

POTENTIAL CARRYING CAPACITY REVIEW

Spektrum Review PCC 2018

ABSTRACT

This report was commissioned by Landgate to reassess the Potential Carrying Capacity of the majority of the leases in the Kimberley, Pilbara and Southern Rangelands. Spektrum consulting was commissioned to complete this review. This report provides the updated potential carrying capacities, methodology used to calculate these and the supporting data.

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[Spektrum Consulting]

NOTE: This is an extract from the full report. Data relating individual stations has been removed to maintain confidentiality.

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DISCLAIMER

The SPEKTRUM Consultants have prepared this Report for Landgate (the client), in accordance with contract provided to Spektrum and the assumptions and limitations listed in this report. This project has been completed with care and a professional approach. The authors have qualifications and have relevant experience with rangeland ecology and the pastoral industries. On that basis, they have provided the estimate of the Potential Carrying Capacity for the relevant leases in good faith using the information provided and additional information available in the public domain. The estimates and recommendations are based on the information provided, generally accepted practices and standards at the time of its preparation. This requires professional estimates and hence there is a requirement for subjective assessments relating to forecasts and recommendations. The authors accept no liability for any omission or changes within and beyond the scope of this document. No other warranty, expressed or implied, have been made as to the professional advice included in this Report.

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1. Background

1.1. Project Aims and Background

This project was initiated by Landgate, Department of Primary Industry and Regional Development (DPIRD) and the Pastoral Lands Board (PLB). Lester Cousins the Valuer General from Landgate has provided guidance and managed the project. The aim of the project has been to conduct a review of rangelands carrying capacities and related services within Western Australia on behalf of Landgate.

The Potential Carrying Capacity calculations provided through this review will be utilised in Landgate's review and determination of the annual rent payable for a Pastoral Lease. This review was conducted by the Valuer-General as part of his Legislative requirements under Division 6, Section 123 (1) of the Land Administration Act 1997.

1.2. Terms of Reference

The Valuer General had provided the following terms of reference to Spektrum as a basis for the calculation of the Potential Carrying Capacity: The calculation of the PCC must assume;

- The PCC is the estimated number of livestock equivalents (CU) that can be annually carried over the long-term on a lease while maintaining or improving rangeland condition.
- All pasture types are in good rangeland condition (that is the potential for producing palatable pasture hasn't been reduced),
- The area is fully developed (particularly with respect to water point distribution and placement) and available to livestock,
- All feral herbivores are under control and good grazing management is practiced.
- The estimate is the average carrying capacity across the full range of seasonal conditions.
- An understanding of each land unit's ability to support sustained livestock grazing;
- Good rangeland condition is assessed as; the perennials being present include all or most of the palatable plant species expected, though some less-palatable species may be present and total perennial groundcover is close to the optimal for the site.
- Areas that are physically inaccessible are removed from assessment
- Good grazing management has been practiced
- Introduced pastures (eg Buffel) are included in assessment
- No supplementation is provided
- Reserves, UCL stock routes excluded

1.3. Project team and allocation regions

Landgate have appointed the private consulting group, Spektrum, to prepare the PCC assessment. The Spektrum team includes Dr Steve Petty who will be involved in the Kimberley & Pilbara leases, David Blood who will be involved in the Pilbara & Southern Rangelands leases, Jim Addison who will

be involved in the Southern Rangelands leases and Elise Petty who will cover communications and project management. Three of the team members are experienced Rangeland Consultants who have worked across the WA pastoral Industry over many years. All 3 have spent a considerable amount of their professional career assessing the carrying capacity of pastoral leases for clients. Between them they are familiar with most of the land systems and Pastoral Leases in the Kimberley Pilbara and Southern Rangelands. This familiarity and experience has reduced the amount of field verification required and has resulted in a more realistic and reliable assessment. The allocation of leases to team members has been presented in Figure 1 and a breakdown by Region and Shire has been provided in Table 1.

Table 1. Breakdown of Lease allocation by Region and Shire

Region	Shire	David	Jim	Steve	Total
Kimberley	Broome			11	11
	Derby/West Kimberley			30	30
	Halls Creek			33	33
	Wyndham/East Kimberley			17	17
Kimberley Total				91	91
Pilbara	Ashburton	13	13		26
	East Pilbara		9	13	22
	Laverton		1		1
	Leonora		2		2
	Meekatharra		6		6
	Port Hedland			6	6
	Roebourne	6			6
	Upper Gascoyne	1			1
	Wiluna		3		3
Pilbara Total		20	34	19	73
Southern Rangelands	Ashburton	4	1		5
	Carnarvon	20			20
	Exmouth	2			2
	Leonora		3		3
	Meekatharra		15		15
	Upper Gascoyne	18	1		19
	Wiluna		9		9
Southern Rangelands Total		44	29		73
Grand Total		64	63	110	237

1.4. Milestones and time frame for completion

The key milestone, key dates for completion and the performance Indicators for completion for this project are listed in the Table 2 below. These milestones and completion dates were agreed to between Landgate and Spektrum and were the basis of the project reporting.

Table 2. The project Milestones

Stage	Milestone Description	Deliverables	Dates
1.0	Finalisation and Customer sign off of agreed Project Plan, including methodology		
1.1	Presentation and discussion of the Project Plan and detailed methodology	Presentation completed	12-Jul-18
1.2	Review and modify the Project Plan and Methodology	Modified Plan and Methodology	17-Jul-18
1.3	Send updated Project Plan and Methodology to Customer for approval.	Customer in receipt of updated Plan and Methodology	22-Jul-18
2.0	Preliminary assessments completed – Pastoral Properties		
2.1	Source and confirm land system area data for each lease	Table of Land System area for each Lease available	5-Aug-18
2.2	Desktop calculation of the land system carrying capacities using the GLM methodology	Table of Land System Carrying Capacity version 1 available	5-Aug-18
2.3	Collect published carrying capacity data for each land system on the focus leases.	Table of published Land System carrying capacity completed	12-Aug-18
2.4	Assessment of the carrying capacity of land systems within areas that currently do not have published land system data.	This Land System carrying capacity data added to above tables	12-Aug-18
2.5	Desktop calculation of the carrying capacity of each land system based on the data collected.	Table of Land System Carrying Capacity version 2 available	12-Aug-18
2.6	Calculation of draft potential carrying capacity for each of the nominated pastoral leases	Table of draft Carrying Capacity for each lease	19-Aug-18
2.7	Preliminary Industry Consultation	Document providing the preliminary Lease's responses	19-Aug-18
2.8	Presentation of the Draft Potential Carrying Capacities for each Pastoral Lease in each region to the Customer.	Presentation completed	31-Aug-18
3.0	Final assessments completed, and draft report delivered to Valuer-General		
3.1	Review of the Project methodology.	Updated methodology submitted to customer	9-Sep-18
3.3	Government Department Consultation	Document providing Department staff	31-Oct-18
3.2	Detailed Industry consultation	Document providing lessee's responses and summary of consultation completed	31-Oct-18
3.4	Preparation of the Draft report	Draft report submitted to customer	11-Nov-18
4.0	Delivery of final report for acceptance by Valuer-General		
4.1	Review and edit the Draft Report	Edited draft report available	11-Nov-18
4.2	Completion of any additional analysis or consultation required	Additional analysis completed and results integrated into draft report	18-Nov-18
4.3	Completion and submission of the final report for acceptance by the Valuer General	Final report submitted to client	23-Nov-18
5.0	Presentation of final report to Valuer-General		
5.1	Prepare a Power Point presentation on the final report and results	Presentation completed	27-Nov-18
5.2	Prepare maps highlighting the changes	Maps completed	27-Nov-18
5.3	Presentation of the final report to the Valuer General	Presentation completed	30-Nov-18

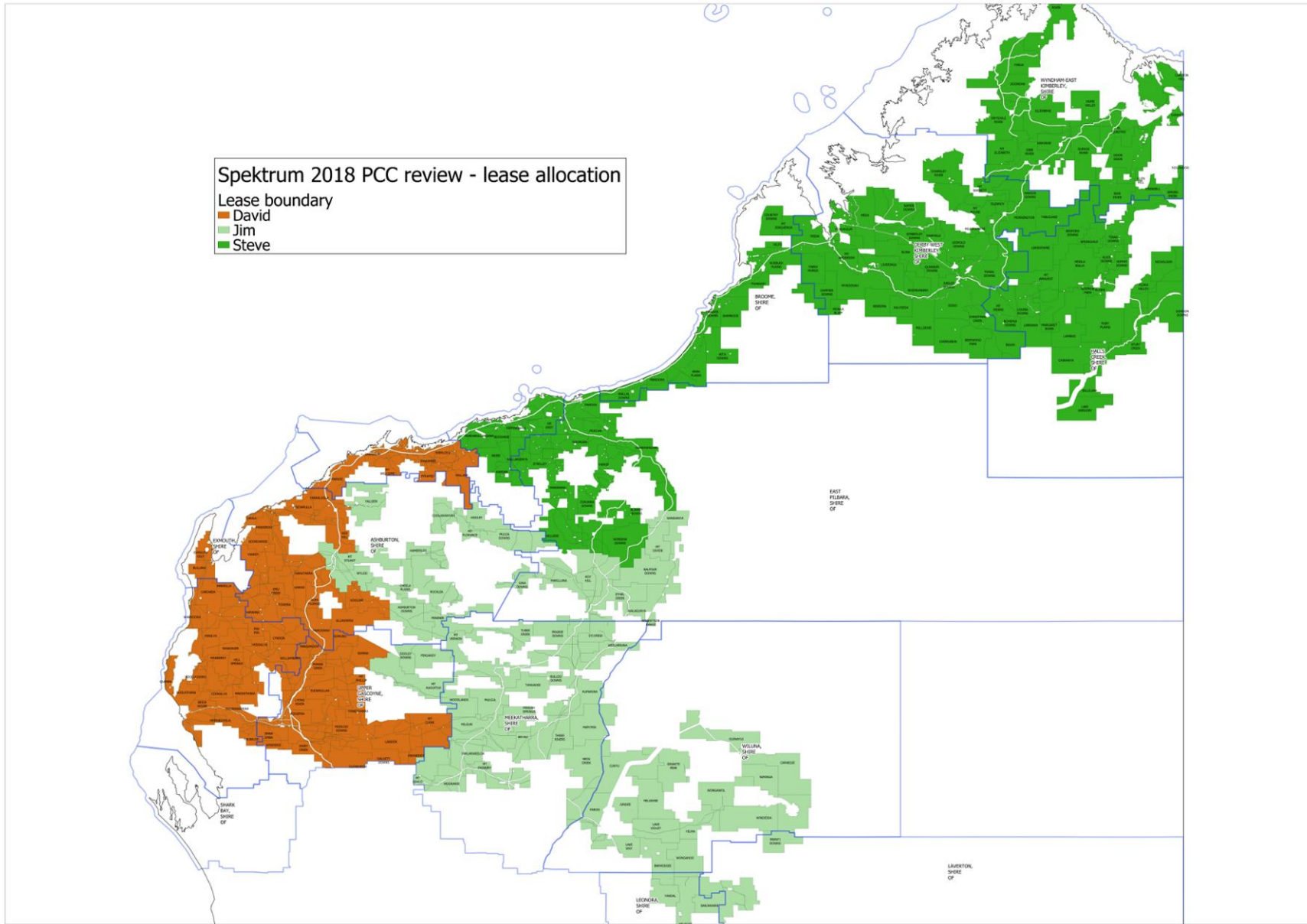


Figure 1. Allocation of the leases to team members

1.5. Leases included in the PCC reassessment project.

Landgate provided a list of the Leases to be included in the PCC reassessment. This list was based on a range of factors with one of the key factors being the discrepancies between existing lease PCC and the Annual Stock Returns reported on the leases. A list of the leases assessed has been provided in the tables in Appendix 1.

2. Assumptions/Limitations

The PCC assessments of the respective leases were predominantly based on a desktop assessment of the carrying capacity of individual land systems and the lease PCC. Conducting the assessment as a desktop exercise was part of the agreed methodology between Spektrum and Landgate, which allowed the project to be completed in a timely and cost-effective manner. The lack of a physical verification of the land systems on the individual leases is a limitation of this methodology. The PCC assessments were conducted using the available data, local knowledge from the project team, other regional experts and the experience of the lessee.

The Spektrum assessment of the Potential Carrying Capacity (PCC) relied on a range of assumptions and principles. These assumptions were an integral part of the calculation for the PCC for each of the nominated Leases.

The key assumptions included;

- This assessment was based on the Grazing Land Management (GLM) methodology developed by Meat and Livestock Australia (MLA).
- The assessments relied on the cadastral information provided by Landgate for the respective leases. It was assumed that Landgate had provided the reliable spatial files for stock routes, roads and excisions.
- The assessments relied on the land system data provided by DPIRD and this data has been assumed to be correct.
- The assessments relied on the land system descriptions and pasture types described in the respective resource data reports developed by DPIRD.
- DPIRD provided the intersected data with the land system areas within the legal lease areas and this data was assumed to be correct.
- The assessment relied on utilisation rates applied to similar land systems in similar climatic zones in the Northern Territory and Queensland.
- DPIRD provided the data with the accessibility of each land system. This data is based on the land systems descriptions and was produced by DPIRD staff. This data was assumed to be correct.
- The project team considered the long-term Annual Lease Stock Returns data for each lease, provided by Landgate. Spektrum used this data as a point of reference for the PCC assessments, but did not use the data directly in any of the PCC calculations.
- The project team relied on the descriptions of the buffel distribution and other on site factors provided by the respective lease Owners and Managers.

Limitations

The calculation of the Potential Carrying Capacity has been based on the Terms of Reference provided by Landgate in Section 1.2. Some of these factors limit the capacity to extrapolate the Land System carrying capacity data beyond the intended use by Landgate for the short to medium term Potential Carrying Capacity of a lease. Examples where the Terms of Reference may limit the capacity to extrapolate the data include;

- **Exclusion of feral animals** – Commercial use of the land systems carrying capacity needs to consider the impact of feral and native animals. This assumption may provide an over assessment of the land system carrying capacity of domestic animals in some areas.
- **Range condition is assumed to be good** – Few leases across the state have land systems that are uniformly in good range condition. It would be very difficult to improve the range condition back to good range condition in the short to medium term on many of the leases. Therefore, the PCC data provided in this report are an over estimate of the current PCC of the majority of the leases in the short to medium term.
- **Exclusion of Reserves, Stock Routes and UCL** – Many leases in the state have stock routes in them that they utilise for graze cattle. Some leases also have excisions on the property. In both cases there is additional carrying capacity on the lease above the PCC listed in this report. This suggests on leases with stock routes and excisions the PCC provided in this report is an underestimate of the actual PCC for the property. Stock Routes tend to follow land systems of above average carrying capacity. This accentuates the impact of the removal of the stock routes on the actual PCC of a lease. Table 3 below provides examples of Leases where stock routes increase the grazable area of the Lease.

Table 3 Removed due to confidentiality of the data

- **Assume no supplementation is used.** Many of the leases use supplementation to increase the nutritional digestibility of the pasture species. The provision of supplementation increases the Herbage Mass intake of the animals and therefore increases the livestock equivalent (CU) per animal. This is particularly the case in high rainfall areas where the digestibility and protein content of the pastures are lower. The assumption that supplementation is not used, results in

a lower assessment of PCC than that being sustained on many of the leases. Therefore, in areas where supplementation is a typical part of the management of a lease, the PCC's quoted in this report will be an under-estimate of the PCC of these leases.

- **Good grazing management is practiced.** In high rainfall leases, as found in North Kimberley, pastoralists use fire as a tool to improve post wet season forage quality. High annual production of low-quality Herbage Mass is replaced by low Herbage Mass yield of higher nutritional quality – albeit for a restricted time period. The spatial and temporal management application of this practise has the capacity to add complexity to PCC estimations. Fire is part of a good grazing management practice in some land systems. It has been assumed that factors such as this were applied uniformly across all of the leases. This may limit the capacity for extrapolation, given not all leases have adopted “good grazing management practices”.

The Authors of this report have assumed that the supporting information is correct and have based the assessment of the PCC on this data. The Authors reserve the right to review any recommendations in light of new information becoming available.

3. Methodology

3.1. Key source data

The first step for estimating the updated PCC was to establish a credible and accurate set of land system areas for each lease. This was an essential step to ensure the data was consistent. The second step was to identify and address the errors in the land system database. This covered lease boundary amendments as a result of the 2015 excisions, boundary swaps and other changes that had not been completely captured. The revision of areas by land system and lease boundary intersection was provided by Phil Thomas from DPIRD on the 24th of August. These first 2 steps were completed over a 4-week period.

This complete data set was used to construct a robust set of spreadsheets that captured as many variables as necessary and available. To reduce complexity of the task while retaining a degree of discrimination a composite key of Survey area, Shire and land system name was used in all separate spreadsheets. This enabled modification, according to regional variations in land system expression such as drainage intensity, variations in canopy cover and presence of buffel grass. In the case of highly anomalous leases, finer adjustments of herbage mass and utilisation could be made at the land system/station level. An example of this are the leases that carry much higher numbers than neighbours due to supplementation or burning practices. The benefit of using compound keys was to reduce complexities of multi factored formulas and use simple lookup formulas.

Table 4 *Removed due to confidentiality of the data*

3.2 PCC Assessment Methodology

The Potential Carrying Capacities of the land systems and leases was calculated using the Grazing Land Management (GLM) methodology. The GLM methodology is an objective, scientifically sound and credible methodology for assessment of the carrying capacity of the Land Systems in these regions. This methodology conforms to the requirements set by Landgate for this project. The GLM methodology has been described in detail in Meat and Livestock Australia (MLA) in their respective manuals and the training courses they run. DPIRD run courses in partnership with MLA on this methodology for Lessees across the rangeland in WA.

This methodology is primarily based on annual herbage mass assessments, sustainable utilisation rates and accessibility of the Land Systems and Land Units by grazing animals. Data on the herbage mass and sustainable utilisation rates are available for many land systems across the NT, Queensland and South Australia as well as some land systems in Western Australia. Data has been sourced and was applied or extrapolated, (with circumspection), to the land systems in this region based on the pasture types, soil types and climatic conditions.

The GRASP model was not directly used to calculate the HM for the land systems in the respective regions. This was due to;

- The lack of calibration data for a large proportion of the land systems in the Kimberley, Pilbara and Southern Rangelands.
- The unreliability of the GRASP model for predicting herbage mass in the shrublands.
- The potential for inconsistency across the land systems and regions if a variable methodology was applied

Data produced by the GRASP model was indirectly used in the PCC calculation. This included the GLM data, which was based on GRASP calculation. A spreadsheet for each region has been prepared with land system, estimated annual average herbage mass, estimated utilisation rates (drawn from published data) and calculated sustainable average land system carrying capacity. Data for these spreadsheets was drawn from;

- Herbage Mass assessments for many land systems assessed while on site by the Spektrum team and from other experienced regional experts. Where suitable pasture Herbage Mass data has not been available, best estimates from experienced managers and ecologists was adopted.
- From research data and publications across the regions.
- From experienced DPIRD staff within each region.
- A similar assessment of PCC in the NT. Similar spreadsheets were prepared for all of the land systems in the pastoral regions of the Northern Territory. These land systems have many similar climatic and geological characteristics. These NT PCC assessments were prepared by the Spektrum staff, allowing this data to be used as a reference.
- The utilisation rates were derived from published data for pasture types within similar climatic regions in the NT and QLD.
- The land system accessibility data was derived from a database provided by DPIRD. This database was prepared as part of the previous PCC assessment and for consistency was used as a base for this assessment. In some cases, the proportional allocation was modified based on the field observations, lessees' feedback and the experience of the project team. The accessibility data was derived from the respective land system and land unit descriptions.

3.2. Supporting Data

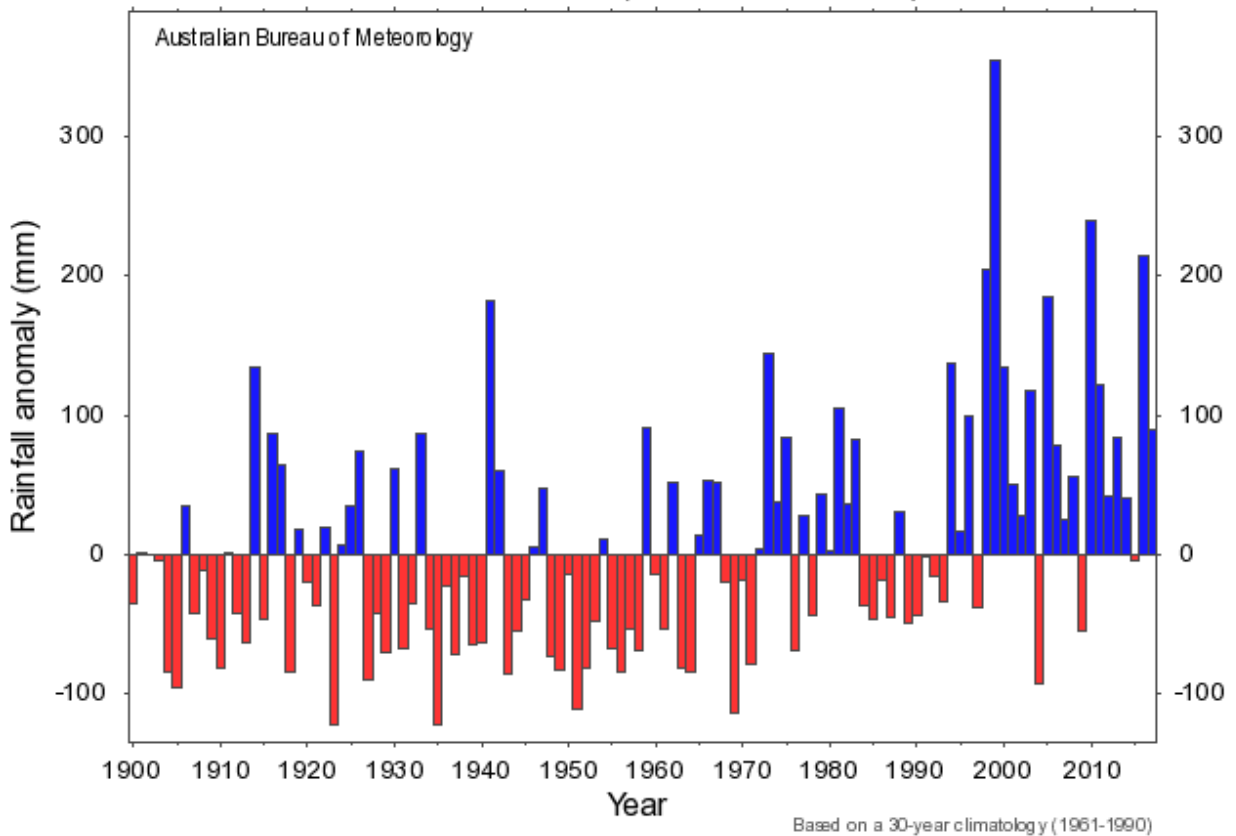
A range of data was sourced to support the potential carrying capacity assessment for each land system. Published land system carrying capacity data was sourced for each land system as a comparison to the calculated land system potential carrying capacity data. This published data included;

- Rangeland Survey Reports
- Past assessments of land system potential carrying capacity prepared by DPIRD
- Land system potential carrying capacity data from the Landgate database
- Research data with Herbage Mass and Utilisation data for individual land systems/pasture types
- Northern Territory Potential Carrying Capacity, Herbage Mass and Utilisation data for all of the Leases in the NT.
- Potential carrying capacity data for comparative land systems in Queensland (Future Beef) and South Australia. These comparisons will be based on similar; geology, geomorphological derivation, pasture types, climatic conditions and position in the landscape. A good example was the use of the Future Beef reports with Herbage Mass data for Land Systems in Queensland.
- Property information and Pastoral Lease Condition Reports held by DPIRD and DPLH.
- The experience of the respective team members in each region. The Spektrum team has over 100 years collective experience across the WA pastoral estate.
- Discussion with key experienced pastoralist across the leases in the respective regions.
- Advice and feedback from experienced DPIRD staff in the regional offices.
- And additional data from reports or other regional staff in the respective Departments.

3.3. Change in climatic conditions

In the typically highly variable rainfall regime of the rangelands, trends since the late 1990's of increased summer rainfall has resulted in a marked and widespread improvement in rainfall (Figure 5) and a resulting increase in pasture growth. Successive summer rainfall events result in sustained germination and better survival of grasses and shrubs. While improvement is not universal, as is indicated by declining trends in shrub populations (Thomas and Rogers, 2017), other measures such as overall ground cover and animal performance have improved to counter these isolated negative trends. A significant trend in the Gascoyne also not clearly identifiable from the WARMS sites, is the spread of buffel grass. In this area many sites traditionally installed to measure shrubs demographics do not record the trends in grass populations. This information has only recently been collected and no objective trends are available. Pastoralists initiated monitoring sites installed in the past 8 years have focused more on grass pastures, though broad reliable trends are not yet available, apart from grass presence at number of sites.

Northern wet season rainfall anomaly Western Australia (1900-01 to 2017-18)



Annual rainfall anomaly Western Australia (1900 to 2017)

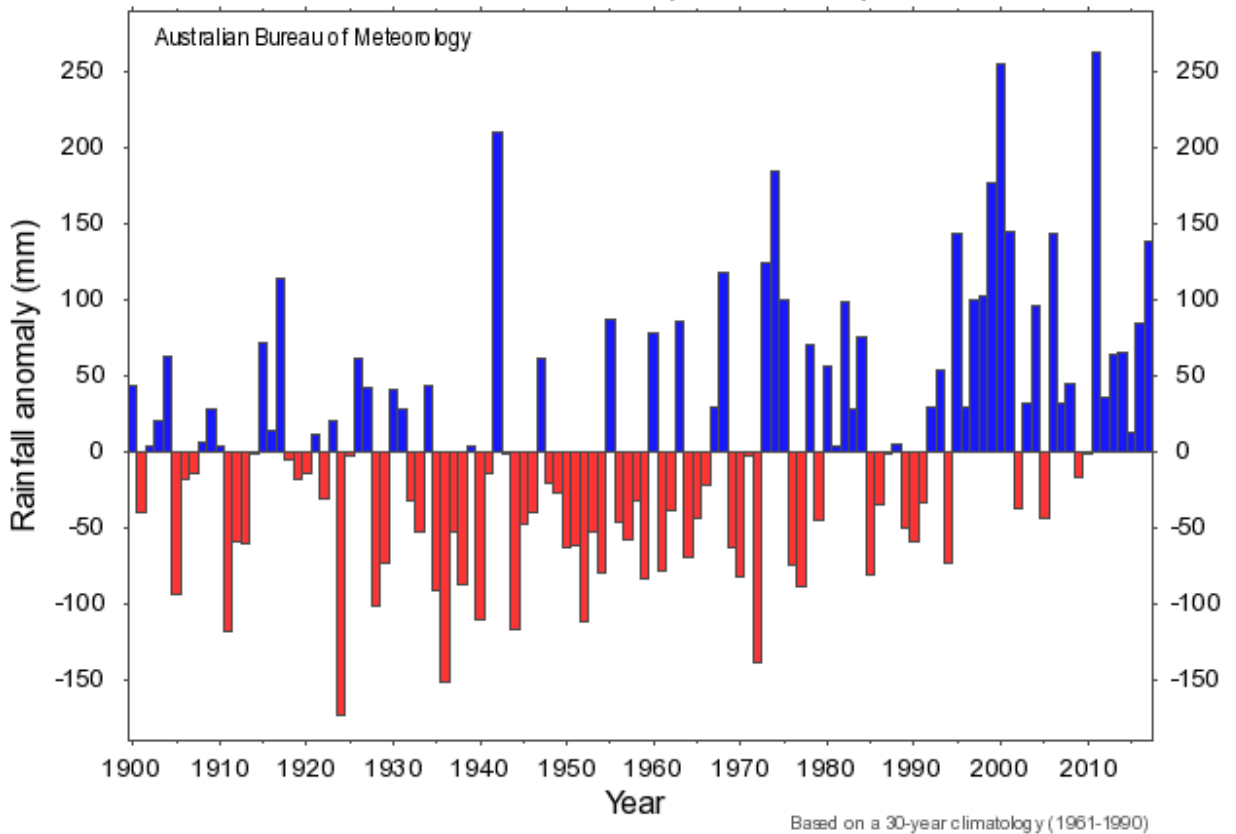


Figure 5: Wet season and annual rainfall anomalies for Western Australia

Most climate models based on current scenarios for the northern rangelands indicate increasing temperatures and increased chance of tropical climate drivers that influence rainfall. This has implications for the growth and survival of rangeland pastures as well as parallel risks including greater probability of fire. The most obvious impact on pastures in the project area is the ongoing spread of buffel grass, which is predicted to be favoured by most accepted climate scenarios (Scott JK, 2014).

The major implication of regional climate change is the slightly increased probability of heavier summer rainfall events driven by extra tropical climate drivers. Dendrochronology analysis of native *Callitris* trees by O'Donnell et al (2015) supports the BOM reported trends in the following graphic - that a shift in regional climate influences has contributed to marked increasing trend in summer and autumn rainfall in the Pilbara, East Gascoyne and Goldfields (Figure 6 and 7). The consequence of this change in drivers is an increased frequency of ex-tropical monsoonal weather systems that affect the East Pilbara, Northern Goldfields and the Interior, resulting in highly episodic above average weather events.

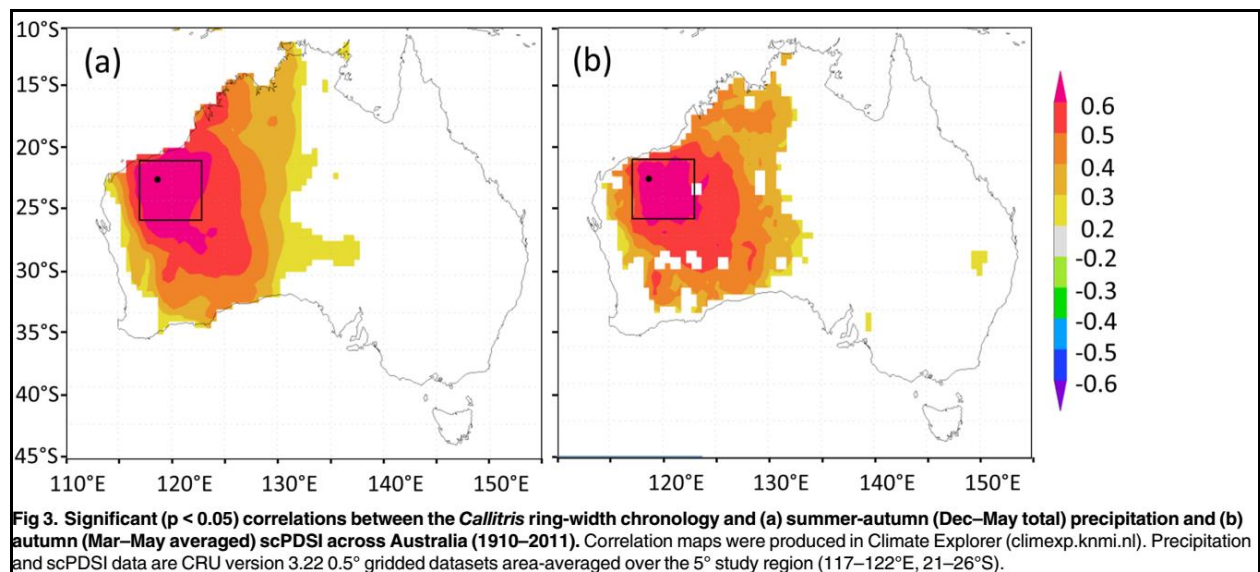


Figure 6: Correlations between tree ring data and (a) summer-autumn rainfall and (b) autumn. (From O'Donnell, et al, 2015)

The key message of the climate forecasting is that the region is likely to experience increased runoff from more irregular and extreme rainfall events and an increase in extended drought periods. The effect of these cycles on native vegetation is expected to be a much more pronounced from a cycle of droughts that cause plant mortality, exposing soils, followed by heavier but more infrequent runoff events contributing to increasing erosion risk. Implications for livestock producers include a greater need for more dynamic stocking management actions when faced with dry periods and a willingness to routinely spell land to avoid loss of perennial pasture species.

Figure 8 provides 20 year rainfall changes as a percentage for the leases in the study area. These trends are similar to the rainfall trend data provided by BOM (Figure 6). Figures 9 to 16 provide examples of the annual and 10 year moving average rainfall for leases in the Kimberley, Pilbara and Gascoyne areas. In all examples the 10 year average rainfall has increased and in most the variability in annual rainfall has also increased.

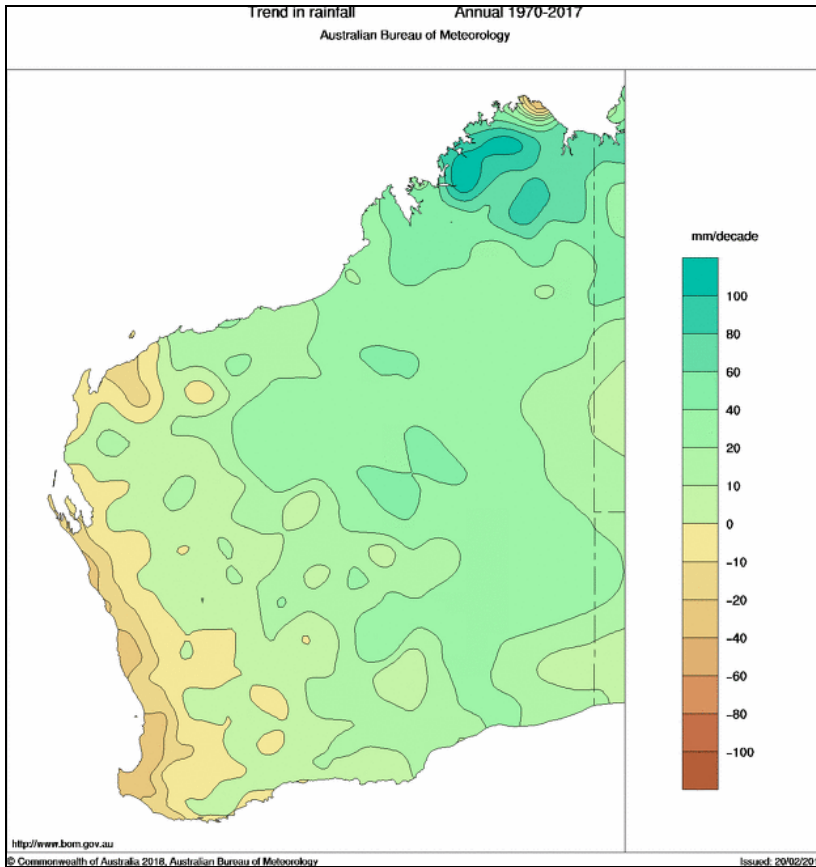


Figure 7. Trend in annual rainfall 1970-2017, isohyets are mm per decade

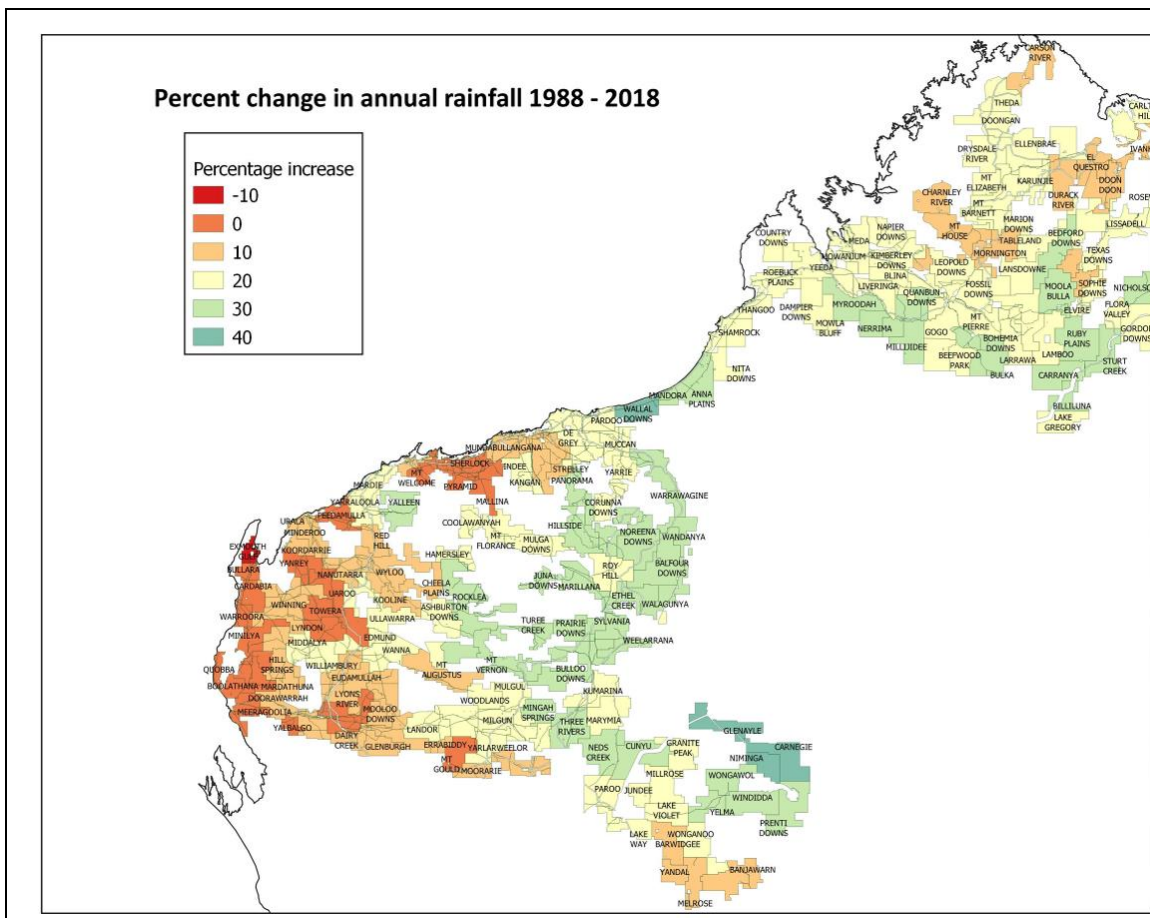


Figure 8. Percent change in lease rainfall 1988-2018

Kimberley

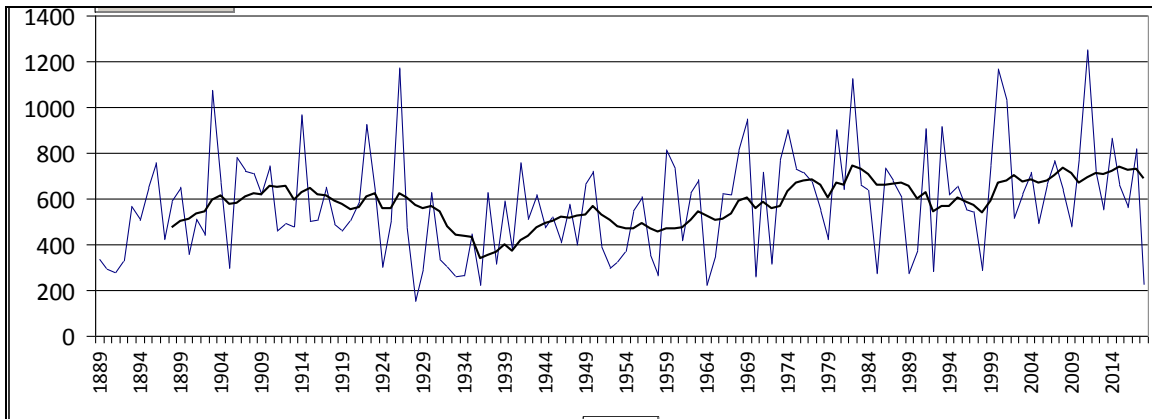


Figure 9. Alice Downs annual rainfall and 10 year moving average. 10 yr change +14%

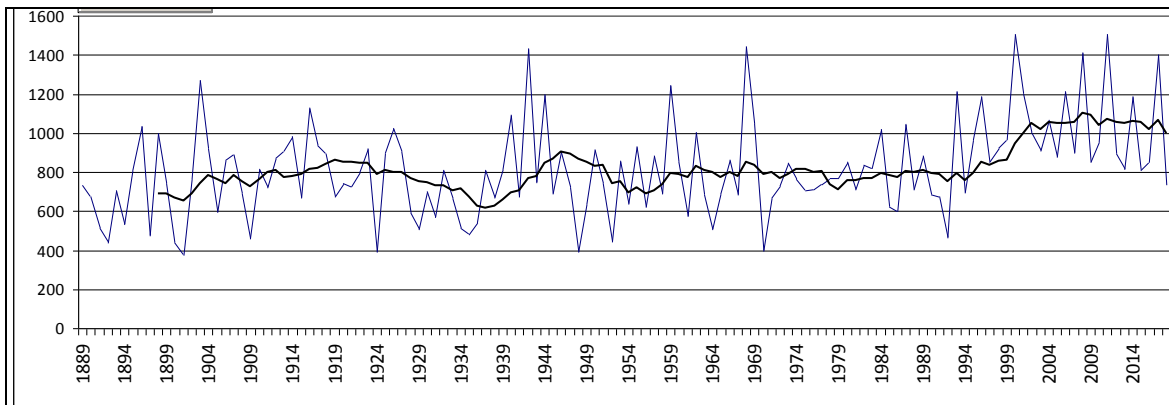


Figure 10. Carlton Hill annual rainfall and 10 year moving average. 10 yr change +21%

Pilbara

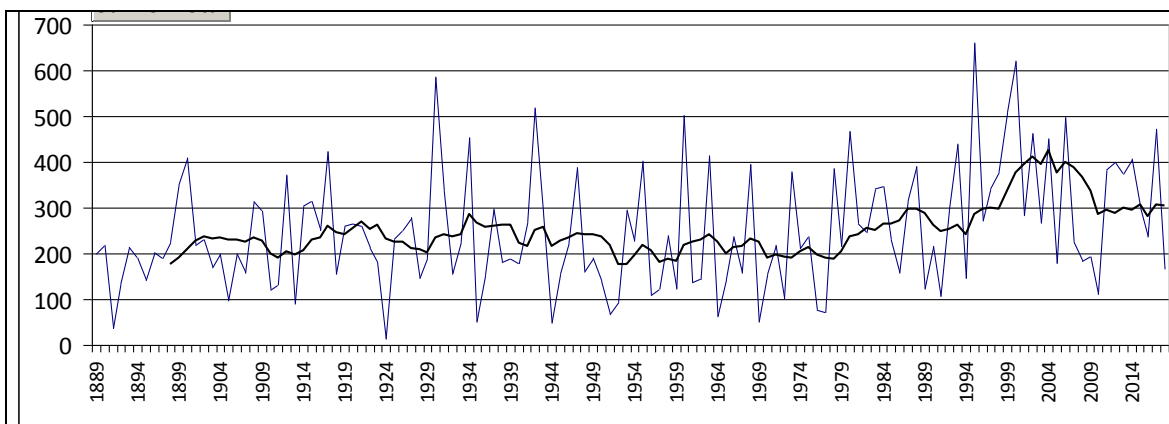


Figure 11. Balfour Downs annual rainfall and 10 year moving average. 10 yr change +29%

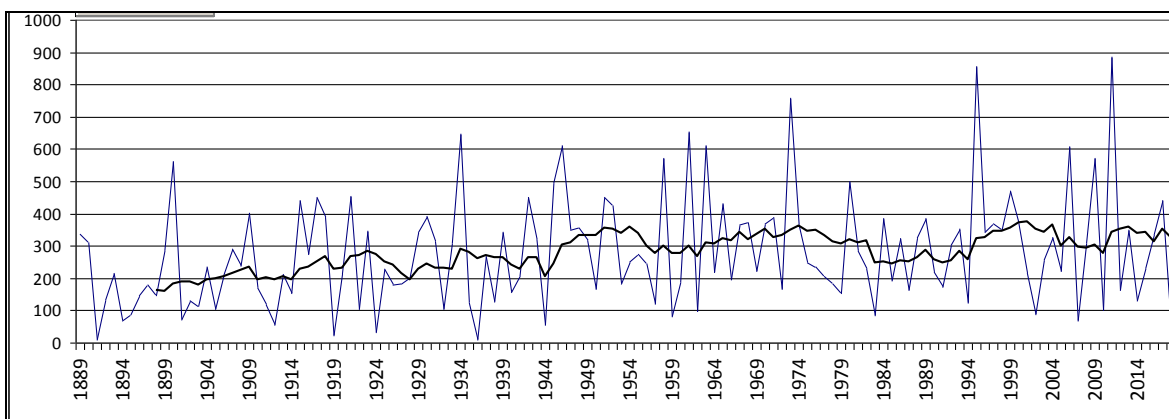


Figure 12. Mardie annual rainfall and 10 year moving. 10 yr change +16%

Goldfields/Wiluna

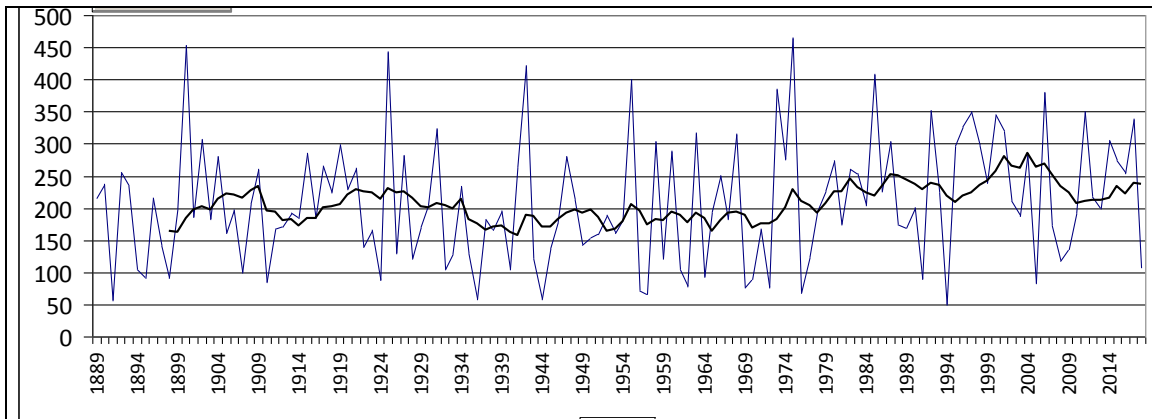


Figure 13. Banjarn annual rainfall and 10 year moving average. 10 yr change +13%

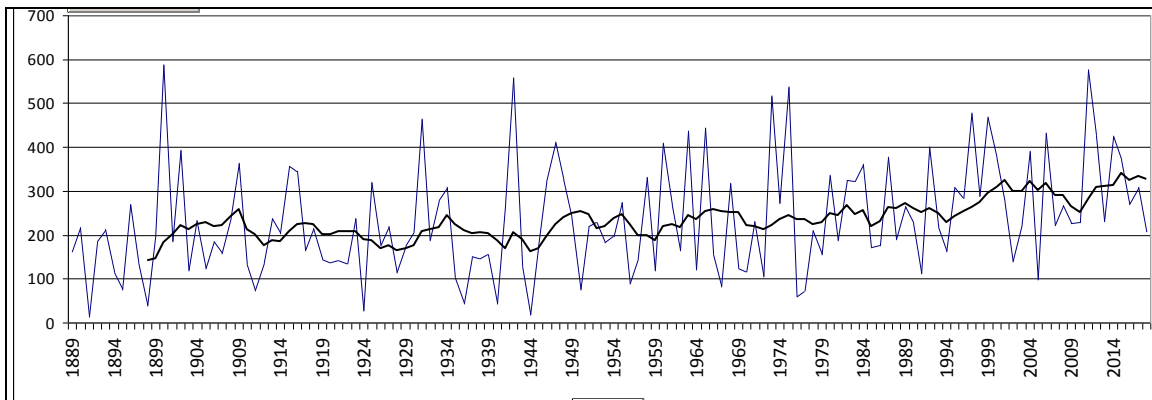


Figure 14. Neds Creek annual rainfall and 10 year moving average. 10 yr change +27%

Gascoyne

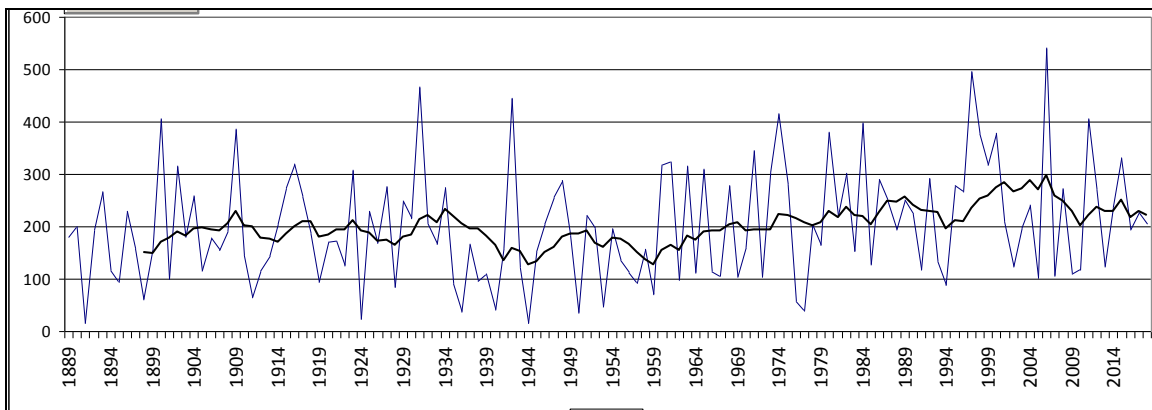


Figure 15. Mt Clere annual rainfall and 10 year moving average. 10 yr change +20%

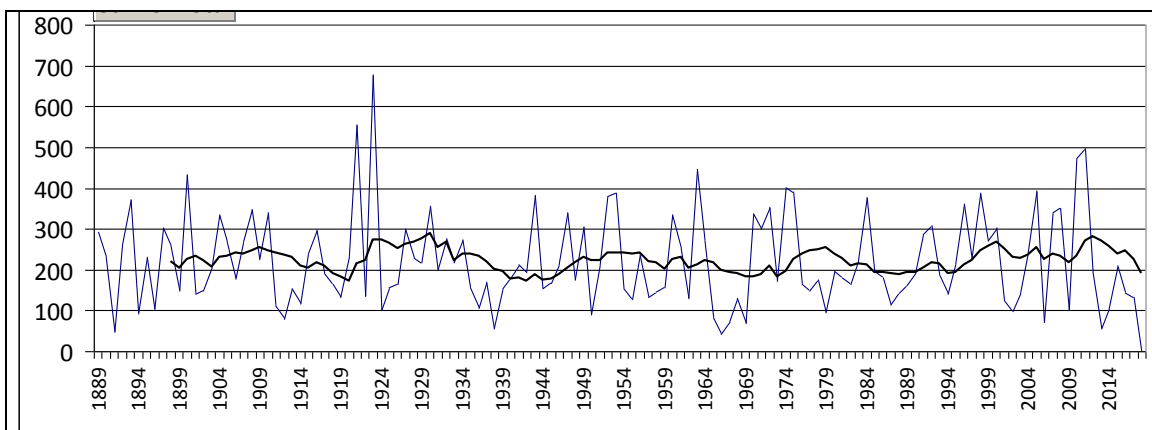


Figure 2. Quobba annual rainfall and 10 year moving average. 10 yr change +2%

3.4. Assessment of areas with missing Land System data

Not all of the leases had land system data to calculate the PCC assessment on. There were eleven pastoral leases without land system data, seven in the Shire of Wiluna and four in the Shire of Meekatharra.

- Shire Wiluna: Millrose, Granite Peak, Glenayle, Carnegie, Nimminga, Wongawol and Prenti Downs
- Shire Meekatharra: Mt Padbury, Ned's Creek, Marymia and Kumarina

These leases are geographically situated in an area of low average annual rainfall, (Ned's Creek 214.2mm), and high annual rainfall variation (of approximately 1.7 times). Annual rainfall variation is defined by BOM as a location's 90 percentile minus 10 percentile divided by the 50 percentile. All eleven leases operate commercial cattle enterprises.

Although these leases do not have land system data, they are covered by the Beard's vegetation types. These were used as de facto land systems. These vegetation types are mapped and described in "Vegetation Survey of Western Australia" Beard J S, 1:1,000,000 Vegetation Series, Great Sandy Desert Bioregion (1974), and Murchison Bioregion (1976). Following review these vegetation types were assigned a potential carrying capacity (PCC) per unit area. Computation produced a lease PCC.

Existing PCCs were available for Beard's vegetation types. The veracity of these PCCs were checked through comparisons with similar vegetation types described in land system information on "adjacent" leases by Jim Addison. Some vegetation types were able to be ground-truthed and the assessments confirmed. Vegetation types on parts of Ned's Creek were inspected on 29 September 2018, Kumarina on 30 September 2018 and Mt Padbury on 5 September 2018. Previously, as a Government employee, Jim Addison had carried out inspections on nine of the eleven leases so was familiar with the vegetation types and their pastoral potential.

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3.5. Industry Consultation

Involvement of industry and experienced government officers was a central aspect of the review process for gathering data and verifying estimates. Most previous reviews of the potential carrying capacity for rental purposes were generally carried out by the Department of Agriculture officers with limited input from industry. Although this was the case the carrying capacities derived by rangeland surveys involved industry input.

The project team sought input from the Lessee's regarding the distribution of pasture types, introduced species, accessibility of areas of each lease and overall impact of the current stocking rates. The project attempted to use the knowledge and expertise of the experienced pastoralists, most of whom have excellent insights into animal and land interactions.

An initial introduction to the project was provided by Landgate at an early stage, hence most were well briefed when Spektrum staff contacted all leases. Reactions to the concept of the consultative process were very positive and staff received many requests for opportunities for individual visits to inspect and discuss their lease lands.

A bulk email was sent to the lessees in mid-late September advising them of the existing PCC for their lease and that they would be contacted in the near future. The project staff completed a field inspection of land systems and some leases that were either unfamiliar to them, were highly representative of the broader region or managed by highly regarded land managers. Sixty two leases were visited by the three staff, in varying detail ranging from a quick drive through to detailed assessments and observations of land systems of interest. The information collected on this inspection

provide reference for herbage mass judgements as well as context for the views of the lessee being interviewed. Each consultant travelled on average of 5,500 kms through the rangeland during their inspections (Figure 17).

Following the field consultation trips, all lessees were contacted again by email confirming they would be contacted by the relevant consultant. Phone calls were made to each lessee where available. Availability of managers was poor at the time because of mustering commitments.

A presentation and consultation were organised with seven relevant government officers across the regions at DPIRD, outlining the project process and the consultation phase. This was valuable in regards to the availability of herbage mass data, monitoring site trends and regional land system variability.

The project team also attended a number of regional meetings to present the project and these were very well received. Jim Addison presented to an audience of about 60 attendees at the Goldfields-Nullarbor Regional Biosecurity Group annual meeting. Steve Petty attended two meetings with regional DPIRD staff and meetings with the Kimberley-Pilbara Cattleman’s Association and the North Kimberley LCDC. David Blood presented at a meeting of the Carnarvon Biosecurity Association meeting and a meeting of DPIRD, Lands and Landgate staff in Perth. Table 4 provides an overview of the consultation conducted by the project team, with an average of 4.9 contacts per lease by the project staff.

Table 4. Consultations statistics during PCC review project

Consultation frequency				
Type	David	Jim	Steve	Total
Bulk emails	315	195	220	730
Email	61	34	24	119
field visit	38	18	6	62
Phone	56	77	127	260

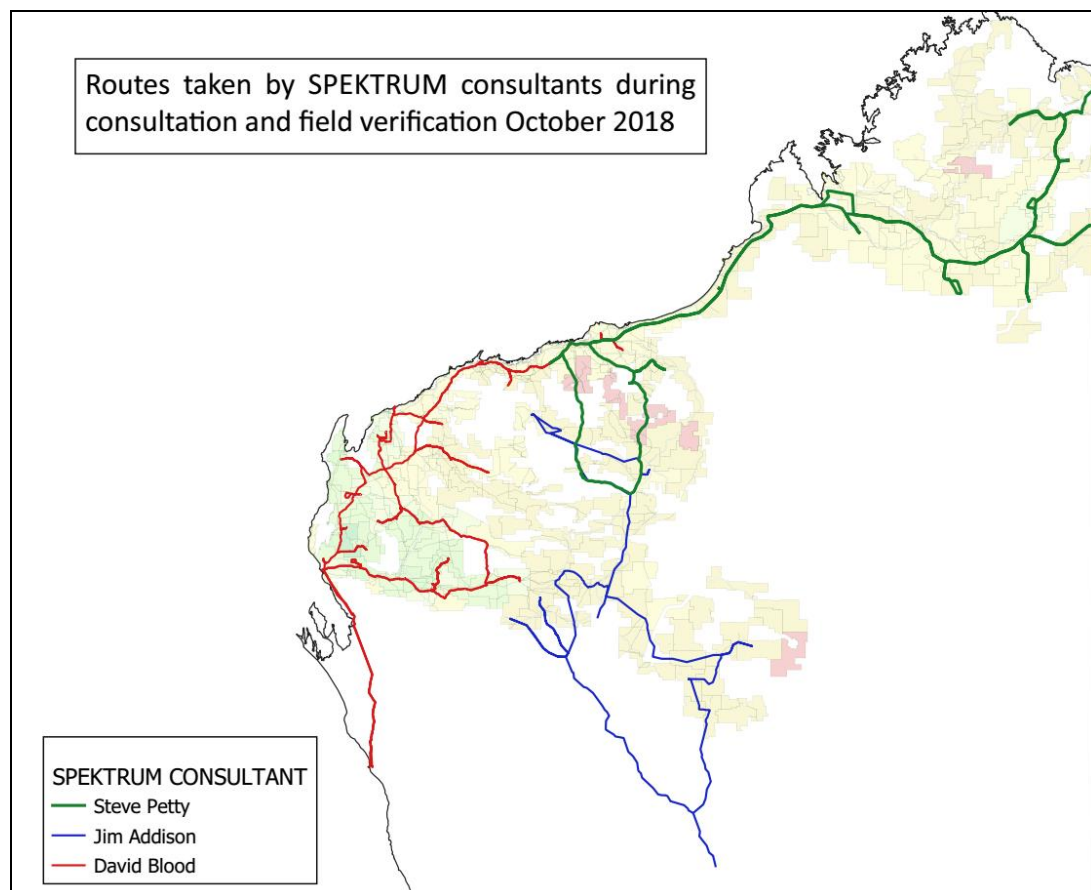


Figure 17. Field visit routes by the Spektrum Team during the assessment

4. Definition of the Cattle Unit

The PCC assessments of the carrying capacity have been presented as Cattle Units (CU) as this is the standard measure of grazing capacity in Western Australia. Many of the eastern states and MLA have standardized to Animal Equivalents. Both are standard measures of grazing loads used in extensive cattle grazing areas across Australia. Despite its common use, the measure has been inconsistently defined and applied across the rangeland in WA and other states, which has limited its application and utility.

In this project, Spektrum have defined a Cattle Unit as a 450 kg animal, consuming 8 kg dry matter per day or 2,920 kg DM/CU/yr. This is the same definition as an Animal Equivalent (AE). This definition;

- Maintains consistency with the last PCC calculation. DPIRD WA adopted 8 kg/hd as the intake of a CU when they last calculated the PCC for the leases across WA (Novelly and Beard, 2008 & *Pers Comm* Ryan K 2018).
- Is consistent with DPIRD published data. The DPIRD web site <https://www.agric.wa.gov.au/rangelands/livestock-comparisons-estimating-grazing-pressure-rangelands>, quotes the Cattle Unit as a 450 kg animal (*Ryan K, 2018*). The DPIRD Publication, “Pastoral Profits Guide”, published by DPIRD in 2008 also stated a Cattle Unit is 450 kg animal.
- Maintaining consistency with the Carrying Capacity assessments in the NT. The Department of Primary Industry in the NT have used 8 kg as their average intake for an AE, which is a 450 kg animal (Walsh and Cowley, 2011).
- Is similar to the revised recommended intake for an AE adopted by MLA, after the intake assumptions are modified (*Pers Comm* McLean 2018).

Meat and Livestock Australia (MLA) conducted a project to accurately definition an AE (McLean and Blake, 2011). In this study they defined the Adult Equivalent standard unit as a 450 kg Bos taurus steer at maintenance, 2.25 years of age, grazing on pasture with diet quality of 7.75 MJ ME/kg DM and walking 7 kilometers each day. Recent research by McLean (*Pers com*) suggests their initial estimate of Herbage Mass intake of 3,419 KG DM/AE/day may be an overestimate and 3,077 kg DM/AE/yr or 8.4 kg/hd/day is more realistic. This is of a similar order to the above CU assumption.

The MLA report provided background on the average diet quality across north Australia and the nutrient demands for the cattle walking. The report suggested the range of diet quality across northern Australia is reasonably consistent and that fixing diet quality has no material effect on the relative Adult Equivalent ratings of animals. The MLA model uses a fixed diet quality of 7.75 MJ ME/kg DM.

Additional dry matter intake data has been sourced from a range of sources (Table 5). This data suggests a dry matter intake of 2,920 to 3,077 kg/AE/yr is the most likely for an AE. It was concluded that the Spektrum adoption of 2,920 kg DM/AE/yr was a reasonable assumption.

Table 5. Estimates of the dry matter intake of a 450 kg AE and the equivalent stocking rate (SR, AE/km²) for a Mitchell Grass pasture with 2,000 kg DM/ha.

Live Weight kg	Diet Quality MJ ME/kg DM	Energy Demand MJ ME/day	Dry Matter Intake		Mitchell	Source
			kg/day	Kg/yr	grass SR (*)	
450	7.75	72.6	9.37	3,419	11.7	McLean and Blakey, MLA
450			8.43	3,077	13.0	McLean and Blakey, MLA, Modified
450			8.00	2,920	13.7	NT VG, PCC Assessment
450			8.00	2,920	13.7	Walsh and Cowley, 2011
450			10.00	3,650	11.0	GLM Workshop
450			8.00	2,920	13.7	Novelly & Beard WA VG, PCC assessment

(*) assuming a HM of 2,000 kg DM/ha

5. Potential Carrying Capacity of the Leases

5.1. The Potential Carrying Capacity data for the Leases

The Potential Carrying Capacity (PCC) of each lease was calculated using the methodology described above and have been presented in Appendix 3 by Region and Shire. The existing PCC for each lease has also been included and the percentage change calculated. These data have been extracted from the master spreadsheet, which Spektrum have provided to Landgate in digital form. A map of the PCC changes from existing to proposed has been presented in Figure 18. These changes were based on adjustments to the potential carrying capacity of the individual land systems. A map of the change in potential carrying capacity of the individual land systems has been presented in Figure 19.

Figure 18. Percent change in PCC by property *Removed due to confidentiality of the data*

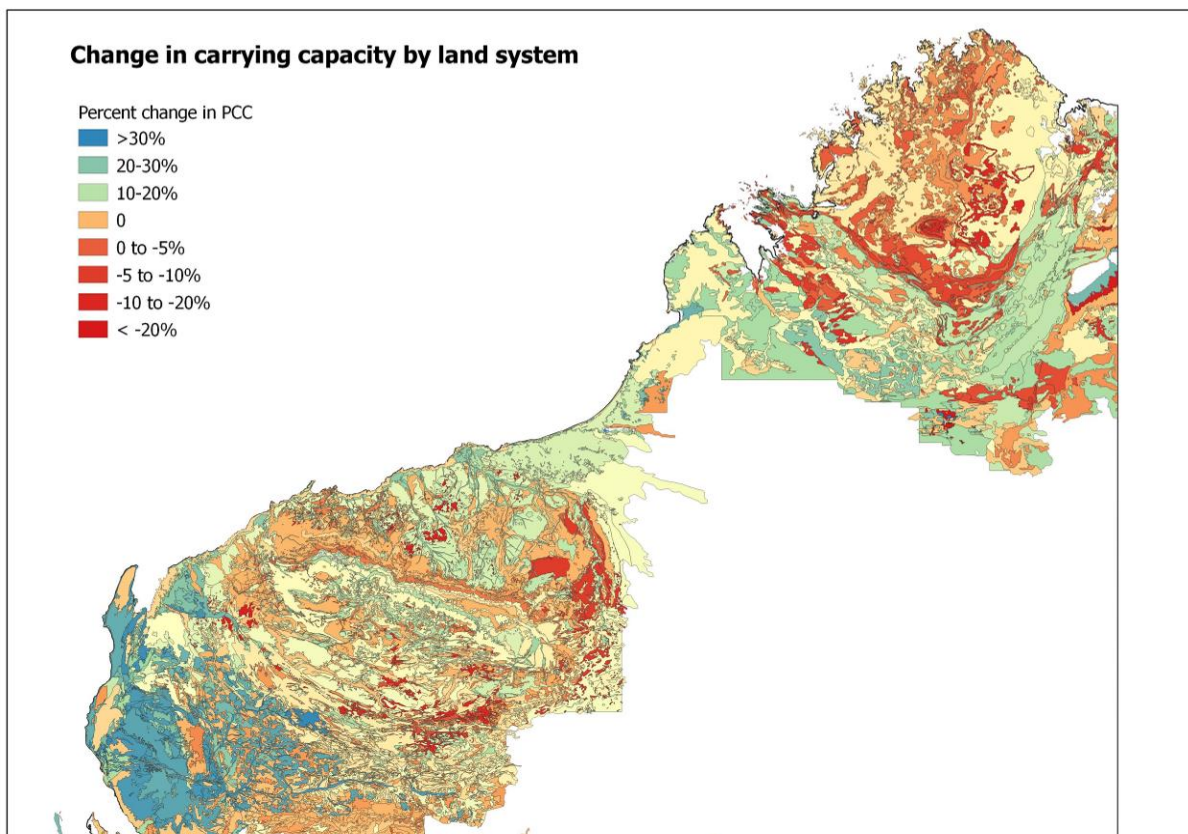


Figure 19. Percent change in land system PCC

5.2. Comparison of Proposed PCC to Existing PCC

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Table 6 *The percentage increase from the current PCC to the upgraded PCC and the Annual Stock Returns (ASR) cattle units as a percentage of the updated PCC*

	No. Leases	Increase from existing PCC to Proposed PCC	ASR (CU's) as a percentage of updated PCC
Kimberley	91	6%	82%
Broome	11	6%	84%
Derby/West Kimberley	30	5%	100%
Halls Creek	33	10%	73%
Wyndham/East Kimberley	17	1%	63%
Pilbara	85	12%	98%
Ashburton	31	11%	80%
East Pilbara	22	4%	139%
Port Hedland	6	14%	102%
Roebourne	6	7%	81%
Upper Gascoyne	20	31%	83%
Southern Rangelands	61	14%	72%
Carnarvon	20	33%	66%
Exmouth	2	36%	95%
Laverton	1	-7%	143%
Leonora	5	4%	95%
Meekatharra	21	5%	68%
Wiluna	12	1%	76%

There are a number of factors that require additional explanation in relation to the changes in PCC. These are covered in the following sections;

5.2.1 Leases where there has been a significant increase in the PCC

The Shires where there was the greatest increase in PCC included; Upper Gascoyne, Carnarvon and Exmouth (Table 6). The 20 leases that have had the greatest increase in PCC are listed in Table 7. These Leases have had an increase in PCC between 34% and 79% and are located across most of the regions (Figure 18). In many cases the increase in PCC was influenced by the increase in dominance of buffel which in turn was influenced by increasing summer rainfall and a transition from sheep to cattle.

Factors that influence this increase in PCC include;

- Change in seasonal rainfall pattern to an increased summer rainfall pattern at the expense of winter rain, essential in maintaining palatable chenopod shrubs.
- These Shires contain soil types that are colonised relatively rapidly by Buffel grass when more favourable climatic conditions present themselves.
- A transition from sheep to cattle began in the late 1990's, coinciding with successive wet summers, encouraging the spread of buffel.

Table 7. The 20 leases with the greatest percentage increase in PCC. Removed due to confidentiality of the data

5.2.2 Leases where there has been a reduction in PCC

There are 57 leases where the PCC has been reduced from the past assessment by between 1% and 48%. These are most of the regions (Table 8). The factors driving this reduction in PCC include;

- The north Kimberley leases have a large bulk of poor-quality pastures. Without supplementation the carrying capacity of these leases is much reduced well below their potential. The PCC calculation assumes no supplementation.
- In the North Kimberley, the Herbage Mass of the desirable palatable perennial species is relatively low. The annual canegrass (*Sorghum stipoides*) and Spinifex species (*Triodia spp.*) dominate many of the more productive land systems. The past assessments appear to overestimate the carrying capacity of these pastures.
- In the north Kimberley the pasture management in this area has changed across much of the area to burning at the end of each wet season. This increases the quality of the pasture in the late wet and early dry season, but significantly reduces the Herbage Mass available late in the dry season. This burning strategy perpetuates the “Boom and Bust” situation in this environment. The increased rainfall in this region does little to increase the carrying capacity as the key limiting factor is not rainfall, but the lack of nutrients in the soil.
- In the North Kimberley, many areas of this region are not accessible for grazing. The accessibility factor excluded the large hills and ranges. There are also inaccessible valleys that have productive pastures but cannot be accessed by domestic cattle. Large rivers also restrict physical accessibility by livestock to portions of the lease. These latter factors have not been considered in the PCC calculations, but need to be considered in the lease valuations. It is unknown what impact this has had on the reduction in PCC, but is likely to be a factor.
- In the upper catchments of the Gascoyne and Murchison rivers, together with internal drainage catchments of the Southern Rangelands, the soil types and climatic conditions are less conducive to establishment of buffel grass. This has limited the spread of buffel and potential to increase the PCC of leases in this region.
- In the areas defined above the carrying capacity of some land systems has been reduced as they are more rugged and inaccessible than the Land Resource data describes. This has resulted in a small reduction in PCC.

Table 8 Removed due to confidentiality of the data

5.2.3 Additional regional factors impacting updated PCC's

North Kimberley

A number of factors have led to a reduction of the PCCs in this area. These have been summarised in 5.2.2 above.

Halls Creek

Buffel has continued to establish across the alluvial land units in this area. This has increased the herbage mass available and has also increased the potential utilisation. These 2 factors have led to an increase in PCC for a number of land systems in this area and a resultant increase in PCC.

Black spears grass has also been increasing in distribution and density in many of the land systems in this region. This has increased the Herbage Mass available. In most cases this black spear grass is not preferentially grazed in the wet season and becomes low quality herbage mass in the dry season. This is reducing the quality of the pasture available and reducing the potential utilisation rate. The net of these 2 factors in many cases results in little change in carrying capacity of the pasture nor PCC of the leases.

Derby/West Kimberley

The quality of the pasture in this region is generally lower than the Halls Creek region, due to the greater abundance of Sorghum species and lower average nutritional value of the pastures. This generally results in a low sustainable utilisation rate. The Herbage Mass of the pasture in this region is higher than the Halls Creek region due to the higher annual rainfall. The net effect is a slightly lower carrying capacity and PCC than the Halls Creek region on similar land systems. The western and southern areas of this region would be better linked to the land systems of the Halls Creek region.

Broome area

The extensive buffel spread in this area was recognised in the past PCC assessment. The buffel has colonised most of the alluvial areas and some of the sandplains in this region. Rainfall in this region has increased slightly over the past 5 years, resulting in a small increase in PCC of the leases in this region.

Port Hedland

Rainfall in this area is increasing. This has assisted the buffel to establish and spread on many alluvial land units across this region. There has been a particular improvement in density and distribution of buffel along the major river systems in this region. Lessees in this region have also modified their use of fire to increase their capacity to utilise the Spinifex pastures. This has increased the carrying capacity of the spinifex pastures in this region. The improvement in rainfall, increase in buffel distribution and improvement in fire management have all contributed to a significant improvement in the PCC of the leases in this region.

North East Pilbara

Buffel has continued to spread across the alluvial areas in this region. This has been supported by the increase in rainfall in the region. Lessees in this region have also modified their use of fire to increase the capacity to utilise the Spinifex pastures. This has increased the carrying capacity of the spinifex pastures in this region. The improvement in rainfall, increase in buffel distribution and improvement in fire management have all contributed to a significant improvement in the PCC of the leases in this region.

Upper Ashburton and South East Pilbara catchment

In the Upper Ashburton and South East Pilbara catchments some of the premiums applied for Buffel colonisation of alluvial soils, have in some cases been offset by formal discounts for inaccessibility in rugged terrains that were not previously applied in rangeland surveys.

East Gascoyne and Murchison catchments

These landscapes are supporting little Buffel colonisation as a result of less reliable rainfall together with lower temperatures autumn through to spring. The leases in these catchments demonstrated little variance between existing and new PCC.

Inland drainage catchments of the Southern Interior

Similar to the Upper Gascoyne/Murchison. Some standardisation of Beard vegetation type PCCs across the leases resulted in some small variance. Some inaccessibility in the Glengarry land system also created some minor discounting. Re-allocation of some Carnegie land system to Lake Bed contributed to minor discounting on one lease.

North and central Pilbara

Field inspections of Buffel colonisation indicated a large variation in extent and sward density across alluvial landscapes. Management practices and consistent adequate quantity of summer rainfall appear to be major drivers of Buffel colonisation.

West Pilbara, Central and West Gascoyne

Widespread increases in buffel density has transformed all land systems in the Ashburton, West Gascoyne and Lyons Valley, sometimes at the expense of native perennial shrubs that have reduced in number to due declining trends of winter rainfall but also strong competition from buffel. The change is particularly pronounced on sandy surfaced and silty alluvial systems. This change has conferred a dramatic increase in productivity that provides a rapidly responding high quality feed source, which although has limits in dry seasons, can be further maximised by supplementation. Real utilisation rates are observed to be much higher than those used in the PCC review, leading in some cases to a significant underestimation of the true capacity. Typical paddock consumption rates of buffel dominated pastures are greater than 50% in most cases.

The transition of sheep to cattle in the 1990's has resulted in a change of pasture use from intense concentrations of sheep to a more extensive and uniform grazing pattern by cattle. Where effective grazing management is practiced, the impacts of cattle grazing are considerably less than for sheep.

5.3. Comparison of Annual Stock returns over a 10 year period to updated PCC

The updated PCC's can also be compared to the Annual Stock Returns (ASR) for the respective leases. This data provided an indication of the stocking rate in Cattle Units being applied on each of the leases, shires and regions. The 2007 to 2016 period was selected. The data is generated from the lessee's declared stock numbers as at the 30 June each year.

The updated average PCC were on average 85% higher than the average declared stock numbers over the 7 year period. The updated PCC was higher than the ASR numbers on 70 leases (29%) and lower on 167 of the leases (71%). A map of the comparisons of the ASR versus updated PCC have been presented in Figure 20. A map of the comparison of the ASR versus the current PCC has also been presented in Figure 21. The key issues to be highlighted are;

- There are a number of leases in the Derby/West Kimberley Shire where the ASR data is higher than the PCC. This is discussed below.
- The majority of the leases in the North East Pilbara also have the ASR data higher than the PCC estimates. This is also discussed below

Care is required when drawing comparisons between new lease PCC and lease-based livestock enterprise data supplied in Annual Stock Returns to the Pastoral Lands Board. The reasons for this include;

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- There is no guarantee that stocking rates being reported are sustainable. Some district WARMS data, over time, suggests that this may not be the case across the board.
- There has been no significant regional “drought” across the WA pastoral areas in the last 15 years to temper stocking rates. The last regional “dry” wet season in Kimberley was 1992. A cycle to a more “long term average” run of seasons would require many of the leases to reduce these stocking rates.
- The PCC assessment assumes that CUs are distributed over a lease in accordance with land system/land unit capacity. The actual lease stocking rate doesn’t follow those rules with some landscapes being heavily grazed while others are untouched. This is particularly the case in open-range cattle grazing (is areas that lack fencing).
- There are often significant differences between leases in terms of management input and opportunity to graze additional areas that are not part of the legal lease. Some of these factors include; spinifex burning practice and use of adjacent UCL.

Figure 20. The pastoral annual stock return as percent of updated PCC Removed due to confidentiality of the data

5.3.1 Leases where the Proposed PCC is less than the Annual Stock Return figure

It is typically unsustainable for a property to be consistently stocked at a higher level than the PCC. Some of the reasons that the data suggests these Leases are stocked higher, as estimated in the annual stock returns, than the calculated PCC include;

- Many of these Leases have stock routes and excisions on their properties, which provides additional carrying capacity where they run additional stock. These areas are not considered in the PCC calculation, but are in the stocking rate data.
- Many of these leases have access to Unallocated Crown Land where they can run additional stock. These areas are not included in the PCC calculation, but are in the ASR data.
- The Stocking Rate data collected from the lease returns may not be a consistent indicator of average annual stock numbers on a Lease as they are a snapshot of cattle numbers on the 30 June. Management such as the selling strategy, cattle transfer strategy, weaning strategy and trading program all impact this number at this time. All of these factors will skew the annual stocking rate. Because the ASR data is “point-in-time” it might be more correctly described as stocking density rather than stocking rate.
- Many of the lessees provide supplementation to their cattle. This allows the cattle to graze lower nutritional value pastures, including the spinifex pastures. This has increased the carrying capacity of many leases. The PCC assessment assumes no supplementation is used, requiring a more conservative assessment of the carrying capacity that can be achieved using supplementation.
- The management of the pastures has improved, allowing a higher level of utilisation than was the possible in the past. These management factors include more considered use of fire with the spinifex pastures, rotational grazing strategies and the increased proportion of tropically adapted cattle within the herds.
- The PCC is a long-term carrying capacity estimate. The past 5 to 10 years have typically been average to above average, with no major droughts. Although it is acknowledged that the climate has been changing in this area, it is important to maintain the PCC as a long-term estimate of the carrying capacity, including poorer seasonal conditions.

The East Pilbara area is a region where there are a number of leases where the stocking rate is 29% higher than the proposed PCC. The proposed PCC of this area has been increased by 12% from the past assessment. All of the factors listed above have contributed to this apparent anomaly.

Comments have been provided in the data that explain what factors are contributing to the situation where the PCC is less than the current Stocking Rate against the respective lease.

figure 21 Removed due to confidentiality of the data

5.3.2 Leases where the PCC is considerably higher than the stock returns

Removed due to confidentiality of the data

5.4. Lessee views on the PCC's within the respective regions

Kimberley (Steven Petty)

The Kimberley respondents generally saw the reassessment process and GLM process in a positive light. They were typically engaged and provided detailed and positive feedback on the potential carrying capacity of their leases and any changes in pasture composition on their leases (eg buffel and black spear grass). There were a number of corporate lessees that were uncomfortable with an increase in PCC for their respective leases and provided robust feedback on this. In the end they understood the process and although not happy accepted the increases. The Private owners were typically conservative in the views with carrying capacity and provided stocking rate data and examples to add to the regional knowledge on the respective land systems. The Indigenous lessees were typically comfortable with the process and GLM methodology.

Pilbara (David Blood, Jim Addison & Steven Petty)

The majority of respondents saw the GLM process as being transparent and equitable. Most discussion centred around Buffel colonisation and livestock accessibility. There was some confusion regarding the definition of the PCC amongst a small number of respondents e.g. is a CU a cow/calf unit? – how does the level of lease development impact PCC? Older lessees tended to favour a rise in PCC, presumably to enhance lease sale value on retirement. Younger lessees preferred to see little or no change, so as to contain annual lease rental charges. Mining Companies were engaged with the process and accepted the PCC computations. They tended to be more concerned about difficulties meeting company corporate OHS requirements within the pastoral operations. The Indigenous respondents were quite accepting of the draft computed PCCs.

Southern Rangelands (Jim Addison & David Blood)

All but two lessees out of 63 leases in the west and south western area of the project were either strongly in favour of a large or modest increase, or accepting of an increase, largely on the basis of the disproportionate benefit that buffel grass offers these leases. Opinions and views of the strengths and weaknesses of buffel varied, as they do in the pastoral industry, though all acknowledged that it has a profound year-round impact in most years. Buffel has a somewhat cyclical nature of persistence in that it will, in modal years, develop long lived tussocks that endure seasonal droughts, but will recede in extended droughts. It will always respond well in extended growing seasons following drought, provided it is rested to allow tussock establishment. Strong gradients in productivity with the same land system was noted in several extensive systems, again the dominance of buffel being a key determinant along with geomorphological variations. This variation was not satisfactorily addressed in this project and needs more detailed herbage mass estimates, particularly in the Gascoyne Catchment, which has not been remapped since the first survey in 1970. The Gascoyne and West Pilbara has been through a cycle of turnover of experienced managers in the last decade, mostly by succession, but some by new lessees, hence opinions varied with experience. Younger and more objective managers tended to have more insightful views on productivity of landscapes, though lack the long-term experience of severe droughts. Nearly all managers interviewed had adopted a conservative approach to stocking to leave sufficient reserve in the event of seasonal drought. Supplementation is widespread and the benefits of this on animal productivity and stocking rates are significant, though difficult to quantify. Some station by station comparison reveals large differences in weaning rates attributable to supplementation.

5.5. Changes in buffel grass distribution

The change in pasture composition across the region has resulted in a change in carrying capacity of many land systems and leases. It is difficult to develop or source objective data on species composition

change, given the lack of base line data and the challenge of collecting additional spatial data on species distribution. The 2 key changes observed by the Authors and highlighted by the Lessees and DPIRD staff were the increase in Buffel grass distribution and increase in Black Spear grass distribution.

Some objective data and photographs of Buffel increase can be identified in the pasture monitoring data (Figures 22, 23, 24, 25). During the project an attempt to provide a subjective estimate of the level of Buffel distribution across the regions was conducted. The level of buffel establishment on each land system was subjectively rated as;

- Widespread and dense
- Widespread but variable
- Localised populations
- None or negligible

These ratings were sourced by each of the Authors local experience and field assessment, the Lessees, DPIRD staff and the WARMS data by land system and region. A summary of this data has been provided in Table 9. This data suggests approximately 15% of the assessed area had widespread buffel and 31% had populations of buffel. A map of this data has also been provided in figure 26.

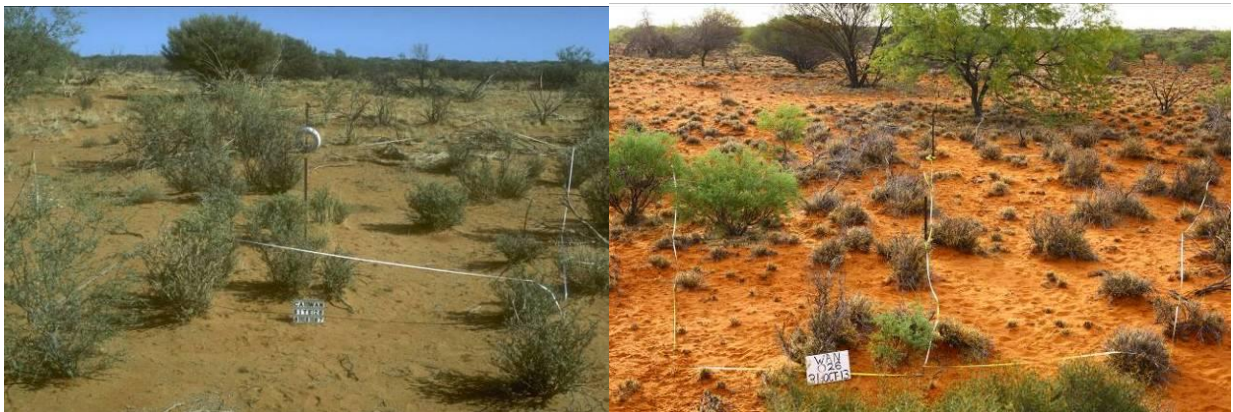


Figure 22. Minilya River 1987 (DAFWA) 2013 (D.Blood)



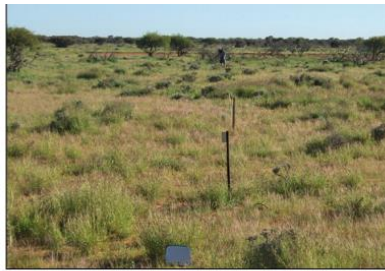
Figure 23. West Gascoyne 1984 (DAFWA) 2013 (DAFWA)



Figure 24. Fortescue River, 1990 (DAFWA) 2012 (D.Blood)



In 2002, there were 1600 silver saltbush plants per hectare



In 2008, there were 1000 silver saltbush plants per hectare, with buffel grass frequency of about 10%



In 2015, there were no silver saltbush plants and buffel grass frequency had increased to 56%

Figure 25. Transition from a chenopod pasture to a buffel grass pasture in the southern rangelands (Source Thomas, Philip and Angela Rogerson, Report card on sustainable natural resource use in the rangelands).

Table 9. Areas of land systems in respective buffel density categories

Buffel density category	Hectares	Percent area
3 - Widespread and dense	3,612,496	3%
2 - Widespread but variable	16,100,754	12%
1 - Localised populations	20,203,545	16%
0 - None or negligible	88,590,488	69%
Grand Total	128,507,283	

Buffel density by land system

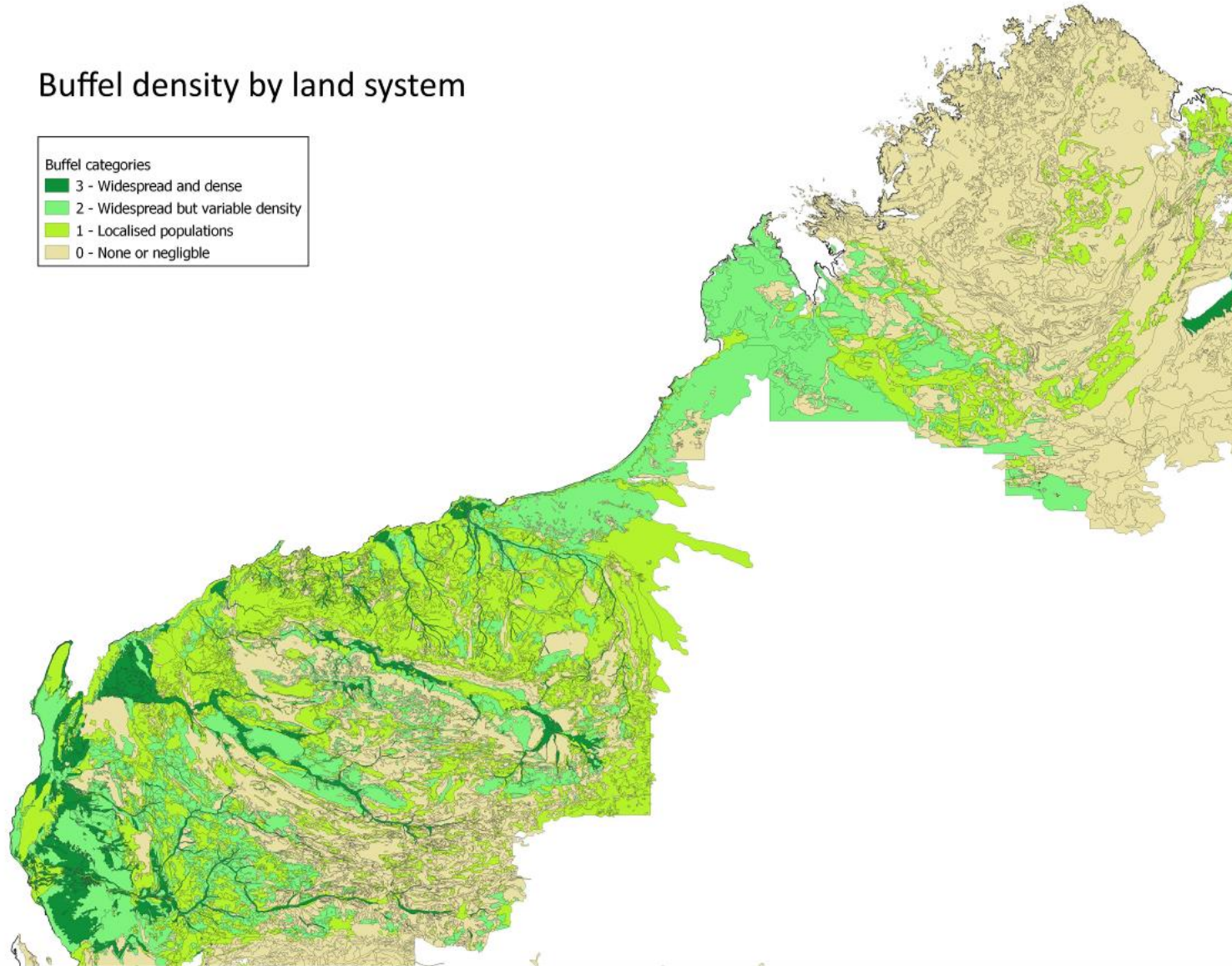
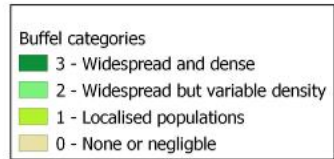


Figure 26. Buffel distribution by land system

5.6. The impact of Black Speargrass increase

Black spear grass has been increasing in distribution and density in the Halls Creek, East Kimberley and North Kimberley regions. An example of this increase has been provided in Figure 27. This colonisation of black spear grass appears to be causing a decline in density and frequency of other native grass species. The increase in Black Spear grass has increased the Herbage Mass of the pastures in these areas. Although this is the case it appears to have reduced the sustainable utilisation rates of these pastures due to the decline in quality of the pasture. The net effect of the 2 changes has typically been little change in the rated PCC for the land systems.

Data from the Future Beef site on Black Speargrass in Queensland suggests a range in Herbage Mass from 1,900 – 3,600 kg/ha and utilisation rates in the order of 10 – 15%. In the East Kimberley area, the Black Spear grass is typically patchy and our observations suggest a Herbage Mass is in the order of 1,200 – 2,000 kg DM/ha. The utilisation rate of this would be expected to be more in the order of 8 to 12%.



In 1998, black speargrass frequency was 49%



In 2004, black speargrass frequency was 78%



In 2013, black speargrass frequency was 100%

Figure 27. Increase in Black Speargrass in the east Kimberley (Source Thomas, Philip and Angela Rogerson, Report card on sustainable natural resource use in the rangelands).

5.7. Land system carrying capacity data

The land system carrying capacity data has been provided in digital form for the Regions and Shires to Landgate. This data has been presented including;

- Dominant pasture type
- Estimated herbage mass
- Estimated utilisation rate
- Accessibility of the Land System
- Updated PCC
- Existing PCC
- Comments against any land systems that had unusual factors linked to them

This is the data that was used to calculate the above PCC data for the leases. The Herbage Mass data and Utilisation data are linked to the pasture types for each region. Within each pasture type there is a considerable variation due to climatic factors, geomorphological factors and other regional variations.

5.8. Conclusion on the PCC assessments

The primary objective of this project was to update the PCC's of the leases in the project area in a credible and considered fashion. The PCC across all of the leases increased by an average of 9.4%. There was, although, considerable variation across regions and across individual leases, with some leases increasing their PCC by 59% and others reducing their PCC by 8%. This report presents some of the factors that are influencing these changes. There are likely to be additional factors driving these changes that have not been mentioned in this report. This report is not intended to provide an exhaustive list of factors influencing the PCC's on the individual leases.

The project has delivered;

1. A report on the updated PCC's and some of the factors driving change in PCC
2. Spreadsheet of land system x HM x Util x Accessibility x CC, with some notes on specific land systems
3. Spreadsheet of Lease x Land System x Area x CC
4. Spreadsheet of Lease x PCC x ASR (2007-2016) with notes on specific leases
5. Spektrum will retain the supporting notes and information for Stage 2 of this project
6. Spektrum will maintain the required insurance for 9 years

This digital data will provide a basis for the next reassessment of the PCC.

Care is required with the use of this data for purposes other than for the intended use by Landgate for valuation purposes. The assumptions used to calculate these PCC's limit the capacity to extrapolate this data for other uses.

Recommendations for future assessments

1. Collect additional Herbage Mass data for land systems across a range of seasons across the regions prior to the next assessment.
2. Provide a longer time frame for completion and facilitate greater support from the respective Department staff to allow a more co-ordinated assessment of the Buffel distribution and other factors that impact the PCC
3. Develop a mechanism to include all grazed areas associated with a rangeland grazing enterprise e.g. Stock Routes and Reserves
4. Carry out a full rangeland survey of the eleven pastoral leases without land system information
5. The Gascoyne Catchment was last surveyed in 1970 and is quite inconsistent with adjoining surveys and requires remapping.

6. Acknowledgements

The project team would particularly like to acknowledge the significant contribution that Phil Thomas has made to the successful outcomes of the project. His knowledge and understanding of the WA rangelands and computing skills are formidable. Thanks also to Matt Fletcher and Kath Ryan for their valuable contributions and insights of pasture production in the Pilbara and Kimberley. The project team would also like to thank Lester Cousins for his consistent direction of the project and Chris Olson for his support and assistance with the project

7. SWOT for the current PCC assessment approach and recommendation for the future

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> • The current approach generates a common understanding of lease pastoral potential • Is a collaborative stakeholder pastoral potential determination process • It facilitates pastoral lease potential comparisons across rangeland jurisdictions • It is relatively simple and requires limited data inputs (land system areas, Herbage Matter DM/ha, utilisation %, accessibility and annual Cattle Unit DM requirement) for PCC computations • More rigour can be applied to the process as superior data becomes available • The methodology is repeatable and can be added to and improved over time • The methodology process delivers an “apples with apples” comparison between lease PCC’s, which provides clarity and transparency 	<ul style="list-style-type: none"> • The methodology contains an element of subjectivity, with the Herbage Mass assessment and the utilisation assumptions. • Limited capacity to geographically extrapolate unreviewed data • Generates a “point in time” assessment to a constantly evolving biophysical resource • The Cattle Unit is based on nutritional energy requirement but does not consider the productivity of that Cattle Unit, which is linked to the protein availability • On leases where a low/very low PCC land system (e.g. Bullimore, Boolaloo) occupy a large area, small PCC adjustments can result in a profound change in lease PCC • The consideration of the Lessee input may skew the assessment of land system carrying capacities slightly • The capacity to understand the distribution of buffel is limited by accessibility and the lessee’s understanding of the distribution.
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> • To build on the Spektrum PCC base data to further improve the confidence and reliability of the data • Provides an opportunity to focus producers on land use capability as well as livestock management • An App might be developed to assist grazing enterprise managers to determine the full PCC of their lease including the non-lease grazing lands e.g. Stock Routes and Reserves 	<ul style="list-style-type: none"> • The use of consultation to improve the assessments may be impeded by inalcitrant and/or uncooperative stakeholders • The lack of objective Herbage Mass data and sustainable utilisation rates across a range of seasons for each land system limits the reliability of the PCC assessment. • Resultant PCCs may be inappropriately employed by unscrupulous real estate agents • The PCC definition must preclude its use in setting stocking rates

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Appendix 1 list of stations *Removed due to confidentiality of the data*

Appendix 2 List of Land systems, current PCC, proposed PCC and % change *Removed due to confidentiality of the data*

Appendix 3 Lease existing PCC, Proposed PCC, Annual Stock Returns (ASR) and rainfall
Data Removed due to confidentiality of the data

Appendix 4 Summary of industry Consultation

The Industry Consolation included;

- Email sent to Lessee's from Landgate
- Email sent to Lessee's from Spektrum
- Field verification by Spektrum
- Second email from Spektrum
- Phone call to all Lessee's
- Meetings with key DPIRD staff
- Presented at 5 industry meetings
- Two Newsletter articles

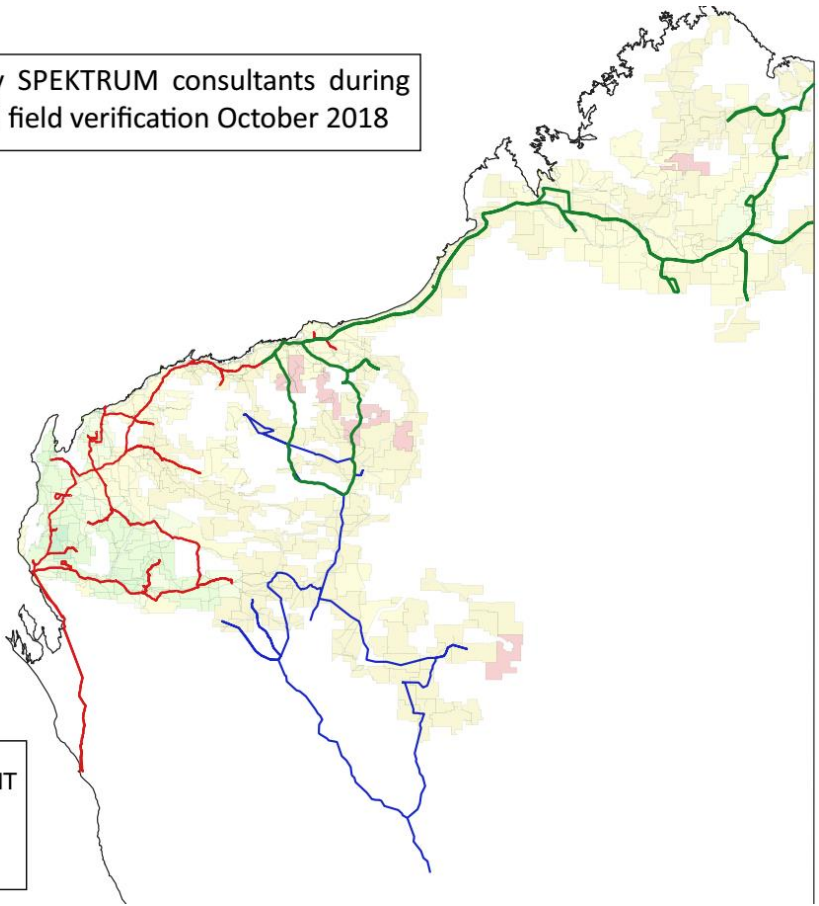
Table of all consultation with Industry and Government

Type	David	Jim	Steve	Total
Bulk emails	315	195	220	730
Email	61	34	24	119
Field visit	38	18	6	62
Phone	56	77	127	260

Route taken By Spektrum Consultants during the field inspection.

Routes taken by SPEKTRUM consultants during consultation and field verification October 2018

SPEKTRUM CONSULTANT
— Steve Petty
— Jim Addison
— David Blood



Appendix 5: Article published in KPCA newsletter

Review of Potential Carry Capacity – Kimberley, Pilbara and Southern Rangelands

Every five years Landgate conducts a review of annual rentals on all pastoral leases in Western Australia, as required by the Land Administration Act 1997. Landgate are currently conducting this 5 year review. As a part of this review Landgate will reassess the Potential Carrying Capacity (PCC) of pastoral leases across the majority of the Southern Rangelands and Kimberley region and all of the Pilbara region. The recalculation of the PCC will be utilised in Landgate's review and determination of the annual rents payable for Pastoral Leases and for use by the Pastoral Lands Board and DIPIRD. Rentals determined in this review will apply from 1 July 2019.

The Valuer General, Lester Cousins from Landgate is managing the project. Landgate have appointed the private consulting group, Spektrum, to assist with the PCC assessment. The Spektrum team includes Steve Petty who will be involved in the Kimberley & Pilbara leases, David Blood who will be involved in the Pilbara & Southern Rangelands leases, Jim Addison who will be involved in the Southern Rangelands leases and Elise Petty who will cover communications and project management.

The PCC is assumed to be the number of Cattle Units a lease could carry if it were fully developed and grazing animals could graze all of the accessible pastures on the lease. The PCC review will be conducted using the Grazing Land Management methodology (GLM). The GLM methodology is primarily based on herbage mass assessments, sustainable utilisation rates and accessibility of the Land Systems and Land Units by grazing animals. The review will involve:

- Collection of published carrying capacity data for each land system on the focus leases.
- Assessment of the carrying capacity of land systems within areas that currently do not have published land system data.
- Limited inspection of areas where there is insufficient data to conduct the review
- Detailed Industry consultation to discuss land system carrying capacity, accessibility of the land systems to grazing animals and distribution of desirable pasture species.
- Government Department Consultation
- Completing the project and final report by the 30th Nov 2018

Given the variability in range condition, level of development and management of the pastoral leases across the state, the Valuer General has provided the following assumptions for the Potential Carrying Capacity assessment;

- All Land Systems are in good range condition
- The PCC assessment is the average across the full range of seasons
- Leases are fully developed allowing 100% access to water
- Areas that are physically inaccessible are removed from assessment
- Good grazing management has been practiced
- Introduced pastures (eg Buffel) are included in assessment
- Feral and native herbivores are assumed to be removed
- No supplementation is provided
- Reserves, UCL stock routes excluded

The review includes Industry consultation and communication. All leaseholders should have received an email from Landgate advising if they are included in the review or not. Spektrum will contact leaseholders by email advising of the process and information that will be discussed. Leaseholders will then be contacted via phone regarding this review to discuss the PCC of their lease. A number of factors may contribute variances between their existing PCC and the reviewed PCC, including change of vegetation type e.g. buffel grass colonisation, exclusion of areas of no pastoral value e.g. lake bed or areas inaccessible to grazing, and adjustments to land system areas. Spektrum will be seeking constructive feedback regarding any PCC variance together with additional comments leaseholders may have regarding the review. A small percentage of leases will be inspected where there is insufficient data available to accurately make an assessment. If leaseholders have any queries or concerns regarding this process, please contact Domenic Audino on 08 92739453 or Chris Olsen on 08 9273 9455 from Landgate. Should you have any technical questions regarding the PCC review, please contact Elise Petty at Spektrum on 08 9169 3444.

Review of potential carrying capacity

Dr Steve Petty, Spektrum, Kununurra

Every five years, Landgate conducts a review of annual rentals on all pastoral leases in Western Australia, as required by the *Land Administration Act 1997*. Landgate is currently conducting the five-year review.

As a part of the review, Landgate will reassess the Potential Carrying Capacity (PCC) of pastoral leases across the majority of the Southern Rangelands and Kimberley region, and the entire Pilbara region.

The recalculation of the PCC will be utilised in Landgate's review and determination of the annual rents payable for Pastoral Leases and for use by the Pastoral Lands Board and the Department of Primary Industries and Regional Development. Rentals determined in this review will apply from 1 July, 2019.

Valuer General, Lester Cousins, of Landgate, is managing the project. Landgate has appointed the private consulting group, Spektrum, to assist with the PCC assessment.

The Spektrum team includes Steve Petty, who will be involved in the Kimberley and Pilbara leases, David Blood, who will be involved in the Pilbara and Southern Rangelands leases, Jim Addison who will be involved in the Southern Rangelands leases, and Elise Petty, who will cover communications and project management.

The PCC is assumed to be the number of Cattle Units a lease could carry if it was fully developed and grazing animals could graze all of the accessible pastures on the lease.

The review will be conducted using the Grazing Land Management methodology (GLM), which is primarily based on herbage mass assessments, sustainable utilisation rates and accessibility of the land systems and land units by grazing animals.

The review will involve:

- Collection of published carrying capacity data for each land system on the focus leases.
- Assessment of the carrying capacity of land systems within areas that do not currently have published land system data.
- Limited inspection of areas where there is insufficient data to conduct the review.
- Detailed industry consultation to discuss land system carrying capacity, accessibility of the land systems to grazing animals and distribution of desirable pasture species.
- Government department consultation.
- Completing the project and final report by 30 November, 2018.

Given the variability in range condition, level of development and management of the pastoral leases across the State, the Valuer General has provided the following assumptions for the PCC assessment:

- All land systems are in good range condition.
- The PCC assessment is the average across the full range of seasons.

- Leases are fully developed, allowing 100 per cent access to water.
- Areas that are physically inaccessible are removed from assessment.
- Good grazing management has been practiced.
- Introduced pastures, such as buffel, are included in assessment.
- Feral and native herbivores are assumed to be removed.
- No supplementation is provided.
- Reserves and UCL stock routes are excluded.

The review includes industry consultation and communication. All leaseholders should have received an email from Landgate advising whether they are included in the review or not.

Spektrum will contact leaseholders by email with information about the process. Leaseholders will then be contacted by phone regarding the review to discuss the PCC of their lease.

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Spektrum will be seeking constructive feedback regarding any PCC variance, together with additional comments leaseholders may have regarding the review.

Where there is insufficient data available to accurately make an assessment, a small percentage of leases will be inspected.

If leaseholders have any queries or concerns regarding the process, contact Domenic Audino on +61 (0)8 9273 9453 or Chris Olsen on +61 (0)8 9273 9455 from Landgate.

Technical questions regarding the PCC review should be directed to Elise Petty at Spektrum by calling +61 (0)8 9169 3444.