking rate may be too high to permit a profit. In dry periods in particular, even the most conservative stocking rate may have a detrimental impact on range condition. Yet, it is at these times that the capacity to modify stock numbers is limited. Therefore, making an economically optimal decision on stocking rate is difficult. This is exacerbated by the fact that stocking rates above the ecologically optimum stocking rate are financially most attractive at anything other than a zero discount rate (Wang and Hacker, 1997). Such economic factors and the cost/price squeeze virtually require pastoralists to focus on short-term profitability, and often require an increase in stocking rates and consequently forage utilisation to levels well above the long-term sustainable carrying capacity. The facility to adopt this approach is enhanced by the time lag in the negative trend in condition to become obvious, suggesting, in the short term at least, no long term loss to rangeland productivity.

Palatable and perennial species define range condition. They are a proxy for range condition, with condition synonymous with the density of desirable species relative to the potential of the vegetation type in question. These species confer a degree of stability on the production system in the face of varying seasonal conditions. Overgrazing removes desirable (and previously dominant) perennial shrubs and grasses, with these species often reduced to isolated plants or scattered patches, particularly close to waterpoints. Desirable plants are replaced either with less palatable species, or perennial vegetation disappears almost entirely. In many instances, ground cover is completely lost, and soil erosion and almost total deterioration of the soil's hydrological properties results (Holm *et al.,* 2003). Rain, when it does fall, is often ineffective in generating vegetative growth, with run-off high and infiltration rates low.

Although annuals, ephemerals and short-lived perennials are often palatable and more nutritious to grazing animals than perennials (hence the high animal productivity in degraded rangeland in good seasonal conditions), they cannot maintain soil stability since they drop their leaves, decline in numbers or disappear in dry conditions. However the capacity of degraded rangeland to produce substantial forage in average or above rainfall years masks the true impact of overgrazing and decline in land capability.

Evidence for significant and widespread rangeland degradation is in the Southern Rangelands is unequivocal. The demise of the desirable plants as a consequence of heavy grazing has been long documented (Wilcox and McKinnon, 1972; Jennings, 1979; Payne *et al.,* 1987; 1988; House *et al.,* 1991) and is frequently associated with accelerated soil loss and subsequent implications for future vegetation productivity. Such decline is evident across all districts (Table 5).

Table 5. Summary of vegetation condition for rangeland surveys in Western Australia

Region surveyed & field work date	**Total area (km^2)**	**%Good condition**	**%Fair condition**	**%Poor condition**
Gascoyne, 1970 (*the criteria adopted to differentiate the range condition classes for this report are uniquely different to the criteria later adopted.)*	63,400	32%	53	15
Eastern Nullarbor, 1974	47,400	50	10	40
Ashburton, 1976-1978	93,600	64	27	16
Carnarvon Basin (*Exmouth/Shark Bay)*, 1980-1982	74,500	45	32	23
Murchison, 1985-1988	88,360	21	37	42
North-eastern Goldfields, 1988	100,570	39	32	29
Sandstone-Yalgoo-Paynes Find, 1992	94,710	45	32	23
Lower Murchison (2002)	13 039	78	9	13
Western Nullarbor (2005)	118,358	66	26	8

Grazing management must be also optimal for rehabilitation to occur. Grazing management is an effective option for rehabilitation if degraded rangelands are not subject to too severe a depletion in desirable vegetation and are not subject to severe soil loss. Under these conditions, some rehabilitation is likely through adjusting the level of grazing pressure or, more likely, total destocking (Gardiner 1986a; 1986b). However, in areas where vegetation has been severely depleted and extensive soil erosion or changes to soil hydrological parameters has occurred, reclamation relying solely on grazing management is unlikely to occur (Gardiner, 1986a; 1986b), while mechanical intervention has a very low probability of delivering a cost-effective outcome.

Year-to-year rainfall variation, as well as episodic events (Watson *et al.,* 1996) are the major factors driving both rangeland degradation and the likelihood of recovery (Watson *et al.,* 1997). However, it is simplistic to merely focus on the lack of rainfall and its variability as the major cause of rangeland degradation. Many land systems have inherently low productive potential, while more productive land systems are often severely degraded, reducing their potential to support livestock grazing. A main driver of degradation has been carrying too many animals for the potential of the rangeland, not only when the rangeland was under stress when rainfall was below the mean, but also during average seasons (the effect of continuous processes (Watson *et al.,* 1996)). This highlights that a major management issue is to optimise economic performance, yet at the same time maintain stocking rate within carrying capacity and avoid the degradation risk (the legislative requirement). That this must be done within a highly variable and unpredictable environment in terms of rainfall and financial returns, within the context of total grazing pressure from not only domestic stock but also native (such as kangaroos) and feral (such as camels, goats and rabbits) herbivores adds to the problem.

The consequences of the climate and vegetation resources are that sustainable rangeland management and the pastoral businesses that depend on these resources in the Southern Rangelands are difficult, and the difficulty is exacerbated by required responses to financial pressures.

DAFWA reports trends in regional and district land condition in pastoral rangelands annually to the PLB, providing a contemporary picture of rangeland trend. Reports are based on data collected in the WARMS program. WARMS is designed to report on rangeland trend at the district or regional level, not at the individual pastoral lease level. WARMS sites in the Southern Rangelands are assessed every 5 years.

Current data reflect Cycle 2 (1999 to June 2006) and Cycle 3 (May 2005 to 2009). Recorded change in the shrub density on WARMS sites over this period was, given the geographical range, quite variable. In general, shrub densities declined in the Gascoyne Ashburton Headwaters, Murchison, Lyndon, Meekatharra, Shark Bay and Upper Gascoyne LCDs, and were stable or increased slightly in other LCDs. Overall, fewer shrubs were recorded at Cycle 2 than Cycle 1so suggesting overall conditions declined.

Analysis indicates an 8% average fall in shrub numbers between Cycle 1 and Cycle 2. However, this was affected by seasonal conditions (Table 3).

- Sites rated as “below average” seasonal quality have the largest average fall of 15% in shrub numbers.
- Sites rated as “average” seasonal quality had an average fall of 6% in shrub numbers.
- There was a 3% average fall in plant numbers recorded on sites that were rated as “above average” seasonal quality.

Trends in the reported stock numbers varied region. Of the 16 LCDs, stock numbers in 2008 compared with 1998 had declined in 5 and increased in 4 LCDs. However, there was considerable variation, both declines and increases recorded in all LCDs.

The percentage change in shrub numbers within each LCD and the relative stocking levels over the previous 5 years are illustrated in Figure 3. Changes in recorded shrub numbers from WARMS sites are represented horizontally, either increasing (to the right of the figure) or decreasing (to the left) over the assessment period. Reported animal numbers relative to the assessed Present Carrying Capacity (Present CC – the Potential CC discounted for current range condition) of leases within each LCD are represented vertically. LCDs with average stock numbers above the average Present CC are in the upper half of the figure, and those with average stock numbers below the average Present CC in the lower half. Ideally, the place to be is on the right hand side (Wiluna, NE Goldfields, Mt Magnet, Sandstone, Cue and Yalgoo). Results show that for some LCDs, the grazing pressure in times of “below average” seasons and in some cases “average” seasons is not sustainable, with average declines in plant numbers of 44% being recorded in some areas.

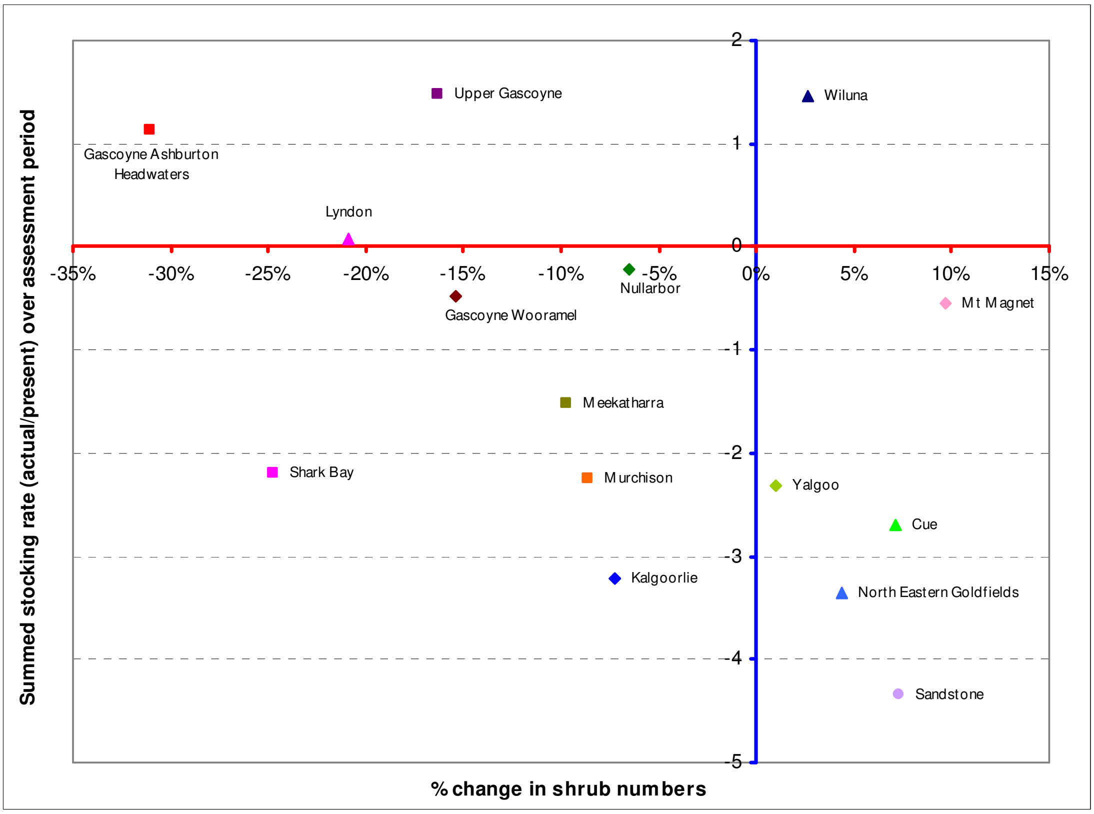

Figure 3. Changes in recorded shrub populations in relation to grazing pressure, Southern Rangelands LCDs.

Overall, recorded shrub numbers declined at WARMS sites, with a 3% decline even at sites which had recorded “above average” seasonal conditions. This suggests that season alone was not the factor, but that excessive grazing pressure also contributed to the decline.

In good seasons shrub numbers should increase. However, in 6 LCDs where seasonal conditions were rated as “above average”, numbers declined, suggesting stock densities are too high to allow the favourable seasonal conditions to encourage shrub germination and establishment. As an example, in the Gascoyne Ashburton Headwaters LCD, which recorded “above average” and “average” seasons, substantial falls in shrub numbers were recorded. Although the “above average” years have lower decline than those sites in “below average” seasons, a 16% decline in sites with “above average” seasonal conditions was recorded.

Conversely, WARMS sites assessed in the Wiluna LCD had either “above average” or “average” seasonal conditions, and although the stocking rate for the period 1999 to 2006 (when the sites were assessed) has increased, the density of shrubs basically remained stable.

In particular, there has been substantial decline in recorded shrub populations in the Gascoyne – Ashburton Headwaters, Gascoyne - Wooramel, Lyndon, Shark Bay and Upper Gascoyne LCDs. Smaller declines were recorded in the Murchison LCD. In some cases below average seasonal conditions were not reflected in reduced stock numbers and desirable shrub numbers declined.

The matching of stocking rate to seasonal quality is the key factor influencing changes to plant populations (excluding natural events like floods or fire). LCDs such as Mt Magnet and North Eastern Goldfields have increased shrub numbers, even under “average” and “below average” seasonal conditions because of their seasonally appropriate stocking rates. However, the results indicate that for many LCDs the current grazing pressure in times of below average seasons and in some cases average seasons is too high, and that range condition decline is current and continuing.

4 RESULTS

4.1 Regional Analysis

A total of 292 leases in the Southern Rangelands were assessed and their carrying capacity defined for a range of land potential scenarios (Table 6). In particular, as outlined in the analysis process, the impact of allocating a zero Potential CC to land systems in which a positive return to investment in waterpoint development was not possible was assessed.

Table 6. The number of leases in the Southern Rangelands in relation to Potential Carrying Capacity classifications (assumes all rangeland in "good" range condition) meeting the viability threshold.

	Number of Leases Reaching Viability Thresholds		
Viability threshold (dse)	**All land systems included**	**Only land systems with carrying capacity > 5.5 dse/sq km included**	**Only land systems with carrying capacity > 7.5 dse/sq km included**
7 500	210 (72%)	156 (53%)	111 (38%)
10 000	161 (55%)	111 (38%)	73 (25%)
15 000	99 (34%)	62 (21%)	41 (14%)

The number of leases reaching viability thresholds declined as varying proportions of the landscape were removed. Importantly, however, over 25% of the assessed 292 pastoral leases failed to reach a minimum Potential CC threshold of 7,500 dse, even when all rangeland potential productivity classes were included.

Potential CC assumes "good" range condition. However, rangeland condition decline has been recorded across the Southern Rangelands (Table 5), and reflects a lower expectation of rangeland carrying capacity compared with the non-degraded state. While animal productivity may be maintained in average or better seasons as range condition declines (Holm et al., 2005), this is not so as seasons fail (Hacker and Tunbridge, 1991). Moreover, while rangeland in "poor" condition may be productive in average seasons at stocking rates close to those appropriate for "good" condition, legislation requires a return of "poor to "good" condition, which can only be achieved at stocking rates below those appropriate for peak animal production. Discount factors (Appendix 1) to account for this were used to reduce the lease carrying capacity according to the most recent range condition assessment. This, in turn, reduced the number of leases that met the viability threshold.

Plant species exhibit different growth response to different rainfall events. This response to rain is confounded by the presence or absence of grazing pressure (Gardiner, 1986a). However, strict grazing management is an effective option for rehabilitation if degraded rangelands are not subject to too severe a depletion in desirable vegetation and are not subject to significant soil loss. Based on data provided by Gardiner (1986a; 1986b), optimal grazing management is, in many instances complete destocking for an extended period. Under these conditions, some degree of rehabilitation is likely. However, management strategies based on the reduction in numbers or complete removal of domestic stock are often insufficient to guarantee an improvement in range condition if the populations of kangaroos and feral herbivores are not similarly controlled. Moreover, it is really only during extended periods of favourable soil moisture that substantial improvement in range condition is possible, independent of stock numbers (Watson *et al.,* 1997; Watson *et al.,* 2007).

Based on the above assessment, it was assumed that a substantial period (say 5 years) of rehabilitative management (essentially total destocking) could improve range condition. The choice of five years was related to the assumed capacity of an individual business to tolerate a period during which possibly substantial proportions of the lease would be unavailable for grazing. While it is appreciated that longer time periods (decades or more) of destocking may achieve substantial improvements in range condition, the capacity of a business to consider this a financially feasible option is doubtful.

Consequently, a range of scenarios related to improvement in range condition was considered. These scenarios were defined from assessment of the WARMS rangeland monitoring data.

Essentially, these scenarios consisted of an improvement of the areas of rangeland assessed as being in "fair" and "poor" range condition by various percentages over the five years of destocking, hence increasing the carrying capacity of the individual leases. These four scenarios were:

1. Improvement in the condition of 40% of the "fair" condition rangeland to "good" condition; no improvement in "poor" condition rangeland;
2. Improvement in the condition of 50% of the "fair" condition rangeland to "good" condition; no improvement in "poor" condition rangeland;
3. Improvement in the condition of 50% of the "fair" condition rangeland to "good" condition; improvement in the condition of 10% of the "poor" condition rangeland to "fair" condition;
4. Improvement in the condition of 60% of the "fair" condition rangeland to "good" condition; improvement in the condition of 10% of the "poor" condition rangeland to "fair" condition.

Using these scenarios, leases were then ranked into three groups (Tables 7 and 8, and Figures 3 and 4). These groups were:

Category A	Lease viable as a stand alone pastoral enterprise in 2010 given current range condition and with the capacity to remain so under appropriate management.
Category B	Lease not viable as a stand alone pastoral enterprise in 2010, but considered able to attain viability following five years of "rehabilitative management" (essentially destocking) through improvement in range condition.
Category C	Lease not viable as a stand-alone pastoral enterprise in 2010 and having no biophysical capacity to become so within a 5-year time scale through improvement in range condition.

Lease numbers in Tables 7 and 8 are lower than those in Table 6 because of the discount in carrying capacity caused by deteriorated range condition. For direct comparison, the number of leases in Classification A in Tables 7 and 8 relates to the number of leases in Table 6. In other words, while 111 leases are classed as financially viable utilizing rangeland with a Potential CC of 5.5 dse/sq km or better and a viability threshold of 10 000 dse if current range condition is ignored Table 6), accounting for the decline in range condition assessed on each individual lease reduces this number to 77 leases (Table 7). Moreover, of the remaining 215 leases, only an additional 12 leases reach the viability threshold in the most optimistic scenario for range condition improvement following destocking. Equivalent numbers when only land systems with a potential of 7.5 dse/sq km or better are considered are 46 and 7 respectively (Table 8). This highlights the impact of the percentage of "poor" range condition, and the limited options for its improvement. However, as stated above, the ability of "poor" condition rangeland to produce substantial ephemeral vegetation of high nutritive value in exceptional years often masks the impact of range condition decline on lease viability.

Table 7. Effect of percentage improvement in range condition on the number of "financially viable" pastoral leases, considering land systems with a Potential CC ≥ 5.5 dse/sq km.

Viability Threshold	**Extent of Improvement (Fair to Good & Poor to Fair)**			
	40% & 0%	**50% & 0%**	**50% & 10%**	**60% & 10%**
7,500 dse 116 leases in Category A*	B = 9 C = 167	B = 12 C = 164	B = 13 C = 163	B = 15 C = 161
10,000 dse 77 leases in Category A	B = 7 C = 208	B = 10 C = 205	B = 10 C = 205	B = 12 C = 203
15,000 dse 47 leases in Category A	B = 6 C = 239	B = 8 C = 237	B = 8 C = 237	B = 8 C = 237

* See text for definition of Categories A, B and C.

Table 8. Effect of percentage improvement in range condition on the number of "financially viable" pastoral leases, considering land systems with a Potential CC ≥ 7.5 dse/sq km.

Viability Threshold	**Extent of Improvement (Fair to Good & Poor to Fair)**			
	40% & 0%	**50% & 0%**	**50% & 10%**	**60% & 10%**
7,500 dse 67 leases in Category A*	B = 8 C = 217	B = 11 C = 214	B = 12 C = 213	B = 15 C = 210
10,000 dse 46 leases in Category A	B = 6 C = 240	B = 7 C = 239	B = 7 C = 239	B = 7 C = 239
15,000 dse 24 leases in Category A	B = 3 C = 265	B = 4 C = 264	B = 4 C = 264	B = 4 C = 264

- See text for definition of Categories A, B and C.

SOUTHERN RANGELANDS PASTORAL LEASE VIABILITY

(MODELLED 10,000 DSE ON 5.5 DSE/SQ KM OR BETTER PASTORAL POTENTIAL LAND SYSTEMS)

Figure 3. Distribution of Southern Rangelands pastoral leases rated as Classification A, B or C based on land systems with Potential CC > 5.5 dse/sq km and rehabilitation of 50% of "fair" to "good" range condition.

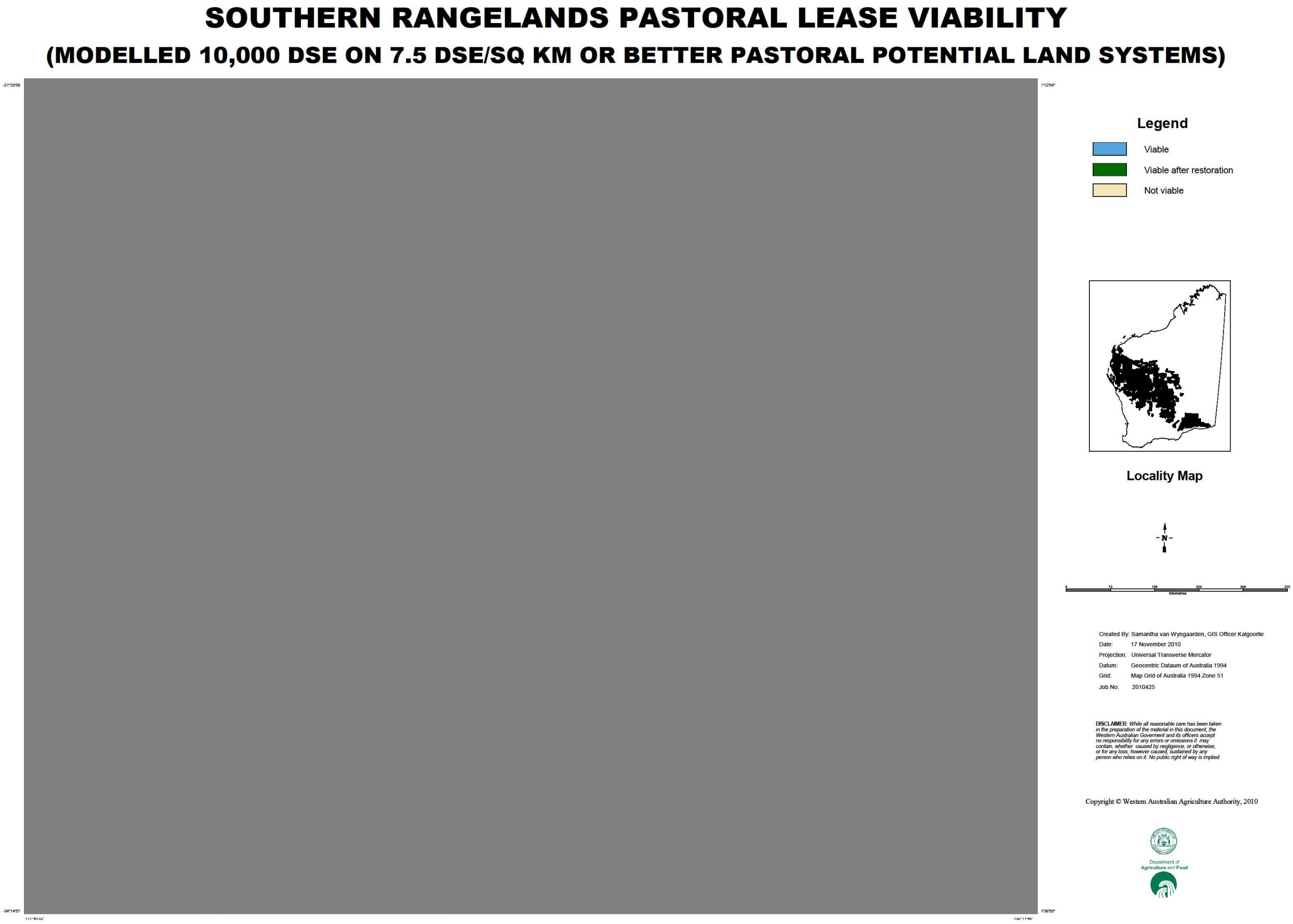

Figure 4. Distribution of Southern Rangelands pastoral leases rated as Classification A, B or C based on land systems with Potential CC > 7.5 dse/sq km and rehabilitation of 50% of "fair" to "good" range condition.

4.2 Analysis at the LCD Level

While the drivers of lease viability (lease size, land system potential and range condition) are evident across the Southern Rangelands region, their impact is not consistent across LCDs. While direct comparisons are complicated by the different number of leases in each LCD, the assessment of viability indicated that the proportion of viable leases in LCDs varies, and that some LCDs are dominated by leases classified as Category C, if in fact not composed solely of Category C leases (Tables 9 and 10).

Fundamentally, the most financially viable LCD (at a viability threshold of 10,000 dse) is Lyndon LCD. In Lyndon LCD, either 13 or 12 of the 21 leases (62% or 57% of the total) are classed as being financially viable at current range condition considering > 5.5 dse/sq km or > 7.5 dse/sq km rangeland potential respectively. Moreover, given its location (Figure 1), pastoral leases in the Lyndon LCD would not be disadvantaged by distance from rural [redacted] Other LCDs also have few viable leases but, in many instances, there are only a few leases in the LCD.

Table 9. Classification of leases at LCD level, based on Potential CC and a viability threshold of 10,000 dse and rehabilitation of 50% of "fair" to "good" range condition.

LCD	Leases	Land System Potential					
		> 5.5 dse/sq km			> 7.5 dse/sq km		
		Viability Classification					
		A	B	C	A	B	C
BIN	4	[redacted]					
CUE	9						
GAH	15						
GAW	16						
KAL	22						
LYN	21						
MEK	20						
MML	2						
MTM	17						
MUR	26						
NEG	29						
NUE	21						
PER	3						
SAN	13						
SBY	13						
UPG	19						
WIL	18						
YAL	19						
YLG	5						

The numbers of leases in Tables 9 and 10 suggest that significant areas of the Southern Rangelands do not possess sufficient viable leases (using the standard criteria) to provide a critical industry mass, and that service provision by rural businesses to these areas would be uneconomic, if those leases identified as being non-viable were removed, despite some leases being above the threshold. That this is occurring is evident from the closure of businesses that support pastoral operations in regional towns e.g. Elders stores in the towns of Meekatharra and Kalgoorlie.

Table 10. Percentage of leases classified "C" at LCD level, based on PCC, a viability threshold of 10 000 dse and rehabilitation of 50% of "fair" to "good" range condition.

LCD	Leases	Percentage of leases classified "C" (unviable)	
		> 5.5 dse/sq km	> 7.5 dse/sq km
BIN	4		
CUE	9		
GAH	15		
GAW	16		
KAL	22		
LYN	21		
MEK	20		
MML	2		
MTM	17		
MUR	26		
NEG	29		
NUE	21		
PER	3		
SAN	13		
SBY	13		
UPG	19		
WIL	18		
YAL	19		
YLG	5		
All LCDs	292	70%	82%

4.3 Analysis at the Individual Lease Level

A listing of individual leases and their classifications (A, B or C) for both > 5.5 dse/sq km and > 7.5 dse/sq km pastoral potential is provided in Appendix 2.

Leases in the Southern Rangelands have a Potential CC ranging from above 56 000 dse to below 350 dse, a Discounted Productive Carrying Capacity ranging from 310 to 37,000 dse, and lease areas ranging from below 6,000 ha (60 sq kms) to well over 595,000 ha (5,950 sq kms). The impact of the reduction in Potential CC through the removal of land systems of limited productivity varies between leases and within and between LCDs (Appendix 2), while, as mentioned previously, 82 leases fail to meet a minimal viability threshold of 7, 500 dse even if all land systems are included and there is no discount for a decline in range condition (Table 6).

5 DISCUSSION

Successfully managing grazing enterprises is complex. Overgrazing leads to plant mortalities and vegetation/range condition decline. The difficulties in making correct management decisions when faced with a range of uncertainties including climate and finances are obvious. These difficulties are exacerbated if the inherent productivity of the resource is not well understood by the land manager, with unrealistic expectations leading to overgrazing. This inability to accurately assess carrying capacities and grazing pressure, which form the basis of forage budgeting, militates against the adoption of ecologically sustainable grazing practices. The adoption of conservative stocking rates and a stock management policy responsive to climatic variability (and subsequent pasture availability) are clearly the required strategies to prevent degradation and promote pasture recovery. However, it appears that some (many?) pastoral lessees feel either compelled (presumably by a combination of insufficient carrying capacity and financial consideration) to stock the rangeland resource to (or beyond) its limit (Wang and Hacker 1997), or are unable to correctly assess the potential of the rangeland resources such that they manage livestock numbers within the capability of the rangeland. Therefore, in many situations, the current status of rangeland condition suggests that degradation processes are already in train whenever drought occurs, and that drought hastens the inevitable decline in range condition.

This analysis suggests a significant proportion of Southern Rangelands pastoral leases are non viable based on a biophysical assessment incorporating the inherent productive potential of the land systems and the most recent assessment of range condition and economic modelling of production systems (Herbert, *pers com*). This assessment is unsurprising as it is consistent with previous assessments (Wilcox and McKinnon, 1972; Jennings *et al.,* 1979; House *et al.,* 1991; Holm *et al.,* 1995; among others). Many pastoral businesses struggle with poor returns and inadequate capital performance, with little or no productivity improvement through innovation over the past decades. Even where there is willingness towards innovation, few businesses have any capacity to adopt change without government support, while current lease conditions lessen the incentive of the lessee to make capital investment in diversified activities. Yet the declining terms of trade evident elsewhere are also evident in the pastoral industry, and many businesses struggle to generate sufficient capital for survival without such government support. For this reason, as identified in the *Annual Return of Livestock and Improvements,* a growing number of pastoral leases serve simply as the base for a non-pastoral income.

There has been (and still is) a general over-estimation of the carrying capacity of the rangeland resources in the Southern Rangelands by managers and lessees. It is important to consider that the climate in this arid environment is dominated by years of low rainfall, with very dry seasons or years common, together with intermittent and quite infrequent periods of above average rainfall. Stock numbers generally increase during periods of above-average rainfall, and these numbers become the norm. A return to average seasons often witnesses continuation of these elevated stocking rates, with the grazing off-take greater than the sustainable productive capacity of the rangelands. The obvious adverse outcomes of such heavy utilisation of the desirable perennial species is reduced livestock performance and marketability, diminution of lessees' equity (primarily through livestock feeding and agistment costs) and risks to animal welfare. The less obvious outcome is further degradation of the rangeland. In particular, the damage caused to the rangeland by retention of livestock during below average rainfall years degrades its drought resilience – that is, its capacity to sustain livestock at the onset of periods of rainfall significantly below the median. This exacerbates the adverse effects of subsequent below average rainfall years on financial performance, initiates calls for government assistance, and delays or even precludes rangeland recovery.

This analysis identifies that the current situation in the Southern Rangelands can be described as one in which a high proportion of pastoral leases have a significant portion of their lease area comprised of inherently low pastoral productivity rangeland, and are subsequently of doubtful viability. Of those that are potentially viable at various viability thresholds, a significant proportion fail to reach the viability threshold when carrying capacity is discounted according to the most recently assessed range condition. At the same time, information from the *Annual Return of Livestock and Improvements* submitted by lessees indicates that many leases have not reduced their current stock numbers to levels appropriate to the current rangeland condition, and, as identified by WARMS data, continue to survive financially by further degrading rangeland condition. Of particular note is the limited effect of extended destocking on improving productivity because of the major impact that "poor" condition rangeland is having, and the near impossibility of returning such rangeland to any form of productivity approaching pristine conditions because of soil loss and the breakdown of soil hydrological cycles.

The Potential CC would appear to represent a readily available and easily appreciated measure of the productivity of the grazing resource, as it integrates and encapsulates the full spectrum of biophysical factors and their variability. However, from a lease manager's viewpoint, animal productivity tends to be a more appreciated, and is certainly a more easily measured, variable. For this reason, the often noted high animal production from degraded rangeland in average or better years masks the reality of the decline in rangeland potential as a consequence of overgrazing, and can provide significant impetus to continue unsustainable stocking rates. However, the steady decline in stock numbers in the Southern Rangelands, noted as early as the 1960s on a regional basis (Wilcox and McKinnon, 1972) does suggest that the capacity of the resource to provide a sustainable return and the necessary resilience to deal with drought has declined significantly, and continues to fall. Moreover, given the time lag in response and the time required for the impacts of overgrazing to be apparent, stock numbers can often still increase during episodes of degradation (Ash *et al.,* 1995).

Primary production in arid and semi arid rangelands is determined by precipitation, the soils and topographic position of an area, not by species composition (Chew and Chew, 1965; Fischer and Turner, 1978; Friedel, 1981), and changes in species composition do not result in substantial differences in biomass production. Consequently, changes in the composition of rangeland from dominance by shrubs to a mixed community containing a significant grass component do not necessarily imply an increase in the original Potential CC (which assumes all the rangeland is in "good" condition), although it may substantially increase the carrying capacity of the degraded landscape because areas rated in "poor" condition prior to grass invasion can be rated as "fair" or even "good" condition if the density and coverage of the grass component is significant, and if the grass species itself is a desirable species with respect to pastoral production. However, such change does not automatically alter the Potential CC of a lease. Therefore, such changes should not necessarily be considered as evidence of some grazing capacity significantly in excess of the pristine state and hence an argument as to viability. However, what does differ is the amount of useable forage among range condition classes, with "good" condition rangeland producing the most useable forage.

The conclusions as to lease viability drawn from this analysis run counter to the fact that there remain 292 pastoral leases in the Southern Rangelands, the majority of which are currently running livestock and supporting pastoral businesses (some leases owned by either mining companies or indigenous groups are effectively destocked and not running a pastoral business). How can this contradiction be explained? Obviously, the initial assumptions made for the analysis (jointly run leases and non-pastoral income have been ignored) go some way to explaining this. Additionally, that there would be different thresholds associated with different pastoral enterprises or enterprise mixes is acknowledged, as is the role of differing levels of managerial expertise, and the opportunistic harvesting/sale of feral animals from virtually zero managerial input. However, the explanation can also be found in the data reported by lessees in their *Annual Return of Livestock and Improvements* to the PLB, and Rangeland Condition Assessments conducted by DAFWA. Many leases are being run with reported stock numbers in excess of the rangeland's inherent potential, and the current condition of the rangeland on the lease, and without due regard to the limitations imposed by seasonal conditions or the limits imposed by legislation. Therefore, such leases appear to have continued to survive by degrading rangeland condition, an activity for which there is no financial cost, at least in the short term. Consequently, in unfavourable seasonal conditions, there is no capacity in the system to absorb the impact.

Moreover, DAFWA's lease level rangeland assessments provided to the PLB have described significant deterioration in the condition of pastoral infrastructure on many leases over a considerable period. Such deterioration can also be regarded as a non-cash cost. It would appear a substantial proportion of leases in the Southern Rangelands have not made sufficient financial provision for infrastructure replacement or upgrade. Consequently, much infrastructure is now at or close to the end of its economic life, and many pastoral businesses appear to have no capacity to reinvest. As an aside, programs such as the Gascoyne Murchison Strategy, which subsidised infrastructure development as a means of industry support, have in fact compounded this problem by effectively either masking the incapacity of lessees to invest by providing them with a subsidy, or have subsidised infrastructure development in situations where the rangeland potential was insufficient to provide a viable financial return. These factors have allowed many pastoral enterprises to continue despite being essentially non-viable.

Viability is not static. The pastoral industry has enjoyed periods of high profitability in the past, particularly during the high wool prices of the 1950s. Such periods have masked the long-term decline in terms of trade, and the impact of deteriorating range condition and failing infrastructure. However, the point has now apparently been reached where these issues can no longer be ignored. The viability threshold is rising, and will continue to rise. Without significant technological advances (unlikely), reversal in the terms of trade (also unlikely) or significant restructuring, it is difficult to conceive a viable future for many leases. Certainly, it is not logical to foresee a viable future for a substantial proportion of individual Southern rangelands pastoral leases without further, potentially irreparable exploitation of already degraded rangelands.

6 CONCLUSIONS

A significant proportion of pastoral leases in the Southern Rangelands (greater than half, dependent on the assumptions used) are non-viable based on the potential carrying capacity and the condition of the rangeland resources. In some LCDs, 100% of pastoral leases are defined as non viable in this assessment, based on the assumptions used. Lease size is too small, the land systems comprising the leases are too often of limited productive potential, and the rangeland condition, particularly in the more productive areas of many leases, has been seriously degraded. This is supported by the number of pastoral leases that appear to depend on some form of off-station or non-pastoral income stream. Current stock numbers and unfavourable seasonal conditions would suggest that both business viability and range condition continues to decline.

While episodic periods of extremely favourable seasonal conditions may provide some hope that a more favourable situation could develop, for the most part many leases in the Southern Rangelands pastoral industry are surviving based on a steady exploitation and deterioration of the rangeland resource and of pastoral infrastructure. Unless there is significant modification of the current leasehold structure or the true and substantial costs of resource deterioration are charged back to the lessee, then unrealistic expectations from the rangeland resource will continue, to the detriment of a large proportion of Western Australia's publicly owned land.

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APPENDIX 1.

Discount factors

Discount factors to account for range condition decline are derived from the carrying capacities obtained at stocking rate workshops held in conjunction with LCDs, during which the knowledge and experience of local managers was obtained. Results from these workshops were compared with published research (Holm, 1994; Fletcher, 1995; Yan *et al.,* 1996 among others) and the opinions of experienced Departmental staff. There was general agreement between the three sources of information (van Vreeswyk, *pers com*).

The discount factors listed below for each survey (and which were used in this analysis) are those from the published rangeland survey reports (Table 1), and reflect the decisions made at that time.

Table A1.1: Discount Factors for Land Systems of the Murchison, North-East Goldfields and Western Nullarbor Rangelands Surveys

Land System Productivity Potential (dse/sq km)	Good	Fair	Poor
~ 20	1	0.6	0.4
~ 12.5	1	0.7	0.4
~ 8	1	0.8	0.7
~ 6	1	0.8	0.8

Note: *The Murchison Survey did not include a "Moderate" productivity classification.*

Table A2.1: Discount Factors for Land Systems of the Sandstone, Yalgoo, Paynes Find Survey

Land System Productivity Potential (dse/sq km)	Good	Fair	Poor
~ 20	1	0.6	0.4
~ 14	1	0.7	0.4
~ 8	1	0.9	0.7
~ 6	1	0.9	0.8

Table A1.3: Discount Factors for Land Systems of the Carnarvon Basin Survey

Land System	Pastoral Productivity Potential (dse/sq km)	Good	Fair	Poor
Barrabiddy	25	1	0.6	0.3
Bidgemia	13	1	0.8	0.5
Brown	10	1	0.8	0.5
Cahill	17	1	0.8	0.5
Cardabia	14	1	0.5	0.2
Carleeda	17	1	0.5	0.2
Channel	7	1	0.8	0.5
Chargoo	25	1	0.6	0.3
Coast	13	1	0.6	0.3
Collier	6	1	0.8	0.6
Cooloomia	8	1	0.8	0.6
Coquina	7	1	0.6	0.3
Cullawarra	25	1	0.6	0.3
Delta	20	1	0.6	0.3
Divide	6	1	0.8	0.5
Donovan	20	1	0.6	0.3
Duffy	7	1	0.5	0.2
Durlacher	8	1	0.6	0.4
Edel	13	1	0.6	0.3
Ella	13	1	0.8	0.5
Firecracker	20	1	0.6	0.3
Foscal	20	1	0.6	0.3
Garry	8	1	0.8	0.6
Gearle	20	1	0.6	0.3
Giralia	10	1	0.5	0.2
Gneudna	14	1	0.6	0.4
Jimba	8	1	0.6	0.4
Jubilee2	10	1	0.5	0.2
Learmonth	14	1	0.5	0.2
Littoral	6	1	0.6	0.3
Lyell	14	1	0.6	0.3
Lyons	10	1	0.8	0.5
MacLeod	6	1	0.8	0.5
Mallee	10	1	0.5	0.2
Mantle	7	1	0.6	0.4
Marloo	20	1	0.5	0.2
Mary	20	1	0.5	0.3
Nerren	7	1	0.8	0.6

O"Brien	10	1	0.8	0.6
Peron	11	1	0.8	0.5
Philips	6	1	0.6	0.4
Prairie	7	1	0.8	0.6
River	17	1	0.5	0.3
Sable	20	1	0.6	0.3
Salune	9	1	0.8	0.5
Sandal	14	1	0.6	0.3
Sandplain	8	1	0.8	0.5
Snakewood	20	1	0.6	0.3
Spot	17	1	0.6	0.3
Tamala	33	1	0.0	0.0
Tarcumba	20	1	0.5	0.3
Target	14	1	0.6	0.3
Toolonga	20	1	0.5	0.3
Trealla	20	1	0.5	0.3
Uaroo	8	1	0.5	0.2
Wandagee	17	1	0.6	0.3
Warroora	17	1	0.6	0.3
Wash	13	1	0.5	0.3
Windalia	7	1	0.8	0.6
Winning	17	1	0.6	0.3
Wooramel	7	1	0.8	0.5
Yalbalgo	6	1	0.8	0.5
Yalkalya	17	1	0.6	0.3
Yarcowie	17	1	0.5	0.2
Yaringa	11	1	0.8	0.5
Yinnietharra	9	1	0.8	0.6
York	20	1	0.6	0.3

Note: *The Carnarvon Basin Survey determined pastoral land productivity and associated discount factors by pasture type, but mapped leases and carrying capacities by land systems. In this instance, discount factors were attributed to land systems according to the discount factor of the most widespread or significant pasture type within the land system.*

Table A1.4: Discount Factors for Land Systems of the Gascoyne Catchment Survey

Land System	Pastoral Productivity Potential (dse/sq km)	Good	Fair	Poor
Beasley	5	1	0.8	0.8
Bibbingunna	14	1	0.6	0.4
Bidgemia	13	1	0.6	0.4
Blech	6	1	0.8	0.8
Bryah	9	1	0.6	0.4
Collier	6	1	0.7	0.5
Divide	6	1	0.8	0.7
Durlacher	8	1	0.5	0.4
Flood	6	1	0.8	0.8
Gascoyne	17	1	0.7	0.4
Horseshoe	7	1	0.8	0.7
Jimba	8	1	0.6	0.4
Jingle	14	1	0.7	0.4
Kurubuka	8	1	0.6	0.4
Landor	6	1	0.8	0.8
Lyons	10	1	0.6	0.4
Macadam	6	1	0.9	0.9
Mantle	7	1	0.8	0.6
Nadarra	9	1	0.7	0.5
Outwash	6	1	0.7	0.4
Peedawarra	13	1	0.7	0.4
Philips	6	1	0.7	0.5
Sandiman	7	1	0.6	0.5
Sugarloaf	8	1	0.8	0.7
Warri	6	1	0.8	0.8
Winmar	6	1	0.8	0.7
Wooramel	7	1	0.7	0.4
Yalbalgo	8	1	0.7	0.5
Yinnietharra	9	1	0.6	0.4

Table A1.5: Discount Factors for Land Systems of the Ashburton Survey

Land System	Pastoral Productivity Potential (dse/sq km)l	Good	Fair	Poor
Ashburton	100	1	0.5	0.4
Cadgie	10	1	0.8	0.6
Cheetara	33	1	0.5	0.4
Collier	6	1	0.7	0.6
Dollar	14	1	0.6	0.5
Dune	14	1	0.7	0.5
Edward	25	1	0.6	0.4
Egerton	6	1	0.8	0.7
Ethel	6	1	0.8	0.7
Ford	6	1	0.8	0.7
Globe	33	1	0.6	0.4
Jamindie	7	1	0.7	0.6
Kooline	13	1	0.7	0.5
Laterite	9	1	0.7	0.6
Minderoo	33	1	0.5	0.4
Nirran	6	1	0.8	0.7
Nooingnin	7	1	0.8	0.6
Onslow	25	1	0.6	0.4
Paraburdoo	14	1	0.7	0.5
Prairie	6	1	0.7	0.6
River	50	1	0.5	0.4
Rous	50	1	0.6	0.4
Table	6	1	0.8	0.8
Tangadee	7	1	0.8	0.7
Three Rivers	7	1	0.8	0.7
Warri	7	1	0.8	0.6
Yankagee	17	1	0.6	0.4
Yanrey	50	1	0.5	0.3

APPENDIX 2.

Lease level assessment of pastoral leases

Name	LCD	Station Area (ha)	Lease Viability Category (A, B, C)
ADELONG	KAL	109736	
ALBION DOWNS	WIL	140489	
ANNEAN	MEK	247458	
ARUBIDDY	NUE	314394	
ATLEY	SAN	205355	
AUSTIN DOWNS	CUE	165542	
AVOCA DOWNS	KAL	121392	
BADJA	YAL	113653	
BALGAIR	NUE	289316	
BALLADONIA	NUE	125305	
BALLYTHUNNA	MUR	124556	
BANJAWARN	NEG	406813	
BARRAMBIE	SAN	100564	
BARWIDGEE	NEG	276396	
BEEBYN	CUE	59815	
BELELE	MEK	279705	
BERINGARRA	MUR	140323	
BIDGEMIA	UPG	388364	
BILLABALONG	MUR	127210	
BIMBIJY	YAL	87723	
BLACK FLAG	KAL	108232	
BLACK HILL	SAN	145395	
BOODANOO	MTM	115990	
BOOGARDIE	MTM	161355	
BOOLARDY	MUR	346748	
BOOLATHANA	GAW	147453	
BOOLOOGOROO	GAW	68939	
BOONDEROO	NUE	308923	
BOOYLGOO SPRING	SAN	233995	
BRAEMORE	NEG	13080	
BRICKHOUSE	GAW	224243	
BRONTIE	YLG	78913	
BRYAH	MEK	122689	
BULGA DOWNS	SAN	273949	
BULLABULLING	KAL	94370	
BULLARA	LYN	109501	
BULLARDOO	MUR	41942	
BULLOO DOWNS	GAH	406489	
BUNNAWARRA	YAL	90154	
BUTTAH	MEK	147843	
BYRO	MUR	237872	
CALLAGIDDY	GAW	65380	
CALLYTHARRA SPRINGS	UPG	84221	
CALOOLI	KAL	8903	
CARBLA	SBY	95193	

CARDABIA	LYN	199328	
CAREY DOWNS	UPG	95536	
CARLAMINDA	YAL	59525	
CARNEGIE	WIL	390696	
CARRARANG	SBY	55364	
CHALLA	GAW	87488	
CLOVER DOWNS	NEG	60662	
COBURN	SBY	100483	
COGLA DOWNS	MEK	199478	
COODARDY	CUE	166037	
COOLCALALAYA	MUR	115592	
COORALYA	GAW	151301	
COWARNA DOWNS	KAL	97830	
CUNYU	WIL	372400	
CURBUR	MUR	178169	
DAIRY CREEK	UPG	165037	
DALGETY DOWNS	UPG	269492	
DANDARAGA	SAN	351940	
DEPOT SPRINGS	NEG	122208	
DIEMALS	SAN	313453	
DOOLEY DOWNS	UPG	117448	
DOORAWARRAH	GAW	219301	
EDAGGEE	GAW	68367	
EDAH	YAL	103536	
EDJUDINA	KAL	329451	
EDMUND	UPG	89031	
ELLA VALLA	GAW	76167	
ENNUIN	YLG	43225	
ERLISTOUN	NEG	330870	
ERRABIDDY	MEK	78628	
EUDAMULLAH	UPG	186435	
EURARDY	BIN	27856	
EXMOUTH GULF	LYN	91891	
FAURE	SBY	5816	
FRASER RANGE	NUE	178672	
GABYON	YAL	271499	
GIDGEE	SAN	112681	
GILROYD	SBY	80928	
GINDALBIE	KAL	135254	
GLEN	CUE	40170	
GLENAYLE	WIL	303958	
GLENBURGH	UPG	224576	
GLENORN	NEG	219076	
GNARALOO	LYN	91308	
GOLDEN VALLEY	YLG	8169	
GRANITE PEAK	WIL	290760	
GUNNADORAH	NUE	333010	
HAMELIN	SBY	201569	
HAMPTON HILL	KAL	300407	
HILL SPRINGS	GAW	138833	
HILLVIEW	MTM	148609	
HY BRAZIL	MTM	16618	
INNOUENDY	MUR	223386	
IOWNA	MTM	60613	
JEEDAMYA	NEG	197008	

JIMBA JIMBA	UPG	144953	
JINGEMARRA	YAL	110462	
JUNDEE	WIL	131887	
KALLI	MUR	85322	
KANANDAH	NUE	359230	
KARBAR	CUE	116182	
KAWANA	YLG	52889	
KILLARA	MEK	262711	
KINCLAVEN	NUE	496581	
KIRKALOCKA	MTM	75747	
KOONJARRA	NUE	325118	
KOONMARRA	KAL	129865	
KOORDARRIE	LYN	116995	
KUMARINA	GAH	305929	
KYBO	NUE	283280	
LAKE BARLEE	SAN	127829	
LAKE VIOLET	WIL	257908	
LAKE WAY	WIL	233433	
LAKE WELLS	NEG	237969	
LAKESIDE	CUE	51528	
LANDOR	GAH	342937	
LAVERTON DOWNS	NEG	215549	
LEINSTER DOWNS	NEG	142104	
LYNDON	LYN	248173	
LYONS RIVER	UPG	206067	
MADOONGA	CUE	113925	
MADOONIA DOWNS	KAL	391804	
MADURA	NUE	366194	
MALLEE	MUR	17434	
MANBERRY	LYN	85408	
MANGAROON	UPG	108723	
MARANALGO	YAL	68849	
MARDATHUNA	GAW	211789	
MAROONAH	LYN	198289	
MARRILLA	LYN	132947	
MARRON	GAW	80503	
MARYMIA	GAH	390068	
MEADOW	SBY	82423	
MEEBERRIE	MUR	185211	
MEEDO	GAW	146289	
MEELINE	MTM	169656	
MEERAGOOLIA	GAW	26040	
MEKA	YAL	364905	
MELANGATA	YAL	45122	
MELITA	NEG	278752	
MELLENBYE	YAL	91016	
MELROSE	NEG	248478	
MENANGINA	KAL	192400	
MENANGINA SOUTH	KAL	69426	
MERTONDALE	NEG	88904	
MIA MIA	LYN	208403	
MIDDALYA	LYN	188464	
MILEURA	MUR	250511	
MILGUN	GAH	334628	
MILLBILLILLIE	WIL	136963	

MILLROSE	WIL	295832
MILLY MILLY	MUR	308641
MINARA	NEG	182932
MINGAH SPRINGS	GAH	204839
MINILYA	LYN	272327
MINNIE CREEK	UPG	201581
MOOLOO DOWNS	UPG	131715
MOONERA	NUE	324821
MOORARIE	MEK	137450
MORAPOI	NEG	53916
MOUROUBRA	YAL	130396
MT AUGUSTUS	GAH	398389
MT BURGES	KAL	246005
MT CLERE	GAH	309812
MT FARMER	MTM	62732
MT GIBSON	YAL	130598
MT GOULD	MEK	240060
MT HALE	MEK	105660
MT JACKSON	YLG	123012
MT KEITH	WIL	97917
MT MONGER	KAL	172614
MT NARRYER	MUR	198873
MT PADBURY	MML	261903
MT PHILLIP	UPG	114965
MT VERNON	GAH	381070
MT VETTERS	KAL	158597
MT VIEW	BIN	8041
MT WELD	NEG	363958
MT WITTENOOM	MUR	116366
MULGUL	GAH	280348
MUNBINIA	MTM	32323
MUNDRABILLA	NUE	384901
MUNGARI	KAL	31142
MURALGARRA	YAL	126778
MURCHISON DOWNS	MEK	156555
MURCHISON HOUSE	BIN	126516
MURGOO	MUR	203317
MURRUM	MTM	101123
NALBARRA	MEK	141709
NALLAN	CUE	98858
NAMBI	NEG	294187
NANAMBINIA	NUE	46266
NARNDEE	MTM	107201
NEDS CREEK	GAH	403294
NERREN NERREN	SBY	72288
NEW FOREST	MUR	93175
NIMINGA	WIL	207769
NINGALOO	LYN	49731
NINGHAN	YAL	206046
NOOKAWARRA	MUR	243884
NOONDOONIA	NUE	184286
NYANG	LYN	124988
OUDABUNNA	YAL	92132
PAROO	MEK	323960
PERANGERY	PER	11886

PERRINVALE	KAL	400540
PINDABUNNA	MEK	238037
PINEGROVE	MUR	60468
PINGANDY	GAH	178053
PINJIN	MEK	127135
PINNACLES	NEG	283158
POLELLE	MEK	90168
PONDANA	NUE	186479
PRENTI DOWNS	WIL	383510
PULLAGAROO	YAL	76611
QUOBBA	LYN	74898
RAWLINNA	NUE	271980
REMLAP	MML	42389
RIVERINA	KAL	179353
SHERWOOD	MEK	177013
SOUTHERN HILLS	NUE	146759
STURT MEADOWS	NEG	402943
TALISKER	SBY	287267
TALLERING	MUR	165216
TAMALA	SBY	72272
TANGADEE	GAH	181942
TARMOOLA	NEG	172211
THREE RIVERS	GAH	376712
TOWERA	LYN	206103
TOWRANA	UPG	120536
TWIN PEAKS	MUR	105114
ULLULA	WIL	136320
VANESK	NUE	595322
VIRGINIA	NUE	244226
WAGGA WAGGA	YAL	89659
WAHROONGA	MTM	83589
WALLING ROCK	KAL	185368
WANARIE	MTM	112474
WANARRA	PER	107908
WANDAGEE	LYN	176734
WANDINA	MUR	79727
WANNA	UPG	360337
WARROORA	LYN	107199
WEEBO	NEG	284991
WHITE CLIFFS	NEG	257870
WHITE WELLS	PER	68410
WILLIAMBURY	LYN	247173
WINDERIE	UPG	69220
WINDIDDA	WIL	355055
WINDIMURRA	SAN	260065
WINDSOR	SAN	230755
WINNING	LYN	157966
WOGARNO	MTM	61724
WONDINONG	MTM	77200
WONGANOO	NEG	349717
WONGAWOL	WIL	275971
WOODLANDS	GAH	209900
WOODLEIGH	SBY	233135
WOOLEEN	MUR	153266
WOOLIBAR	KAL	99222

WOORAMEL	GAW	143210	
WOORLBA	NUE	315026	
WYDGEE	YAL	170132	
WYNYANGOO	MTM	163592	
YAKABINDIE	NEG	195160	
YALARDY	SBY	101141	
YALBALGO	GAW	86499	
YALLALONG	MUR	270804	
YAMARNA	NEG	143819	
YANDAL	NEG	155319	
YANDI	BIN	49706	
YANREY	LYN	250749	
YARINGA	SBY	103405	
YARLARWEELOR	MEK	281845	
YARRABUBBA	MEK	116511	
YARRAQUIN	CUE	131841	
YEELIRRIE	SAN	244552	
YELMA	WIL	215207	
YERILLA	NEG	143267	
YINDI	KAL	245247	
YINNETHARRA	UPG	204341	
YOOTHAPINA	MEK	140465	
YOUNO DOWNS	WIL	162508	
YOWERAGABBIE	MTM	106328	
YUIN	MUR	129830	
YUINMERY	SAN	124925	
YUNDAMINDRA	NEG	220663	