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Factors influencing pasture utilisation in northern Australian rangelands

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Abstract
Annual pasture growth and utilisation were retrospectively modelled using the biophysical GRASP model for 20 pre-existing breeder herd datasets from across northern Australia as part of a broader study to quantify the effect of pasture utilisation rates on the reproductive performance of extensive beef breeding females. Annual pasture utilisation was more influenced by variation in stocking rate in the central and northern Northern Territory (NT) regions, while variation in pasture growth explained more of the variability in pasture utilisation in the Southern NT and north eastern (NE) Queensland regions. In the Alice Springs region, median pasture utilisation was 1.8 x higher than recommended levels on commercial stations compared to the utilisation rate on the research station where it was 0.7 x recommended levels, despite higher relative rainfall for the commercial herd studies. In contrast, in the Barkly the median utilisation on commercial stations was lower than recommended levels (0.7 x recommended) possibly reflecting the high relative rainfall during those studies. On commercial stations in northern NT and NE Queensland regions, median utilisation was 1.2 and 1.3 respectively x recommended levels, but this was for years with rainfall 1.6 and 1.7 times the long-term median respectively.

Introduction
Safe pasture utilisation is commonly used in a pasture sustainability context as the proportion of pasture consumed by livestock that will maintain the underlying resource base over the long term (Hunt 2008). Northern Australian cattle production systems are typically extensive breeding enterprises with herds free-ranging in large to very large paddocks (five to 500 km²), grazing mostly on rain-fed native pastures. The summer-rainfall dominated climate supports mesic to semi-arid tropical and subtropical savannas, through to arid shrublands and grasslands. Recommended safe levels of pasture utilisation to sustain vegetation and soils are typically in the order of 5 to 25% of annual pasture growth. However, these rangelands are often utilised at rates that exceed safe levels. This work was part of the larger Sweet Spot project that examined the impact of pasture utilisation on breeder herd performance. Here we examine the factors influencing pasture utilisation in the dataset and implications for rangeland management.

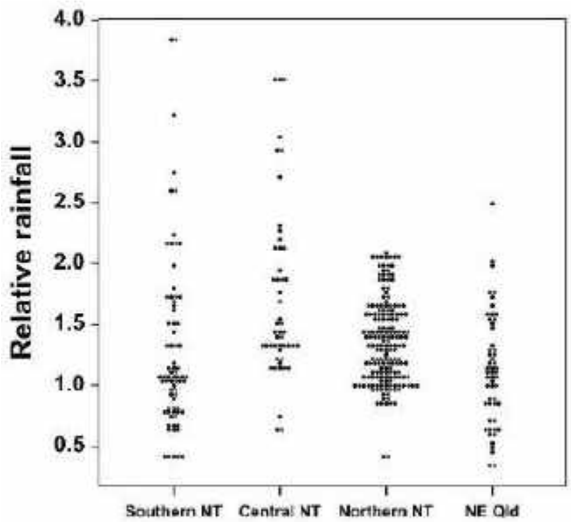
Methods

Pasture growth and utilisation (for the growth year between October 1 and September 30) were modelled using the pasture growth GRASP model (Rickert *et al*. 2000) for existing breeder herd datasets at 60 paddocks (sites) across northern Australia as part of the Sweet Spot project. The herd datasets included 77,000 cattle records from 60 paddocks between 1991 and 2022 for a total of 350 site-years. Climate files for each site from SILO were combined with local/site rainfall where available. Pasture utilisation is a result of both pasture growth and animal intake. Intake and growth were calculated within the watered area (defined as all the area within 3 km and half the area between 3 and 5 km from water). Paddock pasture growth was calibrated using total standing dry matter estimated in the paddock and satellite derived green ground cover. Intake was assumed to be 8 kg/adult equivalent/day (McLennan et al. 2020) with an adult equivalent (AE) defined as a 450 kg *Bos taurus* steer walking 7 kilometres each day (McLean and Blakeley 2014). The number of AE was calculated using measured herd performance for each class and time period using the AE calculator (McLean and Blakeley 2014, version 14.63). As safe utilisation rates vary between land types, we used a simple index of utilisation; relative utilisation = modelled annual pasture utilisation/safe (long term average) utilisation for that site. Long term safe utilisation rates for each land type were determined from the literature (e.g. Ash et al. 1997, Hunt 2007). Relative rainfall = actual annual rainfall / median long-term annual rainfall.

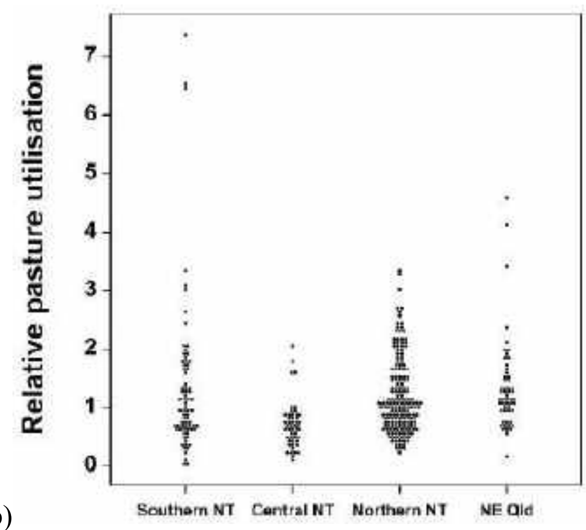
Statistical analyses (R Core Team 2024) were performed to determine whether stocking rate or pasture growth was the greater influence on pasture utilisation in the different regions. Data from properties in each region were used for a linear model to assess the relationship between annual percent pasture utilisation and the explanatory variables of log (annual pasture growth) and stocking rate. Partial correlation coefficients for each explanatory variable were generated using the ppcor package (Kim 2015a, Kim 2015b). The dataset was analysed by broad geographical location.

Results

The dataset was skewed towards wetter years, with above median rainfall in 65% of the 350 site-years (Fig. 1a). Median relative utilisation was one in the Southern and Northern NT regions (indicating safe utilisation levels, Fig. 1b), but was less than one in the Barkly Central NT (0.7) and higher than one in NE Queensland (1.2), reflecting stocking rate trials deliberately testing high stocking rates there. The Alice region in southern NT had some very high relative utilisations which were all found on commercial stations (where the median relative utilisation was 1.8 x higher than recommended level) and which were considerably higher than for a local research station (0.7 recommended level), despite higher relative rainfall for the commercial sites (1.6 vs. 1.1 respectively). In contrast the Barkly median utilisation on commercial stations was lower than the recommended level (0.7 x recommended) possibly reflecting the high relative rainfall during those studies (1.4 x median). On commercial stations in Northern NT and NE Queensland regions, median utilisation was 1.2 and 1.3 x recommended levels, but this was for years with rainfall 1.6 and 1.7 times the long-term median.



a)



b)

Figure 1: Variation in a) relative rainfall, 1 = median rainfall and b) relative simulated pasture utilisation, 1=safe utilisation, across regions of northern Australia on the Sweet Spot sites

Pasture growth explained more of the variation in pasture utilisation in the Southern NT and NE Queensland regions (Table 1, Fig. 2) and stocking rate explained more of the variation in annual pasture utilisation in the Northern NT and Barkly regions (Table 2, Fig. 2).

Table 1: Coefficient of regression between annual pasture utilisation and log annual pasture growth for Sweet Spot broad regions * $P<0.05$** $P<0.01$*** $P<0.00001$

Region – Sub-regions	df	Intercept	Slope	r^2	P
Southern NT - Alice	72	153	-45.6	0.72	***
Central NT - Barkly	47	82.7	-20.5	0.15	**
Northern NT - Katherine / Sturt Plateau / VRD	171	217	-58.9	0.26	***
North East Queensland – Central, North and Far North Qld	52	282	-75.2	0.62	***

Table 2: Coefficient of regression between annual pasture utilisation and annual stocking rate for Sweet Spot broad regions * $P<0.05$** $P<0.01$*** $P<0.00001$

Region – Sub-regions	**df**	**Intercept**	**Slope**	**r^2**	**P**
Southern NT - Alice	72	9.5	2.05	0.03	ns
Central NT - Barkly	47	3.2	1.18	0.48	***
Northern NT - Katherine / Sturt Plateau / VRD	171	1.3	1.46	0.70	***
North East Queensland – Central, North and Far North Qld	52	24.2	0.46	0.03	ns

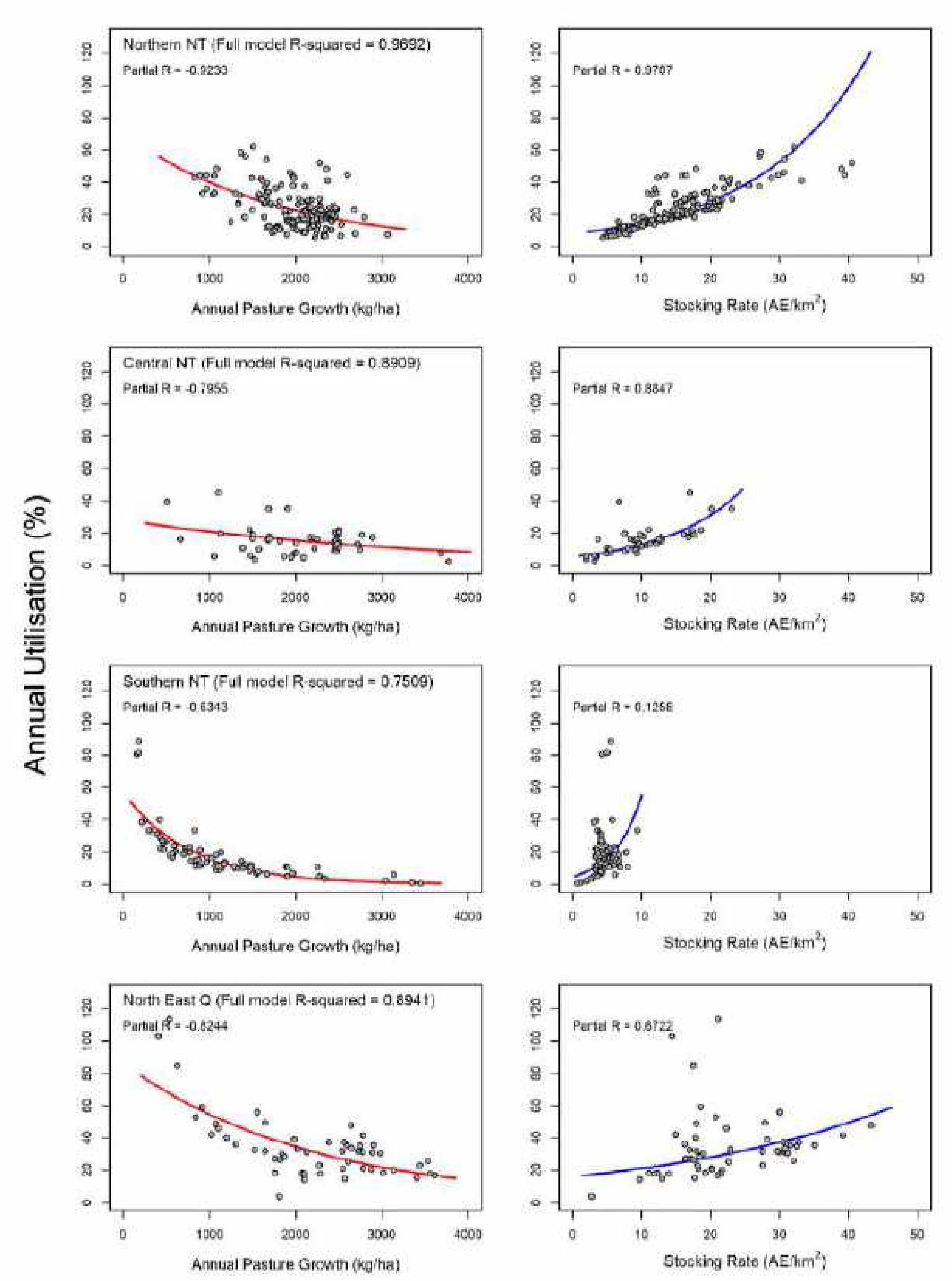


Figure 2: Relationships between pasture utilisation and pasture growth and stocking rate by region

Discussion

This dataset includes data from research herds used in cattle production studies, grazing trials for testing different stocking rates and grazing systems, and studies on collaborating commercial cattle stations. This work involves a meta-analysis of pre-existing datasets where the individual datasets are inherently idiosyncratic in nature, and the regional breakdowns were not balanced for commercial vs. research station, level of infrastructure development, land types represented, or the proportion of dry vs. wet years. Whilst the dataset was not necessarily representative of pasture utilisation rates across the broader industry it was suited to the broader Sweet Spot study where a range of pasture utilisations was needed to compare with breeder performance. Regional comparisons of the pasture utilisation results in isolation can only be made in light of the characteristics of the varying datasets within each region. For example, the Northern NT and NE Queensland regions were heavily represented by stocking rate trials deliberately examining moderate to high utilisation. This compares to the Alice Southern NT region where the research station was deliberately stocked to achieve safe utilisation in most years. Rather we examine the factors influencing the variation in pasture utilisation in the dataset and implications for rangeland management.

The modelling of pasture growth and utilisation for this study was at the paddock or watered area scale. Rather than try to model different land types separately, we used paddock scale satellite derived green ground cover and TSDM observations to calibrate average growth across all land types in the paddock. This will inevitably average across different land types that will potentially respond differently to rainfall, depending on soil water holding capacity and fertility and pasture species composition. Similarly, land type preference and use in relation to distance from water means that the actual spatial distribution of pasture utilisation within paddocks would have varied considerably. This has been partly accounted for by assuming cattle grazed only within approximately 4km from water, when pastures are not limiting within that part of the paddock which is consistent with research findings (e.g. Hodder and Low 1978). However, in very high utilisation years when utilisation was calculated to be more than 80% of growth, as was found on several occasions in the Alice and Queensland sites, it is likely that cattle walked further from water and / or supplemented their diet with browse. These highest utilisation years were due to very low pasture growth in low rainfall years, (<250kg/ha for Alice and <650kg/ha for North Queensland) combined with moderate to high stocking rates.

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