Final report

ANIMAL PRODUCTION

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Delivery of faecal NIRS and associated decision support technology as a management tool for the northern cattle industry (NIRS Task 3)

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Abstract

The NIRS Task 3 project evaluated and demonstrated the commercial role and value of near infrared reflectance spectroscopy analysis of fresh faecal samples (F.NIRS) as a tool for beef cattle producers to improve the nutritional management of their herds. Cattle producers from 151 properties participated in a study evaluating the use of F.NIRS to monitor the seasonal diet quality of their cattle across 119 land types in Queensland and the Northern Territory.

F.NIRS proved a useful tool to help producers better understand and respond to seasonal changes in the diet quality of grazing cattle. The main diet parameters analysed and evaluated were predicted crude protein, digestibility, faecal nitrogen and non-grass proportion. Daily liveweight gain was also predicted. This information assisted producers to make more informed management decisions regarding supplementary feeding, pasture management and adjusting stock numbers. These results were supported by an opinions survey of the project co-operators.

The project identified limitations of the technology. Further research is needed on land types where there is a significant proportion of browse, such as in mulga woodlands, and where there is winter herbage, legumes or forage crops grazed with grass-based pastures.

We recommend MLA and the beef industry support the continued development and extension of the technology. The project highlights the need for ongoing promotion of the technology and for training both producers and those involved in the interpretation of F.NIRS results so the best herd nutritional management outcomes are achieved.

Executive summary

This NIRS Task 3 Project demonstrated that faecal near infrared reflectance spectroscopy (F.NIRS) is a valuable tool for producers to manage the nutrition of their cattle herds. The project analysed over 1500 fresh faecal samples from 119 land types, grouped into 11 land systems, on 151 properties over three years across Queensland and the Northern Territory. The project demonstrated that the F.NIRS results were sufficiently reliable in predicting diet quality for cattle over a wide range of seasons and land systems for producers to better manage their herds' nutritional requirements. The nutritional parameters analysed were crude protein (CP%), dry matter digestibility (DMD%), non-grass proportion (NG%) and faecal nitrogen (FN%). An experimental analysis of liveweight gain prediction was also included.

This project was Task 3 of a 3-phase research and development programme investigating the application of F.NIRS technology for cattle grazing tropical pastures in northern Australia. The Task 3 project achieved its objectives which included: developing a system of regional NIRS specialists; developing communication networks; evaluating the commercial application of the technology and production of district guidelines; and developing a field recording system for use with F.NIRS.

This study found that F.NIRS is a rapid and inexpensive tool that can be used by producers to more accurately measure their herd's diet quality and assist them to make more informed decisions on the nutritional management of their cattle. It appears to be far better than any other technology previously used to measure diet quality of grazing cattle. The calibration equations used in F.NIRS predictions were developed by CSIRO (D Coates) across a limited range of vegetation communities. Limitations of F.NIRS across the wide range of land systems in northern Australia therefore needs to be identified through on-property monitoring across a range of pasture types, seasons and classes of cattle.

Historically, producers have assessed animal condition to make decisions on supplementary feeding, paddock movements and selling stock. Recently, there has been increasing interest to include assessment of both pasture quantity and quality for making stock and grazing management decisions. The methods developed in this project have provided producers with a system of describing their production resources such as landtypes, pastures and the growth phases and growing conditions as well as cattle condition and classes. This resource information is required for reliable interpretation of the F.NIRS results for understanding the current diet quality, and to make more informed decisions on the current and future nutritional management of their cattle.

Seven regions across Queensland and the Northern Territory covering 119 land types were established for sampling. The regions were: North, West, Central, Desert Uplands, South and South-east Queensland and Eastern Northern Territory. The land types were grouped according to soil type, vegetation and pasture communities into 13 major land systems, including: *Aristida/Bothriochloa*, Brigalow/Gidgee, Mitchell grass, Bluegrass downs, Woodland (heavy soil), Woodland (light soil), Black speargrass (light soil), Black speargrass (heavy soil), Rainforest derived (Atherton Tableland), Mulga and Spinifex. Data from 11 of the land systems with the sufficient samples was statistically analysed.

The key findings from F.NIRS monitoring were:

- NIRS predictions of CP% and DMD% in the dry season were influenced to a greater extent by land system and were less variable than those in the wet season. This variation in dry season results may have been due to unseasonal rainfall during this period.
- On all land systems predicted CP% and DMD% increased once >25 mm rain was received.

- Once pasture yield was greater than 1000 kg/ha, predicted CP% and DMD% increased, probably because it allowed for greater selection, while diet quality was highly variable with low yields, below 500 kg/ha.
- Predicted DMD% increased with an increase in non-grass green:dry leaf ratio for all land systems, except Woodland (heavy), suggesting these more fertile soils produce grasses of higher digestibility at the time when the non-grasses have green leaf.
- Woodland (heavy), Spinifex, Mulga and Rainforest derived (Atherton Tableland) were the only land systems where there was always non-grass in the diet during the dry season.
- Rainforest derived (sown pastures on the Atherton Tableland) had the highest predicted CP% and DMD% due to the sown pastures on fertilised soils.
- Frost, either with or without rain, had the biggest negative impact on diet quality, as shown by the lower CP% and DMD% predictions compared with other forms of pasture damage such as by flooding, drought or insects.
- Predicted non-grass % on heavy soils was significantly lower when >75 mm rainfall was received. These high rainfall events occurred in summer and suggest these pastures respond with new grass growth at the expense of forbs (non-grasses).
- Diet quality, CP% and DMD% increased with increasing proportion of forbs and legumes (non-grass %) in the diet. When browse (trees and shrubs) was present in the diet the CP% and DMD% usually decreased.
- As the green:dry leaf % and leaf:stem ratio in grass increased, predicted CP% and DMD% increased. Producers who were able to assess the leaf:stem ratio and green:dry leaf ratio in grass through formal training such as Nutrition EDGE workshops, could confidently identify an upward or downward trend in change in diet quality.
- Mineral deficiencies, including phosphorus, sulphur and sodium, had inconsistent effects on F.NIRS predictions.
- Predicted CP% and DMD% were significantly higher from rotational grazing systems than from cell or continuous systems. There was consistently less variability in CP% and DMD% in cell systems than in the other two systems.

Following the completion of sample monitoring, an opinion survey was conducted of 151 producer co-operators in the project, to gauge how they would use NIRS technology as a management tool. This survey showed that the technology was valued equally as a tool for better understanding pastures, commencing supplementary feeding programs, modifying supplementary feeding programs, assessing stock performance and for managing drought strategies.

F.NIRS technology is now widely used by researchers in Queensland, Northern Territory and WA as a result of the collaborative work done in NIRS Tasks 1, 2 and 3 projects.

An economic report conducted by Agtrans predicted a $3.90/AE increase in GM/AE from using F.NIRS results to make better management decisions. At June 2006 it was estimated that 2% of producers in northern Australia use NIRS. The maximum adoption rate, without further extension and promotion of the technology is expected to peak at 5% by 2011, which equates to a $1.8 M/year return from the total 9.5 M AE's in northern Australia. The adoption and benefits are expected to increase further by continuing promotion of the technology and by providing a reliable interpretation service with practical management recommendations.

It is important that objective land system, pasture and animal descriptions be submitted with samples for analysis to ensure a reliable interpretation of NIRS results. Producers who were trained in objective visual assessment of pasture and cattle condition could confidently follow changes in diet quality, except where there was a high non-grass component, particularly browse, in the diet.

It is essential that there is continuing publicity for raising awareness and improving adoption of F.NIRS technology. This promotion needs to be maintained to ensure producers, researchers and extension officers, consultants and feed companies utilise the technology to its full advantage.

Recommendations for further work identified by this project include:

- Improving the reliability of F.NIRS predictions of diets with high proportion of non-grass:
    - A high proportion of browse such as Mulga causes the CP% estimates to be high, but much of this protein is unavailable to the animal. Mulga is a significant land system covering 1.8 M ha in Queensland and 150 M ha across Australia.
    - A high proportion of legumes, winter herbage (forbs) and forage crops in the diet often results in the NIRS predictions to be lower than they actually are.

- Improving the reliability of predicted liveweight gain, which was considered variable and unreliable, although there was no actual liveweight data to verify.

- Training of producers and industry advisers to ensure the correct use of NIRS predictions for making management decisions.

Contents

1 Background

There is increasing interest from beef cattle producers to include assessment of both pasture quantity and quality for making stock management decisions. The application of near infrared reflectance spectroscopy on fresh faecal samples (F.NIRS) is an inexpensive technology that enables producers to make an assessment of diet quality of grazing cattle (Brooks *et al.* 1984; Stuth *et al.* 1989; Lyons and Stuth 1992; Lyons, Stuth and Angerer 1995) which inturn assists in making timelier and more informed management decisions on supplementation, paddock movements and adjusting stock numbers. Traditionally, producers have visually assessed animal condition score to make these decisions and this can involve a significant lag time relative to diet quality.

The F.NIRS technology was adapted for Australian tropical pasture diet assessment by CSIRO (Coates 1999; Coates 2004), primarily from research at Lansdowne Research Station near Townsville. The calibration equations have since been expanded to make F.NIRS predictions for main pasture types across northern Australia. As producers rely on their F.NIRS results for making nutritional management decisions it was imperative that these calibration equations were tested on a number of major land systems across Queensland and the Northern Territory.

Prior to the project, producers sent faecal samples for NIRS analysis with insufficient information to validate of whether the results described the diet quality reliably. One of the first steps in the project was to develop a field data collection sheet that producers could submit with their faecal samples for NIRS analysis. This data sheet provided the background information for a reliable interpretation of the results and it also equipped producers with a means to objectively assess and record seasonal changes in their pasture and animal performance.

The hypothesis that the NIRS technology could be used on all tropical grass land systems in northern Australia needed to be tested. The technology had been developed in southern United States (Coleman and Stuth 1989) and its potential for improving nutritional management in association with a nutrition decision support system was still being assessed (Stuth and Tolleson 2000).

There was a need for widespread understanding of how the commercial technology works, how producers could use this diet quality information, and if there were limitations for various land systems across northern Australia. The effective application of NIRS technology could enable producers to make a rapid assessment of diet quality to make more timely management decisions on supplementation, paddock stock movements and adjusting cattle numbers.

There were three concurrent tasks in developing F.NIRS technology for north Australian beef producers. The three projects were: Task 1 - Improve the reliability of faecal NIRS prediction regression equations (Coates 2004); Task 2 - NIRS testing a wider range of tropical diets of known quality (Dixon in press); and Task 3 - Test the practical commercial value of the technology on beef herds. A similiar evaluation of the technology was undertaken on commercial properties in northern Western Australia at the same time and using the Task 3 methodology (Smith *et al.* 2007).

This research and extension project (Task 3) was developed to test the validity, role and limitations of F.NIRS technology on commercial properties across different land systems of northern Australia, and to create awareness and assist producers with the adoption of the technology.

2 Project objectives

The aim of this project was to test the efficacy of the F.NIRS technology in assessing diet quality of grazing cattle on a number of land systems across northern Australia, and to train specialists in the interpretation of results. They would then report on NIRS analyses and raise awareness and facilitate adoption of the technology.

Specifically, the objectives were to:

1. Develop a system of regional ‘specialists’ to assist in the uptake and understanding of NIRS technology. This included the development and delivery of a workshop for regional specialists covering:
    - role of faecal NIRS;
    - interpretation of results;
    - monitoring animal performance;
    - diet composition/selection;
    - practical supplementation; and
    - land types/pasture composition identification and monitoring;

2. Develop communication networks among 'regional specialists' and those involved in the research aspects of the project;

3. Produce ‘district’ guidelines on the use of NIRS by land type and pasture community; and

4. Develop reliable and practical field recording systems for use with NIRS. These included documentation of:
    - body condition scoring of large groups of cattle (particularly breeder herds) and existing management; and
    - pasture condition description with respect to pasture yield and apparent nutritional value (e.g. green leaf, stage of maturity, moisture stress, yield, presence of forbs and/or top feed, evidence of selection). This was to be conducted in association with the collection of fresh faecal samples.

The regional specialists were to provide interpretation and recommendations to producers based on the NIRS results. The role of these ‘specialists’ included the development of local monitoring activities as appropriate and the collation of faecal NIRS results with land types, pasture conditions, time of year and animal performance (both documented and anecdotal).

The network was restricted to 5 strategic regions: North, Central, South and South-east Queensland, and Northern Territory.

3 Methodology

3.1 Data collection and analysis

A total of 151 properties participated in the project, however full data sets from 114 properties with sufficient samples (Appendix A) formed the basis of the data analysis for this report.

Measurements

A field data collection sheet (FDCS) (Appendix B - 1) was developed for producers to objectively describe their pasture and stock details. This accompanied the fresh faecal samples collected at the same time, preferably monthly. Details of information provided on each paddock sampled were as follows:-

- The main land types. (Appendix B-2)
- pasture composition and browse species
- mineral deficiencies
- grazing systems ie cell, rotational, continuous etc.
- animal attributes including cattle class, breed, lactation status, herd size, body condition (Appendix B-3) of wet and dry cattle,
- supplementation regimes
- pasture attributes including growth phase (Appendix B-4) , ratio of green to dry leaf for grasses and non-grasses, leaf to stem ratio of grasses, estimate of pasture yield (Appendix B-5), presence of legumes and forbs.
- producer's observation of cattle performance (whether the herd was gaining, holding or losing weight) were recorded. ,
- rainfall in the previous month

Each faecal sample collected was submitted for analysis using NIRS to predict crude protein (CP%), dry matter digestibility (DMD%), faecal nitrogen (FN%), non-grass (NG%), ash (%) and average daily gain (ADG kg/hd/d). The ADG or LWG prediction was based on a calibration assuming a medium frame Brahman cross steer, weighing 300 kg (Coates 2002). From the CP% and DMD% predictions, the DMD:CP ratio was calculated. This ratio is used in the practical interpretation of results to determine whether producers could expect a response from supplementing nitrogen to their cattle, provided there is adequate dry standing feed (Dixon and Coates 2005). (A definition of acronyms used in NIRS and in this report is included in Appendix O).

Resource data on FDCS's was provided by114 properties throughout Queensland and eastern Northern Territory. Properties were allocated to one of seven geographical locations:-

1. Southern Queensland (SQ; based around Roma, north to Springsure, Emerald, Theodore and west to Mitchell),
2. South-east Queensland (SEQ; based around Gayndah and Mundubbera),
3. Central Queensland (CQ; Sarina),
4. North Queensland (NQ; based around Charters Towers, west to Cloncurry and Georgetown, north to Atherton, south to Millaroo),
5. Desert Uplands (DU; Aramac, Blackall, Alpha),
6. Western Queensland (WQ; based around Longreach, south to Cunnamulla, north to Mt Isa),
7. Eastern Northern Territory (NT; Mt Isa to Tennant Creek). From the 114 properties, 1560 samples from 426 paddocks were recorded (Table 1).

Table 1 - Number of properties, paddocks and samples in each location analysed for this report

Geographical location	Properties (no.)	Paddocks (no.)	Samples (no.)
SQ	26	115	304
SEQ	9	12	85
CQ	1	2	5
NQ	35	122	621
DU	16	74	226
WQ	22	72	212
NT	5	29	107
TOTAL	**114**	**426**	**1560**

There were insufficient samples from central (coastal) Queensland due to extended drought, so these were excluded from the data analysis.

3.1.1 Land systems

Each paddock was classified as either light or heavy soils and one of ten broad pasture communities (Aristida/Bothriochloa, Brigalow/Gidyea, Black speargrass, Bluegrass downs, Mulga, Mitchell grass, Rainforest derived (Atherton Tablelands), Channel/Swampy, Spinifex and Woodland) as identified by Tothill and Gillies (1992), resulting in 14 land systems (Table 2). Samples from paddocks that could not be classified into a land system (unclassified - generally due to no primary land type data) and those from paddocks in land systems from only a single property, Brigalow/Gidyea (light) and Channel/Swampy (light and heavy), were excluded from the data set (Table 2, shaded cells), resulting in the statistical analysis of 1432 samples from 362 paddocks.

The details of the land types, soil types, pasture communities and their grouping into 14 broad land systems are shown in tables in Appendix C.

Table 2 - Summary of the number of properties, paddocks and samples in each land system. The shaded cells represent the samples excluded from the statistical analyses

Land System	code	soil type	No. properties	No. paddocks	No. samples
Aristida/Bothriochloa (mostly light)	ab-l	light	33	84	304
Brigalow/Gidyea (light)		light	1	1	5
Brigalow/Gidyea (heavy)	b	heavy	19	45	101
Black speargrass (light)	bs-l	light	6	12	106
Black speargrass (heavy)	bs-h	heavy	8	13	109
Bluegrass downs (heavy)	d	heavy	10	48	172
Mulga (light)	m	light	4	6	20
Mitchell grass (heavy)	mg	heavy	35	100	431
Rainforest derived (heavy)	rd	heavy	6	25	90
Channel / Swampy (light)		light	1	2	5
Channel / Swampy (heavy)		heavy	1	2	4
Spinifex (light)	sp	light	3	3	18
Woodland (light)	w-l	light	10	18	58
Woodland (heavy)	w-h	heavy	4	8	23
Unclassified			19	59	114
Total				**426**	**1560**

3.1.2 Pastures

The primary pasture species on the primary land type were classified as (Appendix C, Table 7):-

- 3P (desirable perennial, palatable and productive native grasses),
- Intermediate grasses (palatable and weakly perennial),
- Annual grasses,
- Legumes (native),
- Legumes (sown),
- Sown pasture grass
- Wiregrass.

Browse species were classified as high or low palatability (Appendix C, Table 8) and samples identified as having browse if browse species were listed for the paddock. As multiple pasture growth phases could be selected, the growth phase was taken as the minimum growth phase recorded for the sample. For example, after rain in spring when new grass leaf grew (growth phase 1) it could be associated with old dry standing grass from last summer (phase 4).

3.1.3 Seasons

Rainfall was categorised into five ranges: 0 mm, <25 mm, 25-50 mm, 50-75 mm and >75 mm. Sample times were identified as two seasons: wet season (December-April) or dry season (May-November).

3.1.4 Cattle class and lactation status

Samples were classified as those from just dry cattle or those from possibly a mixture of wet and dry based on the cattle class and lactation status (Table 3) as described on the FDCS. Samples from cattle classes of *weaners*, *steers/heifers* (apart from 4 samples) and *bulls* were all classified as dry. Those samples with *Unknown* lactation status and a cattle class of *Unknown* were classified as dry based on other descriptive information on the cattle on the FDCS. Therefore, ‘dry cattle’ samples were defined as samples with 0% lactation status or samples with cattle classes of *Steers/Heifers (Yearlings)*, *Bulls* or *Unknown* with an *Unknown* lactation status (Table 3 shaded cells), resulting in 638 samples of dry cattle.

Cattle breeds were divided into 3 groups: *Bos taurus, Bos indicus* or Intermediate.

Table 3 - The number of samples in each cattle class with various levels of lactation status. The shaded cells represent samples with dry cattle only

Cattle Class	**Lactation status**						**Total**
	Unknown	**0%**	**<25%**	**25-50%**	**51-75%**	**>75%**	
Unknown	21	1					22
Weaners (< 12 mths)		76					76
Steers/Heifers (12 mths +)	332	38	1			3	374
Maiden Heifers	18	69	8	3	5	11	114
Breeders (mixed ages)	95	75	83	179	212	151	795
Bulls	10	2					12
Mixed class (male & female)	10	11	7	3	6	2	39
Total	**471**	**275**	**99**	**187**	**224**	**166**	**1432**

Statistical analysis

Box plots were prepared for each of the NIRS attributes against various management practices (grazing system, supplementation, water, cattle breed), observations made by producers (whether cattle were gaining, holding or losing weight/condition, pasture quality, pasture yield) and climatic conditions (season, rainfall). The box plots were as defined by Tukey (1977) with the box spanning the inter-quartile range (the middle 50% of the data within the box) and the line in the box indicating the median. A full description of the box plot statistic is found in Appendix E. The use of the box plot method with this data was reported by Reid and Jackson (2006).

Further, each sample was assumed independent and data analysed by ANOVA with the appropriate observed classification (e.g. breed, weight change observation, leaf:stem ratio, etc.) considered as the treatment. If the treatment effect was significant (P<0.05), means were compared using the l.s.d. P<0.05 and differing means identified in tables using the conventional letter notation (i.e., means with a common letter are not significantly different). If the treatment effect was not significant (P>0.05), all means were identified with a common letter.

3.2 Awareness and adoption

Three faecal NIRS Fact Sheets were produced to explain the technology and how to collect and dry samples (Appendix F). These have been converted into DPI Notes and can be found on the DPI website.

The explanation and application of F.NIRS technology is now an integral part of the Nutrition EDGE workshop.

Four NIRS Co-operator Reports were produced to provide producer co-operators in the project with technical updates and to maintain their commitment to the project (Appendix H).

The F.NIRS technology was presented at seminars, formal workshops, field days, property group meetings and company property meetings, to raise awareness of the technology (Appendix I).

The project work culminated in the publication of a producer report (Anon 2007) which was distributed to all producer co-operators, stake holders and other advisory services who had an interest in NIRS technology.

3.3 Co-operator survey

The project team liaised with MLA in the development of a project survey which was conducted at the end of the field sampling period of the project. Of the 151 co-operators, 135 producers (or 89%) were surveyed to gauge their acceptance and level of adoption of NIRS. This survey (Appendix J) was undertaken because producers had been sampling for over a year and were able to make a reasonable assessment of the usefulness of the technology. Most surprisingly, the technology was valued equally as a tool for better understanding pastures (91%) and commencing a supplementary feeding program (91%), modifying a supplementary feeding program (78%), monitoring stock performance (78%) and drought management strategies (78%). Forty-one percent of producers said they would submit samples on a monthly basis (at critical times) after the project was completed (Appendix K).

3.4 Economic analysis

An economic analysis of implementing F.NIRS by a beef producer was conducted with assumptions of the technology reducing supplementation costs by 75% in one year of six when supplements were supplied to the herd. The set of assumptions used in the analysis are listed in Appendix L.

4 Results and discussion

4.1 F.NIRS results

The F.NIRS results presented to the NIRS Task 3 co-ordinators from analysis of producers' sun-dried fresh faecal samples showed the CP%, DMD%, FN%, non-grass (%), Ash % and LWG or ADG (kg/hd/d). An example of the analysis results from one sample is shown in Appendix M.

4.1.1 Producer sample analyses

The Task 3 co-ordinators presented these results in both tabular and graphical form to the producers after each set of monthly results. The tables and graphs showed the monthly and seasonal trends and the range of deficiencies in crude protein where a response to added nitrogen is expected. The results included a calculation of DMD:CP ratio as an additional guide to the likelihood of a response to adding a nitrogen supplement. If a phosphorus (P) analyses was requested, the P:N ratio was also calculated and presented to the producer. An example of a monthly graphical presentation of results to a producer is shown in Appendix N.

4.2 Relationship between pasture, animal, seasonal and management factors on NIRS predictions

4.2.1 Land system

4.2.1.1 Seasonal effects

Dry season
Results from the dry season were influenced by land system to a greater extent and they had less variability than those from the wet season (Table 4a). The improved pastures in the Rainforest derived land system had the highest average digestibility (DMD%) during both the wet and dry seasons (Table 4a).

The Mulga land system had the second highest dry season average DMD% (Table 4a), which supports claims that this land system is "safe" country during the dry season, by providing a reasonable amount of energy to cattle when there is adequate forage. There wasn't a large sample size for Mulga (10 samples) to be confident that this mean is representative of this land system. The DMD% was high probably due to the high non-grass content on the Mulga land system (44.4%), which can result in a less accurate NIRS analysis of DMD%.

Few samples were taken from the Mulga land system due to the severe drought prior to and during the project which resulted in producers either destocking or pushing mulga to supplement stock. Producers who were pushing mulga couldn't see any additional benefit from using NIRS during this time because the cattle were primarily eating mulga.

Rainforest derived (Atherton Tableland) land system which supports sown pastures, had the highest predicted CP% and DMD% during the dry season. Mulga had the second highest CP% and DMD% during the dry season, while Bluegrass downs and Mitchell grass had the third highest DMD%. The high CP% was due to the high protein in mulga leaves. There was a wide variation in DMD% for Bluegrass downs and Rainforest derived land systems during both the dry and wet seasons (Appendix E, Fig.1). Black speargrass (light), Spinifex and Woodland (heavy) land systems showed the least variability in DMD% during the dry season.

The Mulga lands had a non-grass component in every sample tested with a wide variation within the 50% quartile. Mitchell grass had the second highest non-grass maximums, however, this would have comprised primarily forbs, whereas the Mulga non-grass component would have comprised primarily browse.

Rainforest derived (Atherton Tableland), Spinifex, Mulga and Woodland (heavy) were the only land systems where there was always non-grass in the diet during the dry season, however, the proportions of browse and forbs, which make up the non-grass components, varied widely (Table 4a).

Table 4a - Dry season NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%) and non-grass (NG%) for the 11 land systems

	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Aristida/Bothriochloa (ab)	134	50.6 *d*	40.0	48.0	50.5	53.0	64.0
Brigalow/Gidyea (b)	47	53.8 *c*	47.0	51.3	53.0	56.0	60.0
Black speargrass (light) (bs-l)	50	47.1 *e*	40.0	46.0	47.0	49.0	57.0
Black speargrass (heavy) (bs-h)	51	50.5 *d*	43.0	48.0	51.0	52.0	64.0
Bluegrass downs (d)	97	54.7 *c*	45.0	51.0	54.0	58.0	75.0
Mulga (m)	10	60.8 *b*	54.0	57.0	60.5	63.0	69.0
Mitchell grass (mg)	235	54.6 *c*	46.0	52.0	54.0	57.0	72.0
Rainforest derived (rd)	49	64.1 *a*	54.0	59.0	64.0	69.0	81.0
Spinifex (sp)	12	51.2 *d*	48.0	49.5	50.0	53.0	56.0
Woodland (light) (w-l)	30	50.9 *d*	42.0	47.0	52.0	55.0	58.0
Woodland (heavy) (w-h)	8	50.1 *de*	47.0	48.0	50.0	52.0	54.0
CP (%)							
Aristida/Bothriochloa (ab)	134	5.9 *ef*	2.9	5.0	5.7	6.9	9.9
Brigalow/Gidyea (b)	47	6.2 *de*	3.9	4.8	5.8	6.9	13.5
Black speargrass (light) (bs-l)	51	4.9 *gh*	2.5	4.1	4.8	6.0	7.4
Black speargrass (heavy) (bs-h)	51	6.0 *def*	3.1	5.0	5.7	6.5	12.9
Bluegrass downs (d)	98	7.4 *c*	3.2	5.1	6.6	8.0	21.1
Mulga (m)	10	10.4 *b*	7.3	9.3	10.4	12.1	13.0
Mitchell grass (mg)	241	6.5 *d*	3.6	5.1	5.9	7.2	20.9
Rainforest derived (rd)	50	12.7 *a*	7.5	10.9	12.7	14.9	20.1
Spinifex (sp)	12	4.8 *fh*	3.2	3.9	4.2	5.4	7.6
Woodland (light) (w-l)	30	5.2 *efg*	2.8	3.7	5.0	6.7	8.9
Woodland (heavy) (w-h)	8	5.3 *defg*	4.4	4.6	5.0	5.9	6.7
NG (%)							
Aristida/Bothriochloa (ab)	133	18.9 *c*	0.0	12.0	18.0	25.0	52.0
Brigalow/Gidyea (b)	47	14.3 *d*	0.0	4.0	10.0	20.0	60.0
Black speargrass (light) (bs-l)	50	15.2 *d*	0.0	7.0	14.0	25.0	38.0
Black speargrass (heavy) (bs-h)	51	15.2 *d*	0.0	8.3	13.0	21.8	52.0
Bluegrass downs (d)	99	20.8 *c*	0.0	9.0	20.0	31.0	57.0
Mulga (m)	10	44.4 *a*	27.0	28.0	41.5	60.0	63.0
Mitchell grass (mg)	242	25.1 *b*	0.0	17.0	25.0	31.0	72.0
Rainforest derived (rd)	50	12.4 *d*	2.0	8.0	12.0	15.0	28.0
Spinifex (sp)	13	15.1 *cd*	5.0	13.3	15.0	15.3	30.0
Woodland (light) (w-l)	30	17.4 *cd*	0.0	8.0	19.0	28.0	33.0
Woodland (heavy) (w-h)	8	15.3 *cd*	4.0	6.5	14.5	23.5	29.0

Wet season

There was a wider range of variation over more land systems during the wet season compared with the dry season, for predicted CP% and DMD% (Tables 4a and 4b). This may be due to differences in rainfall amount and distribution rather than differences within a land system. There were areas in several land systems that experienced drought at least one year and in some cases, over the duration of the project.

The Mulga land system showed the least variation in DMD% predictions during the wet season (Appendix E, Fig. 1) whereas most land systems showed considerable variation, particularly Aristida/Bothriochloa, Black speargrass (heavy) and Black speargrass (light) (Table 4b).

During the wet season, predicted DMD% was highest for Rainforest derived (Atherton Tableland) land system (63.5%), but it was not significantly higher than for Mulga land system (Table 4b). There was large variability across a number of land systems, with Mulga and Woodland (heavy) showing the least variability (Appendix E, Fig. 1). Again, there was a high non-grass component in the diet of cattle grazing on Mulga land system (44.4%), which could have contributed to the high DMD% mean.

NIRS predicted CP% during the wet season was highest for the Rainforest derived (Atherton Tableland) land system (11.9%), but again, it did not differ significantly to that for Mulga (Table 4b). This high level in Mulga could be due to the high proportion of mulga leaves in the diet, which are high in protein (12–14%), although it may be unavailable due to condensed tannins (Miller *et al.* 1997). More work needs to be done on the mulga land system to distinguish between mulga leaves and other C3 plants in the non-grass component, to determine whether the high CP% in the NIRS analysis is available to the animal for digestion.

Predicted CP% showed the highest variability in Black speargrass (heavy) and Mitchell grass land systems (Table 4b; Appendix E, Fig. 1).

Predicted non-grass % showed the greatest variation in Aristida/Bothriochloa land system, varying from 0% to 100%, with a mean of 22.4% (Table 4b). Bluegrass downs also showed a high variability from 1% to 80%, as did Mitchell grass, varying from 0%-62%, Brigalow/Gidyea varying from 0%-65%. The least variation occurred in the Spinifex land system.

The highest predicted non-grass % occurred in Mulga land system, at 44.4%, which was sampled from pastures in drought conditions.

Photograph examples of landtypes and cattle sampled in different seasons and in regions are shown in Appendix P.

Table 4b - Wet season NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%) and non-grass % (NG%) for the 11 land systems

	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Aristida/Bothriochloa (ab)	167	55.0 *de*	40.0	51.0	55.0	59.0	70.0
Brigalow/Gidyea (b)	52	59.9 *b*	40.0	57.0	61.0	63.5	71.0
Black speargrass (light) (bs-l)	51	53.7 *e*	41.0	48.0	53.0	59.3	72.0
Black speargrass (heavy) (bs-h)	53	56.8 *cd*	44.0	51.8	56.0	62.0	75.0
Bluegrass downs (d)	71	57.1 *c*	44.0	53.3	57.0	61.0	71.0
Mulga (m)	10	61.8 *ab*	54.0	60.0	62.0	65.0	67.0
Mitchell grass (mg)	179	57.1 *c*	40.0	53.0	57.0	61.0	72.0
Rainforest derived (rd)	40	63.5 *a*	51.0	59.0	62.0	67.0	80.0
Spinifex (sp)	5	56.2 *bcde*	50.0	51.5	54.0	61.8	64.0
Woodland (light) (w-l)	25	55.6 *cde*	43.0	50.0	57.0	60.3	66.0
Woodland (heavy) (w-h)	15	57.4 *bcd*	48.0	53.5	56.0	59.8	72.0
CP (%)							
Aristida/Bothriochloa (ab)	167	8.0 *cd*	3.1	5.9	7.8	10.2	14.5
Brigalow/Gidyea (b)	52	8.3 *cd*	4.5	6.8	8.6	9.9	13.7
Black speargrass (light) (bs-l)	50	8.0 *cde*	3.4	5.5	7.9	9.5	16.7
Black speargrass (heavy) (bs-h)	53	8.4 *bc*	2.9	6.1	7.6	10.6	17.0
Bluegrass downs (d)	73	8.2 *cd*	2.3	5.3	7.9	10.9	15.1
Mulga (m)	10	10.3 *ab*	8.5	9.5	10.7	11.3	11.8
Mitchell grass (mg)	180	7.5 *de*	2.5	5.1	7.1	9.3	17.8
Rainforest derived (rd)	40	11.9 *a*	6.6	9.6	11.0	14.3	17.9
Spinifex (sp)	4	5.5 *e*	3.3	3.8	5.7	7.1	7.1

	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Woodland (light) (w-l)	28	7.8 *cde*	3.2	5.5	7.3	10.1	13.3
Woodland (heavy) (w-h)	15	7.9 *cde*	5.2	6.1	7.0	8.3	14.6
NG (%)							
Aristida/Bothriochloa (ab)	168	22.4 *bcd*	0.0	12.5	21.0	29.0	100.0
Brigalow/Gidyea (b)	52	13.4 *efg*	0.0	4.5	10.0	18.0	65.0
Black speargrass (light) (bs-l)	50	17.3 *e*	0.0	10.0	15.5	23.0	45.0
Black speargrass (heavy) (bs-h)	53	15.9 *ef*	0.0	7.0	15.0	22.3	46.0
Bluegrass downs (d)	72	25.9 *b*	1.0	13.0	25.0	35.0	80.0
Mulga (m)	10	44.4 *a*	25.0	30.0	38.5	59.0	75.0
Mitchell grass (mg)	182	24.4 *bc*	0.0	14.0	22.5	32.0	62.0
Rainforest derived (rd)	39	9.4 *g*	0.0	5.3	10.0	13.0	20.0
Spinifex (sp)	5	12.6 *cefg*	5.0	8.8	13.0	15.8	21.0
Woodland (light) (w-l)	28	18.6 *de*	4.0	14.5	19.0	21.0	35.0
Woodland (heavy) (w-h)	15	9.4 *fg*	0.0	4.3	6.0	13.5	33.0

4.2.1.2 Rainfall effects

DMD%

There was a wide variation in predicted DMD% response at specific rainfall ranges for a number of land systems (Appendix E, Fig. 2). This variation could have been due to timing of rainfall and the rainfall pattern. Any rainfall that fell in the month preceding the sampling was recorded. In drier seasons in particular, some pasture species could go through all four growth phases over this time frame.

There was a trend on most land systems for predicted DMD% to increase once rainfall exceeded 25 mm with the exception of Rainforest derived (Atherton Tableland) (Table 5) and Bluegrass downs land systems. The Bluegrass downs land system didn't show a significant increase in predicted DMD% until >75 mm rainfall was received, confirming these heavier soils require more rainfall to initiate new pasture growth.

Predicted DMD% did not significantly increase with increasing rainfall for Rainforest derived (Atherton Tableland) land system. This may have been because sixty percent (60%) of the samples were from months with rainfall greater than 75 mm, and no samples were taken when there was nil rain for the previous month. As a consequence of frequent rainfall the mean DMD% remained relatively high.

Table 5 - Effect of rainfall (falling in the preceding month) on NIRS predictions of dry matter digestibility (DMD%) for the major land systems

Rainfall (mm)	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0 mm	49	52.0 *cd*	43.0	49.0	52.0	54.3	62.0
< 25 mm	67	50.6 *d*	40.0	48.0	51.0	53.0	63.0
26 – 50 mm	37	52.5 *bc*	42.0	48.0	51.0	56.3	67.0
51 – 75 mm	32	54.7 *b*	46.0	52.0	55.5	58.0	61.0
> 75 mm	52	57.8 *a*	50.0	54.0	58.0	61.0	69.0
Brigalow/Gidyea							
0 mm	15	55.0 *bc*	50.0	53.0	53.0	58.0	61.0
< 25 mm	19	54.4 *c*	47.0	51.0	53.0	57.8	64.0
26 – 50 mm	15	58.3 *ab*	40.0	52.8	60.0	64.0	69.0
51 – 75 mm	16	57.9 *abc*	50.0	55.0	57.5	62.0	65.0
> 75 mm	17	60.2 *a*	52.0	55.5	59.0	64.3	71.0
Black speargrass (light)							
0 mm	23	47.0 *c*	40.0	45.3	47.0	49.0	57.0

Rainfall (mm)	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
< 25 mm	23	47.1 *c*	40.0	43.0	47.0	49.8	57.0
26 – 50 mm	15	51.5 *b*	45.0	47.3	53.0	54.8	60.0
51 – 75 mm	1	54.0 *abc*	54.0	54.0	54.0	54.0	54.0
> 75 mm	19	59.9 *a*	45.0	55.3	61.0	62.8	72.0
Black speargrass (heavy)							
0 mm	23	52.4 *b*	47.0	49.3	52.0	54.8	64.0
< 25 mm	26	49.1 *c*	43.0	46.0	49.0	51.0	58.0
26 – 50 mm	15	53.4 *b*	44.0	49.0	52.0	60.0	66.0
51 – 75 mm	7	53.1 *bc*	48.0	51.3	52.0	55.0	59.0
> 75 mm	25	60.4 *a*	47.0	55.8	60.0	65.0	75.0
Bluegrass downs							
0 mm	32	53.9 *b*	47.0	51.0	53.0	55.5	65.0
< 25 mm	37	55.3 *b*	44.0	50.8	54.0	61.0	75.0
26 – 50 mm	14	53.4 *b*	46.0	48.0	53.0	57.0	65.0
51 – 75 mm	11	55.6 *b*	45.0	53.3	57.0	58.8	64.0
> 75 mm	26	60.9 *a*	52.0	57.0	61.5	64.0	71.0
Mitchell grass							
0 mm	85	56.9 *b*	49.0	54.0	57.0	59.0	72.0
< 25 mm	97	54.0 *c*	46.0	51.0	54.0	56.0	68.0
26 – 50 mm	24	55.7 *bc*	40.0	51.0	56.5	60.0	70.0
51 – 75 mm	14	60.0 *a*	48.0	57.0	58.5	64.0	72.0
> 75 mm	39	60.9 *a*	48.0	56.5	62.0	65.0	71.0
Rainforest derived							
0 mm							
< 25 mm	16	60.6 *a*	51.0	57.0	60.0	63.5	70.0
26 – 50 mm	8	63.5 *a*	54.0	59.0	64.0	69.0	70.0
51 – 75 mm	9	65.9 *a*	57.0	58.8	64.0	71.3	80.0
> 75 mm	47	64.2 *a*	55.0	59.3	64.0	67.8	81.0
Woodland (light)							
0 mm	6	58.3 *ab*	55.0	57.0	58.5	60.0	61.0
< 25 mm	12	51.8 *c*	45.0	51.5	52.0	54.5	56.0
26 – 50 mm	2	52.5 *bc*	47.0	47.0	52.5	58.0	58.0
51 – 75 mm	1	56.0 *abc*	56.0	56.0	56.0	56.0	56.0
> 75 mm	8	59.8 *a*	45.0	59.0	60.5	64.0	66.0
Woodland (heavy)							
0 mm	2	53.0 *ab*	52.0	52.0	53.0	54.0	54.0
< 25 mm	5	49.4 *b*	47.0	47.8	49.0	51.3	52.0
26 – 50 mm	5	49.4 *a*	47.0	47.8	49.0	51.3	52.0
51 – 75 mm	3	53.7 *ab*	50.0	51.3	55.0	55.8	56.0
> 75 mm	9	60.2 *a*	52.0	56.0	59.0	63.5	72.0

CP%

With increasing rainfall, predicted CP% increased for all land systems, however Mitchell grass and Aristida/Bothriochloa were most responsive (Table 6) while Rainforest derived (Atherton Tableland) was least responsive. For all rainfall ranges the predicted CP% means were high relative to cattle nutrient requirements. There were relatively few samples for Woodland (light) and Woodland (heavy).

For a number of rainfall ranges, predicted CP% was skewed on several land systems (Appendix E, Fig. 3). On land systems where browse comprised a large proportion of the diet, the CP% prediction would have been elevated, but in the case where the digestibility of some browse species was low, a significant proportion of the CP% would not be available for absorption by cattle.

Table 6 - Effect of rainfall on NIRS predictions of crude protein (CP%) for the major land systems

Rainfall (mm)	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0 mm	49	6.4 *cd*	3.6	5.3	6.0	7.5	11.7
< 25 mm	67	6.1 *d*	3.3	5.2	6.0	6.7	12.9
26 – 50 mm	37	7.4 *b*	4.2	5.3	6.5	9.1	14.5
51 – 75 mm	32	7.1 *bc*	4.3	5.8	7.3	8.4	9.5
> 75 mm	52	9.6 *a*	5.7	8.1	9.5	11.4	14.0
Brigalow/Gidyea							
0 mm	15	5.8 *b*	4.2	4.6	5.2	6.8	8.0
< 25 mm	19	6.5 *b*	4.2	5.4	6.1	7.1	9.5
26 – 50 mm	15	8.5 *a*	4.4	6.4	9.3	9.9	12.1
51 – 75 mm	16	8.1 *a*	4.5	6.7	7.3	9.7	13.5
> 75 mm	17	8.6 *a*	3.9	6.1	8.5	10.5	13.7
Black speargrass (light)							
0 mm	23	4.8 *c*	3.5	4.3	4.8	5.5	6.9
< 25 mm	23	5.0 *c*	2.5	4.0	5.0	6.1	8.3
26 – 50 mm	15	7.3 *b*	4.0	6.2	7.0	8.5	10.7
51 – 75 mm	1	7.1 *bc*	7.1	7.1	7.1	7.1	7.1
> 75 mm	18	10.9 *a*	7.4	8.2	10.9	12.9	16.7
Black speargrass (heavy)							
0 mm	23	6.5 *bc*	4.2	5.1	6.2	7.3	10.8
< 25 mm	26	5.4 *c*	3.3	5.0	5.5	6.0	7.5
26 – 50 mm	15	7.8 *b*	4.8	5.7	6.8	10.3	12.9
51 – 75 mm	7	6.5 *bc*	5.6	5.8	6.3	6.8	8.0
> 75 mm	25	10.2 *a*	3.1	7.8	9.6	12.0	17.0
Bluegrass downs							
0 mm	32	6.3 *c*	2.5	4.5	6.2	7.6	11.6
< 25 mm	38	7.7 *bc*	3.5	4.9	6.4	9.8	21.1
26 – 50 mm	15	7.2 *bc*	4.8	5.5	6.5	7.9	15.1
51 – 75 mm	11	8.5 *b*	5.0	6.9	7.4	10.6	13.8
> 75 mm	27	11.4 *a*	6.9	9.4	11.2	12.9	17.4
Mitchell grass							
0 mm	88	7.1 *c*	2.5	5.3	6.8	8.1	17.5
< 25 mm	100	5.8 *d*	3.7	4.6	5.5	6.4	11.1
26 – 50 mm	24	7.9 *bc*	3.4	5.5	7.3	9.2	15.5
51 – 75 mm	15	9.4 *b*	5.9	7.0	8.4	11.6	15.4
> 75 mm	38	11.2 *a*	6.9	9.1	11.1	12.2	20.9
Rainforest derived							
0 mm							
< 25 mm	16	10.7 *b*	6.6	8.8	10.2	12.2	16.2
26 – 50 mm	8	11.7 *ab*	8.5	10.1	11.7	13.6	14.3
51 – 75 mm	9	13.3 *a*	9.0	10.1	13.2	15.4	17.9
> 75 mm	48	12.7 *a*	7.7	10.8	12.3	14.8	20.1
Woodland (light)							
0 mm	8	7.8 *b*	5.5	7.0	7.6	8.8	10.3
< 25 mm	12	5.7 *c*	3.5	5.0	5.4	6.9	8.9
26 – 50 mm	3	7.2 *bc*	5.4	5.9	7.4	8.5	8.9
51 – 75 mm	1	7.2 *bc*	7.2	7.2	7.2	7.2	7.2
> 75 mm	8	11.2 *a*	9.6	10.2	11.3	11.7	13.3
Woodland (heavy)							
0 mm	2	5.3 *ab*	4.4	4.4	5.3	6.1	6.1
< 25 mm	5	5.4 *b*	4.5	4.7	5.1	6.0	6.7
26 – 50 mm							
51 – 75 mm	3	6.7 *ab*	5.5	5.8	6.8	7.5	7.7
> 75 mm	9	8.9 *a*	5.9	6.8	7.8	10.5	14.6

4.2.1.3 Soil type

If more than 25 mm rainfall was received predicted CP% and DMD% increased, for both light and heavy soil (Appendix E, Fig. 4). Highest levels ($P<0.05$) occurred after more than 75 mm rain on both soils (Table 7).

Predicted non-grass % decreased significantly on heavy soils if more than 75 mm rainfall was received. On lighter soils NG% did not decrease until >75 mm rainfall was received and then it was only significantly lower than for pastures that received <25 mm (Table 7).

Table 7 - Effect of rainfall on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%) and non-grass % (NG%) for light and heavy soils

Rainfall (mm)	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%) – light soils							
0 mm	158	55.4 *c*	47.0	52.0	55.0	58.0	72.0
< 25 mm	205	54.1 *d*	43.0	51.0	53.0	57.0	75.0
26 – 50 mm	80	56.4 *c*	40.0	50.0	57.0	61.0	70.0
51 – 75 mm	66	58.2 *b*	45.0	55.0	58.0	61.0	80.0
> 75 mm	166	61.7 *a*	47.0	57.0	62.0	65.0	81.0
DMD (%) – heavy soils							
0 mm	84	51.6 *c*	40.0	47.0	51.0	55.0	63.0
< 25 mm	103	50.1 *d*	40.0	47.0	50.0	53.0	65.0
26 – 50 mm	57	52.7 *bc*	42.0	48.0	52.0	56.3	69.0
51 – 75 mm	28	54.3 *b*	46.0	52.0	54.5	57.0	61.0
> 75 mm	78	58.4 *a*	45.0	54.0	59.0	62.0	72.0
CP (%) – light soils							
0 mm	161	6.7 *c*	2.5	5.1	6.3	7.8	17.5
< 25 mm	209	6.6 *c*	3.3	4.9	5.7	7.4	21.1
26 – 50 mm	81	8.3 *b*	3.4	5.8	7.9	10.3	15.5
51 – 75 mm	67	8.8 *b*	4.3	6.7	7.8	10.5	17.9
> 75 mm	167	11.1 *a*	3.1	8.8	11.0	13.2	20.9
CP (%) – heavy soils							
0 mm	86	6.4 *cd*	3.5	4.9	6.0	7.5	13.0
< 25 mm	103	5.9 *d*	2.5	4.8	5.6	6.7	12.1
26 – 50 mm	58	7.4 *b*	4.0	5.4	7.0	8.6	14.5
51 – 75 mm	28	7.1 *bc*	4.7	6.0	7.2	8.4	9.4
> 75 mm	76	10.0 *a*	5.7	8.2	9.8	11.6	16.7
NG (%) – light soils							
0 mm	162	21.5 *a*	0.0	11.0	19.0	29.0	65.0
< 25 mm	208	19.2 *a*	0.0	9.0	17.0	26.0	80.0
26 – 50 mm	82	19.8 *ab*	0.0	10.0	19.5	27.0	65.0
51 – 75 mm	67	18.8 *ab*	0.0	6.3	14.0	26.0	72.0
> 75 mm	168	16.4 *b*	0.0	7.0	13.5	21.5	63.0
NG (%) – heavy soils							
0 mm	86	22.0 *a*	0.0	14.0	20.0	29.0	66.0
< 25 mm	104	23.5 *a*	0.0	14.0	20.0	28.5	100.0
26 – 50 mm	59	23.6 *a*	0.0	14.3	24.0	30.0	63.0
51 – 75 mm	28	20.8 *a*	0.0	9.0	20.5	30.5	52.0
> 75 mm	78	14.2 *b*	0.0	7.0	15.0	21.0	36.0

4.2.2 Producer observations

4.2.2.1 Pasture

4.2.2.1.1 Pasture records

Yield

Predicted CP% and DMD% were lower when pasture yield was between 500 and 1000 kg/ha than when pasture yield was <500 kg/ha (Table 8a). The higher diet quality at the lower yield may be due to sampling within a month after rainfall, when pasture is in phase 1 and 2 growth stage (Appendix B, Figure 5), where diet quality is often quite high, while yield is low. Raymond *et al.* (1956, cited in Minson 1990) and Blaser *et al.* (1960, cited in Minson 1990) determined that as pastures are grazed down in the later growth phases, digestibility of the diet is decreased.

Once the pasture yield exceeded 1000 kg/ha, predicted CP% and DMD% tended to increase. The lower yields (<500 kg/ha) tended to be skewed and there was a wide variation and several outliers in predicted dietary CP% and DMD% (Appendix E, Fig. 5). This could be attributed to winter rain which brought about growth of herbage, while nutritious, isn't produced in bulk. It may also have been attributed to high levels of browse in the diet which can increase CP%. Allden (1962, cited in Minson 1990) and Allden and Whittaker (1970, cited in Minson 1990) reported that when yield of young forage was >2000 kg/ha, ruminants could satisfy their appetite which means that at this yield standing pasture was not limiting diet selection.

Table 8a - Effect of pasture yield on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%) and DMD:CP ratio

Yield (kg/ha)	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
< 500 kg/ha	36	55.5 *cd*	44.0	50.0	54.0	62.0	70.0
500 – 1000 kg/ha	193	52.9 *e*	40.0	49.0	52.0	57.0	74.0
1001 – 2000 kg/ha	495	54.4 *d*	40.0	50.0	54.0	58.0	80.0
2001 – 3000 kg/ha	360	55.4 *c*	40.0	51.0	55.0	59.0	76.0
3001 – 4000 kg/ha	198	57.4 *b*	46.0	53.0	57.0	61.0	81.0
> 4000 kg/ha	39	60.6 *a*	50.0	57.0	61.0	64.0	76.0
CP (%)							
< 500 kg/ha	36	8.4 *abc*	3.1	5.3	8.1	11.7	16.4
500 – 1000 kg/ha	197	6.8 *d*	2.8	4.8	6.2	8.0	17.0
1001 – 2000 kg/ha	499	7.0 *d*	2.3	5.0	6.2	8.5	20.9
2001 – 3000 kg/ha	365	7.6 *c*	2.5	5.5	6.8	9.0	17.4
3001 – 4000 kg/ha	198	8.3 *b*	3.3	6.1	7.6	10.1	20.1
> 4000 kg/ha	39	9.5 *a*	4.2	6.6	8.5	10.9	21.1
DMD:CP ratio							
< 500 kg/ha	35	7.7 *bc*	4.1	5.1	6.6	9.5	14.2
500 – 1000 kg/ha	193	8.5 *ab*	4.3	7.0	8.1	10.2	15.4
1001 – 2000 kg/ha	493	8.7 *a*	2.8	6.7	8.5	10.4	20.4
2001 – 3000 kg/ha	360	8.1 *b*	3.8	6.4	7.8	9.4	19.6
3001 – 4000 kg/ha	198	7.6 *c*	3.5	6.0	7.4	8.8	15.5
> 4000 kg/ha	39	7.2 *c*	3.6	5.7	6.6	8.6	13.8

Grass green:dry leaf ratio

The level of green:dry leaf in grass observed by producers was closely related to diet quality. As the level of green:dry leaf % increased, F.NIRS predictions for CP% and DMD% also increased. This demonstrates the value of visual assessment of pasture quality in conjunction with F.NIRS analysis (Table 8b).

There was a number of outliers in the NIRS predictions for CP% and DMD%, and hence DMD:CP ratio, particularly at the lower estimates of grass green:dry leaf ratio (Appendix E,

Fig. 5). When there was limited green in the grass, if there were sufficient winter rain there would be a good response in herbage growth, which cattle selectively graze. Tropical grasses respond well to summer rain but not to winter rain.

Assessment of the level of green leaf can be quite complex particularly if there are a number of grass and forb species within a paddock, as they vary in sward height and growth phases. The amount of green in stems may also have biased assessments of proportion of green leaf.

Table 8b - Effect of grass green:dry leaf ratio on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%) and DMD:CP ratio

Grass green:dry leaf ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
0%	427	51.6 *e*	40.0	49.0	52.0	54.0	67.0
25%	345	53.8 *d*	40.0	50.0	54.0	58.0	72.0
50%	222	56.3 *c*	40.0	52.0	57.0	59.0	75.0
75%	194	58.6 *b*	40.0	54.0	59.0	62.0	80.0
100%	129	62.5 *a*	45.0	58.0	62.0	66.0	81.0
CP (%)							
0%	432	5.4 *e*	2.5	4.4	5.2	6.1	13.0
25%	352	7.0 *d*	2.8	5.2	6.4	8.1	20.9
50%	225	8.0 *c*	4.1	6.3	7.6	9.5	16.6
75%	195	9.5 *b*	4.4	7.2	9.1	11.7	17.9
100%	126	11.3 *a*	5.2	8.5	11.2	13.8	21.1
DMD:CP ratio							
0%	427	10.1 *a*	5.0	8.5	9.6	11.5	21.6
25%	345	8.4 *b*	2.8	7.0	8.2	9.8	15.7
50%	222	7.5 *c*	3.8	6.3	7.3	8.6	12.7
75%	194	6.6 *d*	3.9	5.4	6.5	7.5	11.6
100%	126	5.9 *e*	3.5	4.8	5.5	6.7	11.2

Grass leaf:stem ratio

F.NIRS prediction of DMD% increased (P<0.05) as the grass leaf:stem ratio increased (Table 8c). Predicted CP% increased (P<0.05) once grass leaf:stem ratio was more than 25%. There was a number of outliers in the relationship between NIRS predictions for CP% and DMD% and grass leaf:stem ratio (Appendix E, Fig. 5). Grass leaf:stem ratio has less effect on diet quality if herbage, or non-grass, contribute significantly to the diet.

Table 8c - Effect of grass leaf:stem ratio on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%) and DMD:CP ratio

Grass leaf:stem ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
0%	37	50.3 *d*	42.0	47.8	50.0	52.0	65.0
25%	396	52.6 *c*	40.0	49.0	53.0	55.5	72.0
50%	583	55.3 *b*	40.0	51.0	55.0	59.0	80.0
75%	257	58.9 *a*	40.0	54.0	59.0	63.0	81.0
CP (%)							
0%	37	5.8 *c*	3.4	4.7	5.4	6.8	10.9
25%	402	6.3 *c*	2.5	4.8	5.8	7.4	14.8
50%	592	7.4 *b*	2.3	5.3	6.8	9.0	17.9
75%	256	9.5 *a*	3.5	6.8	8.6	11.8	21.1
DMD:CP ratio							
0%	37	9.3 *a*	5.5	7.3	9.2	10.6	14.6
25%	396	9.1 *a*	4.4	7.3	8.8	10.6	17.3

50%	583	8.3 *b*	3.9	6.5	8.0	9.6	20.4
75%	255	6.9 *c*	2.8	5.2	6.6	8.1	14.9

Yield x non-grass

There was considerable variation in predicted non-grass % for the Aristida/Bothriochloa when the yield was <500 kg/ha (Table 9a), for Black speargrass (light) when the yield was 1001-2000 kg/ha, and the variation for Mitchell grass was high at a number of yield ranges (Appendix E, Fig. 6).

The trend for Aristida/Bothriochloa and Black speargrass (light) was for predicted non-grass % to decrease as yield increased, whereas for Mitchell grass, there was no relationship between yield and non-grass % (Table 9a).

Table 9a - Effect of pasture yield on the NIRS prediction of non-grass % (NG%) for Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass land systems

Yield (kg/ha)	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
< 500 kg/ha	11	45.6 *a*	18.0	22.5	26.0	80.3	100.0
500 – 1000 kg/ha	40	27.0 *b*	5.0	18.0	23.5	33.0	59.0
1001 – 2000 kg/ha	75	21.4 *c*	0.0	14.3	20.0	27.8	52.0
2001 – 3000 kg/ha	89	19.5 *cd*	0.0	12.0	18.0	27.0	52.0
3001 – 4000 kg/ha	50	16.2 *d*	0.0	7.0	16.5	25.0	40.0
> 4000 kg/ha	7	15.9 *cd*	0.0	4.5	16.0	24.8	36.0
Black speargrass (light)							
< 500 kg/ha	3	22.3 *ab*	14.0	16.3	23.0	28.3	30.0
500 – 1000 kg/ha	18	22.7 *a*	10.0	15.0	24.5	30.0	38.0
1001 – 2000 kg/ha	39	18.0 *a*	0.0	11.0	16.0	24.8	45.0
2001 – 3000 kg/ha	28	12.5 *bc*	0.0	5.5	13.0	19.0	29.0
3001 – 4000 kg/ha	12	8.1 *c*	0.0	0.0	7.0	11.5	27.0
> 4000 kg/ha							
Mitchell grass							
< 500 kg/ha	7	32.1 *a*	8.0	17.3	28.0	49.8	59.0
500 – 1000 kg/ha	66	24.5 *a*	7.0	14.0	24.5	30.0	68.0
1001 – 2000 kg/ha	224	24.6 *a*	0.0	16.0	23.0	32.0	65.0
2001 – 3000 kg/ha	77	24.1 *a*	0.0	15.5	23.0	31.0	62.0
3001 – 4000 kg/ha	29	26.3 *a*	3.0	13.8	24.0	31.0	72.0
> 4000 kg/ha	3	34.7 *a*	17.0	21.8	36.0	47.3	51.0

Grass green:dry leaf ratio x predicted non-grass %

There was no relationship between grass green:dry leaf ratio and non-grass % in Mitchell grass (Table 9b). In Black speargrass (light), non-grass % was significantly lower when grass green:dry leaf ratio increased to 100% compared with 25% green leaf ($P \leq 0.10$) however, the non-grass % at 100% green leaf was not significantly different compared to other levels of green:dry leaf ratio. In the Aristida/Bothriochloa, there was an increase in non-grass % when grass green:dry leaf ratio decreased to ≤25% however, this was not significantly different to the non-grass % when there was 100% green:dry leaf ratio (Table 9b).

Table 9b - Effect of grass green:dry leaf ratio on the NIRS prediction of non-grass % (NG%) for Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass land systems

Grass green:dry leaf ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0%	56	23.2 *a*	0.0	15.0	21.0	31.5	59.0
25%	70	23.5 *a*	3.0	15.0	22.5	30.0	58.0
50%	80	18.1 *b*	0.0	9.5	17.0	27.0	52.0
75%	48	18.4 *b*	0.0	9.5	19.0	27.0	42.0
100%	15	19.0 *ab*	1.0	13.5	22.0	27.5	34.0
Black speargrass (light)							
0%	32	16.2 *ab†*	0.0	10.5	14.5	23.5	38.0
25%	23	19.9 *a*	0.1	13.3	20.0	27.8	40.0
50%	11	14.2 *ab*	0.0	1.5	13.0	24.8	31.0
75%	13	18.2 *ab*	0.0	8.5	20.0	27.0	45.0
100%	21	12.2 *b*	0.0	6.8	14.0	17.3	30.0
Mitchell grass							
0%	198	24.3 *a*	0.0	16.0	23.0	31.0	68.0
25%	116	24.8 *a*	0.0	16.5	24.0	31.0	65.0
50%	43	26.2 *a*	1.0	14.3	23.0	36.8	62.0
75%	31	26.7 *a*	8.0	17.5	25.0	36.8	72.0
100%	19	23.2 *a*	1.0	10.0	22.0	30.0	62.0

† Pair-wise testing performed at P=0.10.

Grass leaf:stem ratio x non-grass %

There was no relationship between grass leaf:stem ratio and non-grass % on Aristida/Bothriochloa (Table 9c). On Mitchell grass, non-grass % at 75% leaf:stem ratio was significantly higher than at 25% and 50%, but not significantly different when there was 0% leaf in the grass.

Table 9c - Effect of grass leaf:stem ratio on the NIRS prediction of non-grass % (NG%) for Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass land systems

Grass leaf:stem ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0%	14	17.9 *a*	0.0	5.0	18.0	27.0	38.0
25%	80	20.1 *a*	0.0	15.0	19.5	28.0	46.0
50%	122	22.2 *a*	0.0	12.0	21.0	30.0	59.0
75%	50	18.3 *a*	0.0	12.0	18.5	26.0	35.0
Black speargrass (light)							
0%	3	25.7 *a*	23.0	23.8	26.0	27.5	28.0
25%	26	17.8 *a*	2.0	11.0	15.0	24.0	38.0
50%	50	13.2 *b*	0.0	6.0	13.5	20.0	30.0
75%	13	15.8 *ab*	7.0	9.8	14.0	19.0	31.0
Mitchell grass							
0%	13	24.9 *ab†*	10.0	15.8	22.0	30.0	54.0
25%	144	23.6 *b*	0.0	14.0	22.0	31.5	68.0
50%	163	24.3 *b*	0.0	16.0	23.0	31.0	65.0
75%	72	28.1 *a*	1.0	20.0	26.5	36.5	72.0

† Pair-wise testing performed at P=0.10.

4.2.2.1.2 Pasture observations and land system

Non-grass green:dry leaf %

As observed non-grass green: dry leaf % increased, F.NIRS predicted DMD% increased for all land systems, except Woodland (heavy) (Table 10). Both Aristida/Bothriochloa and Mitchell grass showed a significant response in predicted DMD% at each incremental level of non-grass green:dry leaf % (Appendix E, Fig. 7).

Table 10 - Effect of observed non-grass green:dry leaf ratio on NIRS predictions of dry matter digestibility (DMD%) for the major land systems

Non-grass green:dry ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0%	24	50.0 *d*	43.0	48.5	51.0	51.5	53.0
25%	53	52.9 *c*	42.0	49.0	53.0	55.3	67.0
50%	60	53.0 *c*	40.0	50.0	53.5	56.0	64.0
75%	42	55.1 *b*	45.0	52.0	55.0	58.0	70.0
100%	33	58.6 *a*	46.0	57.0	59.0	62.0	66.0
Brigalow/Gidyea							
0%	22	54.1 *b*	49.0	52.0	53.0	57.0	61.0
25%	35	56.9 *ab*	40.0	52.5	57.0	60.8	69.0
50%	6	57.3 *ab*	54.0	55.0	58.0	59.0	60.0
75%	16	58.9 *a*	49.0	53.0	60.0	63.0	71.0
100%	17	59.8 *a*	51.0	55.8	62.0	64.0	67.0
Black speargrass (light)							
0%	14	49.7 *bc*	40.0	46.0	48.0	55.0	62.0
25%	11	46.1 *c*	43.0	45.0	46.0	47.0	50.0
50%	8	48.8 *abc*	44.0	47.0	48.0	50.0	56.0
75%	15	51.9 *ab*	41.0	47.0	51.0	54.0	72.0
100%	28	53.8 *a*	43.0	48.0	53.5	61.0	70.0
Black speargrass (heavy)							
0%	12	48.8 *c*	46.0	46.5	48.0	50.0	57.0
25%	16	51.3 *bc*	43.0	49.0	52.0	53.0	57.0
50%	8	50.6 *bc*	48.0	49.0	51.0	52.0	53.0
75%	23	53.2 *b*	44.0	49.3	53.0	56.8	63.0
100%	25	59.3 *a*	44.0	53.8	60.0	64.3	74.0
Bluegrass downs							
0%	10	55.6 *ab*	52.0	53.0	55.0	59.0	61.0
25%	54	53.7 *b*	44.0	49.0	53.0	57.0	75.0
50%	31	56.4 *a*	46.0	52.0	55.0	61.8	68.0
75%	16	56.4 *ab*	50.0	52.5	55.5	60.5	65.0
100%	9	60.2 *a*	45.0	56.3	63.0	64.5	71.0
Mitchell grass							
0%	112	53.3 *d*	48.0	51.0	53.0	55.0	61.0
25%	95	55.4 *c*	48.0	52.0	55.0	57.8	68.0
50%	43	56.5 *bc*	47.0	54.0	57.0	59.8	63.0
75%	34	57.7 *b*	48.0	52.0	58.5	62.0	71.0
100%	24	61.8 *a*	50.0	59.0	62.5	65.0	69.0
Rainforest derived							
0%	3	61.0 *abc*	59.0	59.0	59.0	63.5	65.0
25%	9	59.1 *c*	55.0	56.8	59.0	62.0	64.0
50%	10	61.7 *bc*	57.0	58.0	62.0	63.0	71.0
75%	12	65.7 *ab*	57.0	59.0	65.5	70.5	80.0
100%	29	67.5 *a*	55.0	63.5	68.0	71.0	81.0
Woodland (light)							
0%	6	49.7 *c*	47.0	47.0	49.0	51.0	55.0
25%	14	55.9 *ab*	52.0	54.0	55.5	57.0	61.0
50%	6	53.7 *bc*	45.0	53.0	55.5	56.0	57.0
75%	6	59.3 *ab*	51.0	58.0	59.5	64.0	64.0
100%							
Woodland (heavy)							
0%	2	53.0 *a*	52.0	52.0	53.0	54.0	54.0
25%	2	48.5 *a*	48.0	48.0	48.5	49.0	49.0
50%	3	53.3 *a*	48.0	49.0	52.0	58.0	60.0
75%	5	51.0 *a*	47.0	47.8	52.0	53.5	55.0
100%	3	55.0 *a*	50.0	51.5	56.0	58.3	59.0

For all land systems, as the amount of observed non-grass green:dry leaf ratio increased, NIRS predictions of CP% increased (Table 11), however this increase varied between land systems. On Woodland (light), predicted CP% only increased when non-grass green:dry leaf % increased to 100%, and on Brigalow/Gidyea, CP% was only significantly lower when there was no green leaf. On Bluegrass downs, there was a significant increase in predicted CP% when green leaf increased to 50% but CP% did not increase significantly at higher levels of green leaf.

The distribution of predicted CP% for a number of land systems was skewed, in particular Woodland (heavy), Bluegrass downs, Black speargrass (light) and rainforest derived (Appendix E, Fig. 8).

Table 11 - Effect of observed non-grass green:dry leaf ratio on NIRS predictions of crude protein (CP%) for the major land systems

Non-grass green:dry ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0%	24	5.4 *d*	3.5	5.0	5.5	6.0	6.4
25%	53	6.7 *c*	4.3	5.4	6.3	7.5	14.5
50%	60	7.0 *c*	3.5	6.2	7.2	8.1	11.6
75%	42	8.1 *b*	4.9	6.2	7.6	8.9	14.2
100%	33	9.6 *a*	5.6	7.8	9.9	11.7	14.0
Brigalow/Gidyea							
0%	22	5.5 *b*	4.2	4.8	5.2	5.7	8.8
25%	35	7.3 *a*	3.9	6.0	6.8	8.8	12.1
50%	6	8.6 *a*	4.5	7.3	8.3	9.5	13.5
75%	16	8.4 *a*	4.7	6.9	8.4	9.2	13.7
100%	17	8.4 *a*	4.4	6.7	9.0	10.3	11.4
Black speargrass (light)							
0%	14	5.1 *b*	3.3	4.1	4.6	6.1	8.3
25%	11	4.2 *b*	2.5	3.6	4.4	4.7	5.5
50%	8	5.0 *b*	2.5	3.6	4.7	5.9	9.5
75%	15	7.8 *a*	3.9	6.0	6.9	7.4	16.7
100%	28	8.3 *a*	4.0	5.7	8.1	10.9	14.6
Black speargrass (heavy)							
0%	12	5.3 *c*	3.1	4.9	5.3	5.7	7.7
25%	16	6.3 *ab*	3.7	5.3	5.9	7.1	10.4
50%	8	5.6 *ab*	4.7	5.1	5.7	6.2	6.3
75%	23	7.0 *b*	4.6	5.9	6.5	7.8	12.4
100%	25	10.2 *a*	4.8	8.0	9.4	12.1	17.0
Bluegrass downs							
0%	10	6.3 *b*	3.2	4.9	5.6	7.6	11.1
25%	54	6.8 *b*	3.6	5.0	6.0	7.6	21.1
50%	31	9.2 *a*	4.3	7.0	8.4	11.5	17.4
75%	18	9.6 *a*	6.4	7.8	8.0	11.2	15.1
100%	9	11.0 *a*	6.2	7.7	11.8	13.5	14.6
Mitchell grass							
0%	115	5.8 *d*	3.4	4.7	5.6	6.3	11.4
25%	98	6.8 *c*	3.9	5.4	6.3	8.0	12.0
50%	44	7.0 *c*	4.7	5.8	7.0	7.9	10.0
75%	34	8.5 *b*	4.9	5.9	8.3	9.9	16.8
100%	23	12.6 *a*	7.5	10.6	11.9	14.4	20.9
Rainforest derived							
0%	3	12.0 *ab*	9.5	9.8	10.7	14.5	15.7
25%	9	10.3 *b*	7.5	8.7	9.6	12.4	13.2
50%	10	11.2 *b*	8.5	9.1	11.4	11.8	15.3
75%	13	12.2 *b*	7.9	10.5	11.5	13.2	17.9
100%	29	14.1 *a*	8.3	12.4	14.3	16.0	20.1

Non-grass green:dry ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Woodland (light)							
0%	6	4.6 *c*	3.6	3.7	4.8	5.0	5.8
25%	17	6.4 *b*	3.5	5.0	7.0	7.3	10.3
50%	6	6.7 *b*	4.9	5.5	6.9	7.4	8.9
75%	6	9.3 *a*	5.5	8.9	9.4	11.0	11.6
100%							
Woodland (heavy)							
0%	2	5.3 *a*	4.4	4.4	5.3	6.1	6.1
25%	2	5.0 *a*	4.8	4.8	5.0	5.2	5.2
50%	3	6.3 *a*	4.7	5.2	6.7	7.4	7.6
75%	5	6.1 *a*	4.5	5.0	5.5	7.4	8.5
100%	3	6.9 *a*	6.3	6.4	6.8	7.5	7.7

The population distributions for the relationship between CP:FN ratio and non-grass green:dry leaf % are skewed for a number of land systems (Appendix E, Fig. 9). This may be due to the difficulty in assessing green:dry leaf % for non-grass because many forb species can be at different growth stages at any time and respond differently to rainfall.

CP:FN ratio increased as non-grass green:dry leaf % increased, except in Woodland (heavy) land system (Table 12). This may be due to an increase in the non-grass component of the diet, which would escalate dietary CP% predictions, reducing the reliability of the predictions, and CP:FN ratio. The increase in CP:FN was most pronounced in Mitchell grass, Aristida/Bothriochloa, Black speargrass (heavy) and Bluegrass downs (Table 12).

Table 12 - Effect of observed non-grass green:dry ratio on NIRS predictions of CP:FN ratio for the major land systems

Non-grass green:dry ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
0%	25	4.5 *c*	0.0	4.2	4.8	5.0	5.8
25%	53	5.1 *b*	3.3	4.4	5.0	5.7	7.4
50%	60	5.4 *ab*	3.0	4.8	5.6	6.1	6.9
75%	42	5.3 *b*	3.6	4.5	5.4	5.8	7.6
100%	33	5.8 *a*	4.1	5.4	5.8	6.2	7.9
Brigalow/Gidyea							
0%	22	4.5 *b*	3.6	4.0	4.6	4.8	5.8
25%	35	5.3 *a*	2.8	4.7	5.2	6.1	7.7
50%	6	5.5 *a*	4.4	4.7	5.4	5.8	7.5
75%	16	5.2 *a*	4.2	4.8	5.1	5.6	6.3
100%	17	5.4 *a*	3.9	5.2	5.6	6.0	6.8
Black speargrass (light)							
0%	14	3.7 *b*	2.9	3.2	3.7	4.0	4.8
25%	11	3.9 *b*	2.5	3.5	4.0	4.4	4.7
50%	8	3.8 *b*	2.5	3.2	3.9	4.3	5.2
75%	15	5.0 *a*	2.8	4.2	5.0	5.7	7.3
100%	28	5.0 *a*	3.7	4.2	5.2	5.7	7.0
Black speargrass (heavy)							
0%	12	4.5 *c*	3.6	4.2	4.5	4.9	5.1
25%	16	5.1 *b*	3.6	4.7	5.2	5.7	6.2
50%	8	4.7 *bc*	4.2	4.4	4.7	5.1	5.2
75%	23	5.1 *b*	3.2	4.7	5.0	5.6	6.8
100%	25	6.2 *a*	3.6	5.4	6.1	7.1	8.3
Bluegrass downs							
0%	10	4.4 *c*	2.7	3.6	4.3	4.9	6.3
25%	54	5.1 *bc*	3.6	4.3	4.8	5.6	9.4
50%	31	5.8 *a*	3.3	4.7	5.8	6.6	7.8
75%	17	5.7 *ab*	4.4	4.9	5.4	6.5	7.8
100%	9	5.8 *ab*	4.6	5.2	5.7	6.4	6.6
Mitchell grass							
0%	116	4.9 *d*	0.0	4.3	4.8	5.5	8.0
25%	98	5.2 *bc*	3.4	4.5	5.1	5.7	8.7
50%	45	5.1 *cd*	0.0	4.6	4.8	5.7	7.5
75%	34	5.6 *b*	3.9	5.2	5.7	6.1	7.4
100%	23	6.5 *a*	4.8	6.0	6.5	7.0	9.0
Rainforest derived							
0%	3	6.6 *ab*	5.8	6.1	7.0	7.1	7.1
25%	9	6.4 *b*	5.6	5.6	6.0	7.1	8.0
50%	10	6.6 *b*	5.4	6.1	6.4	7.3	7.8
75%	13	6.4 *b*	4.7	6.0	6.7	6.8	7.3
100%	28	7.4 *a*	6.1	6.7	7.3	8.1	8.9
Woodland (light)							
0%	6	3.8 *b*	3.3	3.4	3.9	3.9	4.6
25%	17	5.4 *a*	3.6	4.6	5.4	6.1	7.0
50%	6	5.1 *a*	3.4	4.9	5.3	5.8	5.8
75%	6	6.0 *a*	4.2	6.1	6.3	6.4	6.5
100%							
Woodland (heavy)							
0%	2	4.4 *a*	4.0	4.0	4.4	4.9	4.9
25%	2	4.2 *a*	4.1	4.1	4.2	4.4	4.4
50%	3	5.0 *a*	4.5	4.6	4.9	5.4	5.5
75%	5	4.8 *a*	4.1	4.2	4.5	5.4	5.7
100%	3	4.9 *a*	4.4	4.6	4.9	5.2	5.3

There was a positive correlation between predicted ADG (kg/hd/d) and observed green:dry leaf % for non-grass in both the wet and dry seasons and across all seasons (Table 13).

Table 13 - Effect of observed non-grass green:dry leaf ratio of the pasture on the NIRS prediction of ADG (kg/hd/d live weight) of dry cattle across all seasons, the dry season and the wet season

Non-grass green:dry leaf ratio	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
All seasons							
0%	77	0.17 *d*	-0.38	0.00	0.10	0.30	1.40
25%	128	0.37 *c*	-0.23	0.10	0.30	0.52	2.40
50%	77	0.54 *b*	-0.30	0.24	0.60	0.80	1.30
75%	78	0.79 *a*	-0.80	0.50	0.78	1.13	2.50
100%	92	0.85 *a*	-0.20	0.60	0.90	1.10	2.90
Dry season							
0%	61	0.13 *d*	-0.38	0.00	0.10	0.30	1.40
25%	88	0.28 *c*	-0.23	0.10	0.20	0.40	2.40
50%	43	0.42 *bc*	-0.30	0.12	0.35	0.70	1.30
75%	22	0.58 *ab*	0.01	0.20	0.45	0.80	2.50
100%	30	0.75 *a*	-0.20	0.41	0.80	1.10	1.60
Wet season							
0%	16	0.31 *c*	0.00	0.18	0.30	0.48	0.80
25%	40	0.56 *b*	-0.10	0.38	0.60	0.78	1.40
50%	34	0.68 *b*	0.08	0.50	0.70	0.80	1.20
75%	56	0.88 *a*	-0.80	0.60	0.88	1.28	2.00
100%	62	0.90 *a*	0.05	0.70	0.90	1.10	2.90

4.2.3 Cattle

4.2.3.1 Breed grouping effect

DMD%

Aristida/Bothriochloa and Mitchell grass were the only land systems that showed a significant difference in predicted DMD% due to breed effect (Table 14). For Aristida/Bothriochloa, predicted DMD% was higher for *Bos taurus* than for *Bos indicus* cattle, whereas for Mitchell grass, there was no significant difference in predicted DMD% between these breed groups. Intermediate breeds had a significantly higher DMD% than *Bos indicus* cattle. Differences could have occurred because of differences in landtypes where animals were grazed. There is a possibility that *Bos indicus* cattle are preferentially grazed on lighter soils. For example, only *Bos indicus* cattle were sampled from the Black speargrass (light) land system.

Table 14 - Effect of breed grouping on NIRS predictions of dry matter digestibility (DMD%) for the major land systems

Breed groupings	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
Indicus	94	51.0 *c*	40.0	48.0	51.0	54.0	63.0
Intermediate	47	52.0 *bc*	40.0	48.0	52.0	56.0	64.0
Taurus	143	54.5 *a*	41.0	50.0	54.0	59.0	70.0
Unknown	17	55.0 *ab*	46.0	49.8	53.0	61.0	70.0
Brigalow/Gidyea							
Indicus	7	56.3 *a*	51.0	52.5	55.0	60.0	64.0
Intermediate	49	58.0 *a*	47.0	54.0	58.0	62.0	71.0
Taurus	38	55.7 *a*	40.0	51.0	55.0	59.0	70.0
Unknown	5	57.6 *a*	54.0	54.8	57.0	59.0	65.0
Black speargrass (light)							
Indicus	101	50.4	40.0	46.0	48.0	54.0	72.0
Intermediate							
Taurus							
Unknown							
Black speargrass (heavy)							
Indicus	93	53.9 *a*	43.0	49.0	52.0	57.0	75.0
Intermediate	9	51.1 *a*	44.0	47.3	51.0	55.0	61.0
Taurus							
Unknown	2	54.5 *a*	53.0	53.0	54.5	56.0	56.0
Bluegrass downs							
Indicus	90	56.4 *a*	47.0	53.0	56.0	60.0	71.0
Intermediate	63	54.5 *a*	44.0	50.0	54.0	58.8	75.0
Taurus	8	57.9 *a*	45.0	53.0	60.0	63.5	65.0
Unknown	7	56.1 *a*	54.0	54.3	56.0	57.8	59.0
Mitchell grass							
Indicus	101	54.4 *c*	46.0	51.0	54.0	57.0	71.0
Intermediate	238	55.9 *b*	46.0	53.0	55.0	59.0	72.0
Taurus	52	55.9 *bc*	40.0	52.0	55.0	59.0	68.0
Unknown	23	58.6 *a*	50.0	54.0	58.0	60.0	71.0
Rainforest derived							
Indicus	49	63.4 *a*	51.0	59.0	62.0	68.3	74.0
Intermediate	28	65.6 *a*	55.0	61.0	65.0	69.0	81.0
Taurus	11	62.0 *a*	54.0	58.3	61.0	65.0	74.0
Unknown	1	59.0 *a*	59.0	59.0	59.0	59.0	59.0
Woodland (light)							
Indicus	28	53.0 *a*	43.0	48.0	54.5	57.0	64.0
Intermediate	25	53.4 *a*	45.0	46.8	52.0	59.3	66.0
Taurus							
Unknown	2	49.5 *a*	42.0	42.0	49.5	57.0	57.0
Woodland (heavy)							
Indicus	1	59.0 *a*	59.0	59.0	59.0	59.0	59.0
Intermediate	10	54.3 *a*	48.0	49.0	52.5	55.0	72.0
Taurus	10	55.4 *a*	47.0	51.0	55.0	59.0	68.0
Unknown	2	53.0 *a*	50.0	50.0	53.0	56.0	56.0

CP%

Predicted dietary CP% was higher for *Bos taurus* cattle on Aristida/Bothriochloa, Bluegrass downs and Mitchell grass ($P \leq 0.10$) (Table 15). There were no differences between breed groups in other land systems. On bluegrass downs, the protein levels are particularly high for *Bos taurus* cattle compared to other breeds. This is related to more high content *Bos taurus* cattle running on improved pastures on bluegrass downs than the other breed groupings where the diet quality is consistently higher.

Table 15 - Effect of breed grouping on NIRS predictions of crude protein (CP%) for the major land systems

Breed groupings	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
Bos indicus	94	6.2 *b*	2.9	4.8	5.8	7.2	11.8
Intermediate	47	7.2 *a*	3.6	5.3	6.3	9.6	12.9
Bos taurus	143	7.6 *a*	3.0	5.8	6.9	8.9	14.5
Unknown	17	7.7 *a*	4.6	5.7	6.9	10.9	12.8
Brigalow/Gidyea							
Bos indicus	7	6.7 *ab*	4.4	5.1	7.2	8.3	8.9
Intermediate	49	7.9 *a*	4.2	5.9	8.2	9.5	13.7
Bos taurus	38	6.6 *b*	3.9	5.2	6.1	7.1	13.4
Unknown	5	7.7 *ab*	5.9	6.7	7.2	8.4	11.0
Black speargrass (light)							
Bos indicus	101	6.5	2.5	4.5	5.7	7.9	16.7
Intermediate							
Bos taurus							
Unknown							
Black speargrass (heavy)							
Bos indicus	93	7.3 *a*	2.9	5.5	6.3	8.7	17.0
Intermediate	9	6.4 *a*	4.2	5.2	5.9	6.7	12.4
Bos taurus							
Unknown	2	7.4 *a*	7.3	7.3	7.4	7.5	7.5
Bluegrass downs							
Bos indicus	93	7.1 *c*	2.3	5.0	6.5	9.0	14.6
Intermediate	63	8.3 *b*	3.6	5.7	7.6	10.0	21.1
Bos taurus	8	11.9 *a*	7.1	9.7	12.7	14.2	15.1
Unknown	7	5.4 *c*	4.1	4.5	4.9	5.4	9.3
Mitchell grass							
Bos indicus	101	6.4 *b*	3.3	5.2	5.9	7.2	16.8
Intermediate	244	6.9 *b*	3.4	5.1	6.2	8.2	15.5
Bos taurus	53	8.0 *a*	3.9	5.7	6.8	8.8	20.9
Unknown	23	7.0 *ab*	2.5	4.3	6.3	9.6	14.6
Rainforest derived							
Bos indicus	50	12.2 *a*	6.6	9.9	12.5	14.5	16.7
Intermediate	28	13.0 *a*	7.5	10.8	13.3	15.8	20.1
Bos taurus	11	11.0 *a*	8.5	9.7	10.8	12.3	15.1
Unknown	1	10.8 *a*	10.8	10.8	10.8	10.8	10.8
Woodland (light)							
Bos indicus	31	6.1 *a*	2.8	4.0	6.5	7.3	11.8
Intermediate	25	7.1 *a*	3.2	4.8	5.8	9.7	13.3
Bos taurus							
Unknown	2	5.1 *a*	3.6	3.6	5.1	6.5	6.5
Woodland (heavy)							
Bos indicus	1	6.3 *a*	6.3	6.3	6.3	6.3	6.3
Intermediate	10	6.8 *a*	4.4	4.8	5.8	7.6	14.6
Bos taurus	10	7.1 *a*	4.5	5.7	6.1	7.8	13.3
Unknown	2	7.3 *a*	6.8	6.8	7.3	7.7	7.7

Non-grass %

Aristida/Bothriochloa, Brigalow/Gidyea and Woodland (light) were the only land systems that showed a significant relationship between breed grouping and predicted non-grass % (Table 16). For both Aristida/Bothriochloa and Brigalow/Gidyea, predicted non-grass % did not differ between *Bos indicus* and *Bos taurus* cattle however, non-grass % was significantly higher in Intermediate breeds than in *Bos taurus* breeds.

Table 16 - Effect of breed grouping on NIRS predictions of % non-grass (NG%) for the major land systems

Breed groupings	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Aristida/Bothriochloa							
Bos indicus	93	22.0 *ab*	0.0	12.8	20.0	30.0	59.0
Intermediate	48	24.8 *a*	1.0	14.5	18.5	29.5	100.0
Bos taurus	143	19.7 *bc*	0.0	12.0	20.0	27.0	52.0
Unknown	17	13.1 *c*	0.0	5.0	12.0	17.0	35.0
Brigalow/Gidyea							
Bos indicus	93	22.0 *ab*	0.0	12.8	20.0	30.0	59.0
Intermediate	48	24.8 *a*	1.0	14.5	18.5	29.5	100.0
Bos taurus	143	19.7 *bc*	0.0	12.0	20.0	27.0	52.0
Unknown	17	13.1 *c*	0.0	5.0	12.0	17.0	35.0
Black speargrass (light)							
Bos indicus	100	16.2	0.0	9.0	15.0	24.0	45.0
Intermediate							
Bos taurus							
Unknown							
Black speargrass (heavy)							
Bos indicus	93	15.7 *a*	0.0	7.8	15.0	22.0	52.0
Intermediate	9	16.8 *a*	2.0	10.0	16.0	24.3	30.0
Bos taurus							
Unknown	2	4.0 *a*	0.0	0.0	4.0	8.0	8.0
Bluegrass downs							
Bos indicus	93	25.7 *a*	0.0	15.0	25.0	36.0	80.0
Intermediate	63	21.4 *a*	0.0	10.0	20.0	28.8	58.0
Bos taurus	8	19.4 *a*	1.0	1.0	17.5	37.0	43.0
Unknown	7	4.3 *b*	0.0	0.0	2.0	6.8	15.0
Mitchell grass							
Bos indicus	102	25.4 *a*	0.0	18.0	24.5	34.0	50.0
Intermediate	245	25.2 *a*	0.0	14.8	24.0	32.3	72.0
Bos taurus	54	23.4 *a*	2.0	16.0	23.0	28.0	62.0
Unknown	23	20.7 *a*	1.0	13.3	20.0	26.8	48.0
Rainforest derived							
Bos indicus	50	10.4 *a*	2.0	7.0	10.0	14.0	23.0
Intermediate	27	11.3 *a*	0.0	6.0	10.0	15.0	28.0
Bos taurus	11	13.6 *a*	7.0	10.5	14.0	15.8	22.0
Unknown	1	13.0 *a*	13.0	13.0	13.0	13.0	13.0
Woodland (light)							
Bos indicus	31	15.3 *b*	0.0	7.0	14.0	22.8	33.0
Intermediate	25	21.2 *a*	7.0	17.0	20.0	25.8	35.0
Bos taurus							
Unknown	2	19.0 *ab*	13.0	13.0	19.0	25.0	25.0
Woodland (heavy)							
Bos indicus	1	6.0 *a*	6.0	6.0	6.0	6.0	6.0
Intermediate	10	13.8 *a*	0.0	4.0	12.0	23.0	33.0
Bos taurus	10	10.7 *a*	0.0	5.0	8.5	15.0	24.0
Unknown	2	6.0 *a*	6.0	6.0	6.0	6.0	6.0

Breed group effect on NIRS parameters

Overall, predicted CP% and DMD% were lower for *Bos indicus* than Intermediate and *Bos taurus* breed groups (Table 17a). Predicted non-grass % was significantly higher for the Intermediate breed group, but didn't differ between *Bos indicus* and *Bos taurus* breed groups. Predicted ADG (kg/hd/d) was highest for *Bos taurus* cattle followed by the Intermediate breed group. Differences could be explained by the higher proportion of *Bos indicus* cattle run on lighter soils, while *Bos taurus* cattle tend to be run on heavier soils.

Table 17a - Effect of cattle breed on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, non-grass (NG%) and average daily gain (ADG kg/hd/d)

Cattle breed	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Bos indicus	583	54.1 *b*	40.0	50.0	53.0	58.0	75.0
Intermediate	486	56.0 *a*	40.0	52.0	55.0	60.0	81.0
Bos taurus	262	55.4 *a*	40.0	51.0	55.0	59.0	74.0
Unknown	60	56.5 *a*	42.0	53.0	56.0	59.0	71.0
CP (%)							
Bos indicus	589	7.1 *b*	2.3	5.0	6.3	8.4	17.0
Intermediate	492	7.7 *a*	3.2	5.2	7.0	9.5	21.1
Bos taurus	263	7.8 *a*	3.0	5.8	6.9	9.1	20.9
Unknown	60	7.1 *ab*	2.5	5.0	6.5	7.9	14.6
DMD:CP ratio							
Bos indicus	580	8.6 *a*	4.1	6.7	8.2	10.0	20.4
Intermediate	486	8.1 *b*	3.6	6.1	7.9	9.8	15.1
Bos taurus	262	7.8 *b*	2.8	6.4	7.8	9.0	14.6
Unknown	60	9.1 *a*	4.8	6.8	8.6	10.8	21.6
Non-grass (%)							
Bos indicus	590	19.5 *b*	0.0	10.0	18.0	27.0	80.0
Intermediate	493	23.3 *a*	0.0	12.0	21.0	30.0	100.0
Bos taurus	264	18.7 *b*	0.0	10.0	18.0	26.0	62.0
Unknown	60	14.1 *c*	0.0	6.0	13.0	20.0	48.0
ADG (kg/hd/d)							
Bos indicus	569	0.40 *c*	-0.80	0.08	0.30	0.70	2.60
Intermediate	477	0.48 *b*	-0.30	0.15	0.40	0.76	2.40
Bos taurus	257	0.57 *a*	-0.40	0.20	0.50	0.80	2.90
Unknown	56	0.52 *ab*	-0.20	0.16	0.60	0.85	1.30

Predicted DMD% was significantly higher for weaners, steers/heifers and mixed classes compared to breeders. Steers/heifers and weaners had a higher predicted DMD% than maiden heifers and mixed classes (Table 17b).

Predicted CP% was also significantly lower in breeders than all other classes of stock except for bulls, while steers/heifers had a higher predicted CP% than maiden heifers (Table 17b).

The breeders had a significantly higher DMD:CP ratio than all classes of stock except for mixed classes and bulls (Table 17b).

Predicted non-grass % was lowest for bulls, followed by steers/heifers, while weaners, maiden heifers and breeders did not differ significantly from each other (Table 17b). It is not possible to determine if these differences are due to more browse or forbs in the diet.

Predicted ADG (kg/hd/d) was lowest for breeders, but not significantly different to mixed class (Table 17b). Predicted ADG takes into account the other NIRS dietary predictions, however, it does not take into account feed intake, which can have a major impact on production.

4.2.3.2 Class of stock

Table 17b - Effect of cattle class on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, non-grass (NG%) and average daily gain (ADG kg/hd/d)

Cattle class	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
1. Weaners	75	57.9 *a*	45.0	53.0	57.0	62.0	74.0
2. Maiden heifers	110	55.0 *bc*	43.0	51.0	54.5	59.0	72.0
3. Breeders	773	53.8 *c*	40.0	50.0	53.0	57.0	75.0
4. Steers/Heifers	363	57.0 *a*	40.0	52.0	57.0	61.0	81.0
5. Mixed class	38	56.9 *ab*	41.0	53.0	57.0	60.0	72.0
6. Bulls	10	56.7 *abc*	50.0	53.0	55.0	59.0	75.0
CP (%)							
1. Weaners	76	8.4 *ab*	3.9	5.6	7.1	10.8	16.4
2. Maiden heifers	111	7.5 *b*	3.3	5.5	6.8	9.3	16.7
3. Breeders	780	6.9 *c*	2.3	4.9	6.2	8.3	20.9
4. Steers/Heifers	366	8.3 *a*	2.5	5.7	7.6	10.6	20.1
5. Mixed class	39	8.1 *ab*	3.8	5.4	7.3	10.2	17.8
6. Bulls	10	7.7 *abc*	4.4	5.7	6.3	7.0	21.1
DMD:CP ratio							
1. Weaners	75	7.8 *b*	4.3	6.1	7.9	9.5	13.2
2. Maiden heifers	110	8.0 *b*	4.3	6.4	8.0	9.3	14.2
3. Breeders	770	8.7 *a*	2.8	6.7	8.4	10.2	20.4
4. Steers/Heifers	363	7.8 *b*	3.9	5.9	7.5	9.2	21.6
5. Mixed class	38	8.1 *ab*	3.5	5.9	7.6	9.5	14.7
6. Bulls	10	8.5 *ab*	3.6	7.7	9.0	9.7	11.6
Non-grass (%)							
1. Weaners	76	18.9 *bc*	0.0	7.0	18.5	28.0	72.0
2. Maiden heifers	112	23.2 *ab*	0.0	13.0	20.0	30.0	66.0
3. Breeders	784	21.4 *bc*	0.0	13.0	20.0	28.0	100.0
4. Steers/Heifers	364	17.8 *d*	0.0	7.0	15.0	26.0	80.0
5. Mixed class	39	26.6 *a*	0.0	13.3	26.0	37.5	62.0
6. Bulls	10	6.3 *e*	0.0	0.0	5.0	6.0	26.0
ADG (kg/hd/d)							
1. Weaners	68	0.56 *abc*	0.00	0.20	0.40	0.78	2.90
2. Maiden heifers	106	0.47 *cd*	-0.38	0.12	0.50	0.75	1.60
3. Breeders	757	0.40 *d*	-0.80	0.10	0.30	0.70	2.80
4. Steers/Heifers	359	0.57 *ab*	-0.80	0.20	0.55	0.90	2.50
5. Mixed class	38	0.47 *bcd*	-0.30	0.10	0.38	0.70	1.80
6. Bulls	10	0.77 *a*	-0.20	0.50	0.70	0.90	2.40

4.2.3.2.1 Lactation effect

There was a large number of outliers for predicted DMD%, CP% and non-grass % in lactating cows (Appendix E, Fig. 14). The high CP% values may be related to a high browse intake. Many browse species with a low digestibility have a high CP% level (e.g. mulga trees).

Predicted DMD% was highest for dry stock and in herds where 76-100% of breeders were lactating, followed by herds where 51-75% of breeders were lactating (Table 14c). Herds where 1-25% and 25-50% of breeders were lactating had the lowest predicted DMD%. These differences are more related to the time of year and pasture growth phase when the cattle are lactating rather than the stage of reproduction of the breeders. This may be related to the time of year when the breeders were calving, particularly in control-mated herds. At the end of the dry season when there is a smaller percentage of lactating breeders, the quality of the pasture is expected to be poorer, compared with the early wet season when the majority of the breeder herd is lactating.

Predicted CP% was highest for dry cattle, cattle with unknown lactation status and monitor herds where 76-100% of the breeders were lactating (Table 17c). In spite of this, DMD:CP was lowest in herds where 76-100% of breeders were lactating therefore likely to show the least response to nitrogen supplementation. This was probably due to timing of calving, where there was a large percentage of lactating cows during the wet season, when CP% and DMD% are not limiting.

Predicted non-grass % was lowest in dry stock (Table 17c). Dry stock are more likely to walk further distances enabling greater selection of pastures.

In herds where 1-25% of breeders were lactating, predicted ADG (kg/hd/d) was the lowest but not significantly lower than herds where 25-50% of breeders were lactating (Table 17c). This may be due to either out-of-season calves in the dry season, or in control-mated herds, late in the dry season when feed quality is poor. This highlights the importance of spike feeding heifers and providing adequate energy supplements prior to calving. Coupled with the low ADG prediction, in herds that are control-mated, the 1-25% lactating group at the end of the dry season would typically consist of breeders with young calves. Females reach peak lactation, and hence, peak nutrient requirements, in early lactation, so provision of a high energy and protein supplement is paramount during this period. Herds in which 76-100% of breeders were lactating had the highest predicted ADG, although it was not significantly higher than that for dry cows. The ADG prediction is based on a 300-kg medium frame steer, so the gain is not based on the stage of reproduction of the breeders, but is a reflection of differences in pasture diet quality between these breeder groups.

Table 17c - Effect of lactation status on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, non-grass (NG%) and average daily gain (ADG kg/hd/d)

Lactation status	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Dry	615	56.3 *a*	40.0	52.0	56.0	60.0	81.0
1-25% lactating	96	51.5 *c*	40.0	48.0	51.0	55.0	69.0
25-50% lactating	179	52.8 *c*	40.0	49.0	52.0	55.0	75.0
51-75% lactating	216	54.1 *b*	40.0	50.0	54.0	57.0	70.0
76-100% lactating	164	56.6 *a*	46.0	53.0	56.5	60.5	72.0
Unknown	121	55.4 *ab*	46.0	51.0	54.0	59.0	72.0
CP (%)							
Dry	620	7.8 *a*	2.3	5.5	7.0	9.5	21.1
1-25% lactating	98	6.5 *b*	2.5	4.7	5.9	7.2	20.9
25-50% lactating	185	6.6 *b*	3.0	4.8	5.9	8.0	15.1
51-75% lactating	216	6.9 *b*	3.2	5.0	6.4	8.1	15.5
76-100% lactating	164	8.0 *a*	3.2	6.3	7.8	9.5	16.1
Unknown	121	7.6 *a*	3.7	5.2	6.7	8.9	17.8
DMD:CP ratio							
Dry	615	8.1 *c*	3.6	6.2	7.8	9.5	21.6
1-25% lactating	96	9.0 *a*	2.8	7.3	8.8	10.4	19.2
25-50% lactating	179	8.9 *a*	4.1	6.8	8.7	10.5	16.6
51-75% lactating	213	8.6 *ab*	4.2	6.8	8.3	10.4	17.3
76-100% lactating	164	7.6 *d*	4.0	6.1	7.4	8.7	15.9
Unknown	121	8.2 *bcd*	3.5	6.5	8.1	9.8	14.7
Non-grass (%)							
Dry	619	18.7 *b*	0.0	8.0	16.0	27.0	88.0
1-25% lactating	98	21.0 *ab*	0.0	12.0	20.0	27.0	59.0
25-50% lactating	184	22.5 *a*	0.0	14.5	22.0	28.0	100.0
51-75% lactating	219	22.1 *a*	0.0	14.0	21.0	28.0	75.0
76-100% lactating	166	21.2 *a*	0.0	14.0	20.0	28.0	55.0
Unknown	121	21.6 *a*	0.0	9.0	19.0	30.0	68.0
ADG (kg/hd/d)							
Dry	597	0.51 *ab*	-0.80	0.15	0.50	0.80	2.90

1-25% lactating	96	0.27 *e*	-0.40	-0.12	0.20	0.50	2.40
25-50% lactating	177	0.34 *de*	-0.80	0.05	0.20	0.70	1.50
51-75% lactating	211	0.43 *cd*	-0.30	0.15	0.40	0.70	2.80
76-100% lactating	163	0.58 *a*	-0.22	0.30	0.60	0.80	2.60
Unknown	115	0.48 *bc*	-0.30	0.11	0.40	0.80	1.80

4.2.3.2.2 Mating management

There were no significant differences in predicted DMD% and FN% between continuous and controlled mating (Table 18). Predicted CP% and ADG (kg/hd/d) were higher for controlled mating however, ADG (kg/hd/d) predictions, based on a 300-kg medium frame steer, are not a reliable reflection of growth rate of breeders.

Table 18 - Effect of method of mating on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%), non-grass (NG%) and average daily gain (ADG kg/hd/d)

Mating method	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Continuous	371	53.7 *a*	40.0	50.0	53.0	57.0	75.0
Controlled	426	54.1 *a*	40.0	50.0	54.0	58.0	72.0
CP (%)							
Continuous	375	6.7 *b*	2.3	4.9	6.2	8.1	15.5
Controlled	430	7.2 *a*	2.8	5.2	6.7	8.5	20.9
DMD:CP ratio							
Continuous	368	8.8 *a*	4.1	6.8	8.5	10.2	20.4
Controlled	426	8.3 *b*	2.8	6.6	8.0	9.6	17.3
FN (%)							
Continuous	376	1.35 *a*	0.81	1.15	1.27	1.51	2.37
Controlled	432	1.35 *a*	0.79	1.14	1.29	1.49	2.48
Non-grass (%)							
Continuous	376	23.4 *a*	0.0	15.0	22.0	29.0	100.0
Controlled	433	21.3 *b*	0.0	13.0	20.0	29.0	68.0
ADG (kg/hd/d)							
Continuous	360	0.36 *b*	-0.80	0.10	0.30	0.70	1.40
Controlled	423	0.44 *a*	-0.40	0.10	0.40	0.70	2.80

4.2.3.2.3 Weight gain observations

For both supplemented and unsupplemented cattle, as producers observed increased weight gain in cattle, predicted CP% and DMD% also increased (Table 19). It was interesting to note that predicted DMD% was approximately 50% when producers observed that animals were losing weight. Recommendations to begin supplementing energy were generally made when predicted DMD% dropped to 50%. Means for predicted DMD% for both unsupplemented and supplemented animals that were losing weight were 50.3% and 50.9% (Table19).

Predicted CP% was below 6% for all cattle, and both supplemented (5.4%) and unsupplemented (5.7%) when producers observed that animals were losing weight (Table 19).

When animals were observed to be losing weight, DMD:CP ratio ranged from 9.7–10.1 for the three groups, whereas the mean ratio ranged from 8.4–8.9 for animals that were holding and the mean ratio ranged from 7.0 to 7.2 for animals that were gaining weight. The current recommendation is that there is likely to be a response to supplementing nitrogen when the DMD:CP ratio is greater than 8.

In supplemented animals, predicted non-grass % increased as producers' observations of animal weight changes went from gaining to losing (Table 19). Non-grass % predictions were unaffected by observed weight gain in unsupplemented animals.

For all cattle and unsupplemented cattle, there was a trend for predicted ADG (kg/hd/d) to increase with producers' observations of increased weight gain (Table 19). In supplemented animals there were no significant differences in ADG predictions between animals that were observed to be holding and those observed to be losing weight. Predicted ADG (kg/hd/d) was significantly higher for those observed to be gaining weight. The range of means for animals that were losing weight was 0.11 to 0.15 kg/hd/d, a weight loss that would be difficult to assess visually. Also, animals may have lost weight prior to sampling, particularly following rain, so although visually they could have obviously lost weight, the recent change in diet quality would suggest that they should be gaining weight.

Table 19 - Relationship between the general observation of all cattle, supplemented cattle and unsupplemented cattle on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass % (NG%)

General Observation	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%) – all cattle							
Gaining	484	58.3 *a*	45.0	54.0	58.0	62.0	80.0
Holding	493	53.5 *b*	40.0	50.0	53.0	57.0	81.0
Losing	195	50.6 *c*	40.0	47.0	50.0	54.0	71.0
DMD (%) – supplemented							
Gaining	185	57.2 *a*	45.0	53.0	56.0	61.0	80.0
Holding	215	52.9 *b*	40.0	49.3	52.0	55.0	81.0
Losing	101	50.3 *c*	40.0	47.0	50.0	53.3	62.0
DMD (%) – unsupplemented							
Gaining	299	59.1 *a*	45.0	55.0	59.0	63.0	75.0
Holding	278	54.0 *b*	40.0	50.0	54.0	57.0	70.0
Losing	94	50.9 *c*	40.0	48.0	50.5	54.0	71.0
CP (%) – all cattle							
Gaining	485	8.9 *a*	3.6	6.6	8.3	10.9	21.1
Holding	498	6.7 *b*	3.0	5.1	6.1	7.8	20.9
Losing	200	5.5 *c*	2.5	4.4	5.0	6.1	15.3
CP (%) – supplemented							
Gaining	188	8.6 *a*	3.9	6.3	8.0	10.6	17.9
Holding	219	6.4 *b*	3.0	4.9	5.9	7.4	20.1
Losing	104	5.4 *c*	2.5	4.3	4.9	6.2	12.5
CP (%) – unsupplemented							
Gaining	297	9.2 *a*	3.6	6.8	8.5	11.4	21.1
Holding	279	7.0 *b*	3.4	5.2	6.2	8.2	20.9
Losing	96	5.7 *c*	2.9	4.5	5.2	6.0	15.3
DMD:CP – all cattle							
Gaining	481	7.1 *c*	3.5	5.6	6.9	8.3	15.8
Holding	493	8.6 *b*	2.8	7.1	8.5	10.0	16.6
Losing	195	9.9 *a*	4.1	8.3	9.6	11.6	18.8
DMD:CP – supplemented							
Gaining	185	7.2 *c*	4.0	5.6	7.0	8.7	14.6
Holding	215	8.9 *b*	4.0	7.4	8.8	10.2	16.6
Losing	101	10.1 *a*	4.8	8.2	10.0	11.8	18.8
DMD:CP – unsupplemented							
Gaining	296	7.0 *c*	3.5	5.5	6.9	8.0	15.8
Holding	278	8.4 *b*	2.8	6.9	8.2	10.0	15.0
Losing	94	9.7 *a*	4.1	8.4	9.4	11.1	15.5
NG (%) – all cattle							
Gaining	487	18.8 *b*	0.0	8.0	16.0	27.0	72.0
Holding	499	21.1 *a*	0.0	13.0	20.0	28.0	75.0
Losing	201	21.1 *a*	0.0	12.0	19.0	28.0	66.0
NG (%) – supplemented							
Gaining	187	16.7 *c*	0.0	7.0	15.0	25.0	61.0
Holding	221	20.4 *b*	0.0	14.0	20.0	27.0	75.0
Losing	105	23.1 *a*	0.0	14.0	20.0	31.0	66.0
NG (%) – unsupplemented							
Gaining	300	20.0 a	0.0	9.0	18.0	28.0	72.0

General Observation	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Holding	278	21.6 a	0.0	13.0	20.0	29.0	63.0
Losing	96	18.9 a	2.0	11.0	18.5	25.0	59.0
ADG (kg/hd/d) – all cattle							
Gaining	265	0.71 *a*	-0.80	0.40	0.70	1.00	2.90
Holding	170	0.31 *b*	-0.25	0.08	0.20	0.45	2.00
Losing	47	0.14 *c*	-0.38	-0.09	0.09	0.24	1.40
ADG (kg/hd/d) – supplemented							
Gaining	97	0.66 *a*	-0.20	0.30	0.70	0.90	2.50
Holding	62	0.26 *b*	-0.25	0.10	0.20	0.40	1.60
Losing	13	0.11 *b*	-0.30	-0.11	0.10	0.21	1.10
ADG (kg/hd/d)) –unsupplemented							
Gaining	168	0.74 *a*	-0.80	0.42	0.70	1.00	2.90
Holding	108	0.34 *b*	-0.19	0.07	0.26	0.50	2.00
Losing	34	0.15 *c*	-0.38	-0.05	0.09	0.28	1.40

4.2.3.2.4 Mineral deficiencies

a) Phosphorus

Predicted DMD%, CP% and ADG (kg/ha/d) were significantly higher on country that is not phosphorus (P) deficient, while predicted non-grass % was higher on phosphorus-deficient country (Table 20a). A significant number of land systems in northern Australia that are phosphorus-deficient have a browse component, but also grow forbs during the wet. The proportions of browse and forbs comprising the non-grass component cannot be ascertained.

Table 20a - Effect of P deficiency on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, non-grass (NG%) and average daily gain (ADG kg/hd/d)

P Deficiency	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Deficient	420	53.0 *b*	40.0	48.0	52.0	57.0	74.0
Not Deficient	446	56.0 *a*	40.0	51.0	55.0	59.0	81.0
Unsure	525	56.1 *a*	43.0	52.0	55.0	60.0	75.0
CP (%)							
Deficient	427	6.8 *b*	2.5	4.8	6.1	8.3	16.7
Not Deficient	450	7.7 *a*	2.3	5.4	6.8	9.1	20.9
Unsure	527	7.7 *a*	2.5	5.5	7.0	9.1	21.1
DMD:CP ratio							
Deficient	418	8.7 *a*	4.1	6.7	8.4	10.4	18.8
Not Deficient	446	8.2 *b*	2.8	6.4	7.9	9.5	20.4
Unsure	524	8.1 *b*	3.6	6.4	7.8	9.4	21.6
Non-grass (%)							
Deficient	432	21.3 *a*	0.0	13.0	18.0	27.0	100.0
Not Deficient	446	18.4 *b*	0.0	7.0	16.0	27.0	63.0
Unsure	529	21.5 *a*	0.0	12.0	20.0	29.0	80.0
ADG (kg/hd/d)							
Deficient	413	0.39 *b*	-0.40	0.09	0.30	0.70	2.80
Not Deficient	433	0.50 *a*	-0.30	0.15	0.49	0.80	2.90
Unsure	513	0.50 *a*	-0.80	0.15	0.50	0.80	2.60

b) Sodium

Predicted CP% and DMD:CP ratio were significantly higher in sampling sites where there wasn't an identified sodium (Na) deficiency (Table 20b). There was no significant difference in predicted DMD% between sampling sites that were sodium-deficient and those that were not sodium-deficient. Predicted non-grass % was significantly lower on sites that were not sodium-deficient. Based on the DMD:CP ratio, animals that are running on sodium-deficient (DMD:CP of 8.5) are more likely to respond to nitrogen supplementation, while animals on non-sodium-deficient

(DMD:CP of 7.1) were unlikely to respond to nitrogen supplementation(Table 20b). There was no difference in ADG (kg/hd/d) between deficient and non-sodium-deficient country.

Table 20b - Effect of Na deficiency on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, non-grass (NG%) and average daily gain (ADG kg/hd/d)

Na Deficiency	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Deficient	56	54.0 *b*	40.0	48.0	54.0	59.5	68.0
Not Deficient	810	54.6 *b*	40.0	50.0	54.0	58.0	81.0
Unsure	525	56.1 *a*	43.0	52.0	55.0	60.0	75.0
CP (%)							
Deficient	56	8.3 *a*	4.5	5.8	7.2	10.3	14.5
Not Deficient	821	7.2 *b*	2.3	5.0	6.4	8.5	20.9
Unsure	527	7.7 *a*	2.5	5.5	7.0	9.1	21.1
DMD:CP ratio							
Deficient	56	7.1 *c*	3.9	5.7	7.0	8.4	10.8
Not Deficient	808	8.5 *a*	2.8	6.6	8.3	10.2	20.4
Unsure	524	8.1 *b*	3.6	6.4	7.8	9.4	21.6
Non-grass (%)							
Deficient	56	30.4 *a*	3.0	17.5	27.0	41.5	66.0
Not Deficient	822	19.1 *c*	0.0	10.0	17.0	26.0	100.0
Unsure	529	21.5 *b*	0.0	12.0	20.0	29.0	80.0
ADG (kg/hd/d)							
Deficient	56	0.46 *a*	-0.15	0.10	0.45	0.78	1.50
Not Deficient	790	0.44 *a*	-0.40	0.10	0.40	0.75	2.90
Unsure	513	0.50 *a*	-0.80	0.15	0.50	0.80	2.60

c) Sulphur

Predicted CP% and non-grass % were significantly higher on country that is sulphur-deficient while the DMD:CP ratio was higher on non-deficient country (Table 20c). The non-grass component may be contributing to the high CP% on sulphur-deficient country because basalt country has a high proportion of forbs while on mulga country CP% levels are high from both consumption of mulga leaves as well many of the forbs.

Predicted DMD% and ADG (kg/hd/d) did not differ significantly between sulphur-deficient country and country that was not sulphur-deficient (Table 20c).

Table 20c - Effect of S deficiency on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, non-grass (NG%) and average daily gain (ADG kg/hd/d)

S Deficiency	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Deficient	124	54.5 *b*	40.0	49.0	54.0	60.0	72.0
Not Deficient	742	54.5 *b*	40.0	50.0	54.0	58.0	81.0
Unsure	525	56.1 *a*	43.0	52.0	55.0	60.0	75.0
CP (%)							
Deficient	126	8.1 *a*	2.8	5.4	7.8	10.4	15.7
Not Deficient	751	7.1 *b*	2.3	5.0	6.4	8.3	20.9
Unsure	527	7.7 *a*	2.5	5.5	7.0	9.1	21.1
DMD:CP ratio							
Deficient	124	7.6 *c*	4.1	5.7	7.2	9.2	15.5
Not Deficient	740	8.6 *a*	2.8	6.7	8.3	10.2	20.4
Unsure	524	8.1 *b*	3.6	6.4	7.8	9.4	21.6
Non-grass (%)							
Deficient	126	27.3 *a*	2.0	15.0	25.0	36.0	100.0
Not Deficient	752	18.6 *c*	0.0	10.0	16.0	26.0	75.0
Unsure	529	21.5 *b*	0.0	12.0	20.0	29.0	80.0
ADG (kg/hd/d)							
Deficient	121	0.47 *ab*	-0.30	0.10	0.40	0.81	1.50
Not Deficient	725	0.44 *a*	-0.40	0.10	0.40	0.70	2.90
Unsure	513	0.50 *b*	-0.80	0.15	0.50	0.80	2.60

Phosphorus plus supplementation

There was a positive relationship between producer observations of animal weight gain and predicted ADG (kg/hd/d) on country that was not phosphorus-deficient and cattle were not supplemented, as well as on phosphorus-deficient country regardless of whether they were supplemented or unsupplemented (Table 21a). As producer observations went from cattle losing weight to holding to gaining weight, predicted ADG (kg/hd/d) also increased significantly on phosphorus-deficient country. On country that was not phosphorus-deficient and where cattle were supplemented, there was no significant difference in predicted ADG (kg/hd/d) between cattle that were observed to be losing weight and cattle that were observed to be gaining weight.

Table 21a - Effect of soil P deficiency on the relationship between the observation and the NIRS prediction of average daily gain (ADG kg/hd/d) of cattle with and without supplementation

General observation P status	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
P Deficient							
Supplemented							
Gaining	42	0.71 *a*	0.10	0.50	0.80	1.00	1.20
Holding	93	0.32 *b*	-0.25	0.10	0.20	0.56	1.20
Losing	65	0.10 *c*	-0.40	-0.20	0.10	0.25	1.20
Not P Deficient							
Supplemented							
Gaining	76	0.64 *a*	-0.20	0.30	0.65	0.93	1.50
Holding	41	0.30 *b*	-0.10	0.10	0.25	0.43	1.60
Losing	16	0.10 *b*	-0.20	-0.05	0.03	0.23	0.70
P Deficient							
Not Supplemented							
Gaining	48	0.85 *a*	0.05	0.60	0.80	1.05	2.80
Holding	66	0.32 *b*	-0.19	0.10	0.30	0.51	1.10
Losing	35	0.14 *c*	-0.38	-0.10	0.03	0.30	1.50
Not P Deficient							
Not Supplemented							

Gaining	101	0.77 *a*	0.05	0.50	0.70	1.00	2.90
Holding	95	0.47 *b*	-0.15	0.16	0.40	0.70	2.40
Losing	28	0.27 *c*	-0.30	-0.08	0.20	0.50	1.40

Sodium plus supplementation

On country that was both sodium-deficient and country that was not sodium-deficient, regardless of whether animals were supplemented, there were significant differences in predicted ADG (kg/hd/d) between cattle that were observed to be gaining, holding or losing weight (Table 21b). There was no significant difference in predicted ADG (kg/hd/d) in cattle observed to be either holding or losing weight on sodium-deficient country where they were supplemented. Predicted ADG (kg/hd/d) was actually lower for cattle observed to be holding than cattle observed to be gaining however, the predicted mean ADG for supplemented cattle on sodium-deficient country was 0.30 kg/hd/d. Sampling may have occurred soon after rain when cattle had visually lost weight. However the diet quality would be on the rise and stock may have been gaining weight. NIRS analysis does not take into account feed availability so although diet quality would predict that dry cattle should be gaining weight, feed intake may not be sufficient for animals to meet their maintenance requirements.

Cattle running on country that was not sodium-deficient that were are not supplemented showed significant differences in predicted ADG (kg/hd/d) relative to observed weight gain (Table 21b). Animals that were observed to be losing weight had a significantly lower predicted ADG (kg/hd/d) than animals that were holding, which had a significantly lower predicted ADG (kg/hd/d) than animals that were observed to be gaining weight.

Table 21b - Effect of soil Na deficiency on the relationship between the general observation and the NIRS prediction of average daily gain (ADG kg/hd/d) of cattle with and without supplementation

General observation Na status	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
Na Deficient Supplemented							
Gaining	5	0.80 *a*	0.50	0.50	1.00	1.00	1.00
Holding	13	0.12 *b*	-0.10	0.00	0.04	0.30	0.60
Losing	7	0.30 *b*	-0.15	-0.11	0.40	0.58	0.90
Not Na Deficient Supplemented							
Gaining	113	0.66 *a*	-0.20	0.34	0.70	0.95	1.50
Holding	121	0.33 *b*	-0.25	0.10	0.25	0.50	1.60
Losing	74	0.08 *c*	-0.40	-0.10	0.10	0.20	1.20
Na Deficient Not Supplemented							
Gaining	12	0.58 *b*	0.05	0.20	0.60	0.88	1.20
Holding	13	0.41 *b*	0.02	0.20	0.40	0.63	0.80
Losing	1	1.50 *a*	1.50	1.50	1.50	1.50	1.50
Not Na Deficient Not Supplemented							
Gaining	137	0.81 *a*	0.05	0.50	0.75	1.00	2.90
Holding	148	0.41 *b*	-0.19	0.15	0.30	0.65	2.40
Losing	62	0.18 *c*	-0.38	-0.10	0.10	0.40	1.40

Sulphur plus supplementation

Irrespective of sulphur status of the country, both supplemented or unsupplemented cattle that were observed to be gaining weight had a higher ADG (kg/hd/d) than those that were holding or losing (Table 21c). However cattle that were holding weight did not significantly differ from those that were losing weight in predicted ADG.

For all of the cattle that were observed to be losing weight, the predicted ADG was positive however, again this may be related to timing of sampling with rainfall.

Table 21c - Effect of soil S deficiency on the relationship between the general observation and the NIRS prediction of average daily gain (ADG kg/hd/d) of cattle with and without supplementation

General observation S status	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
S Deficient Supplemented							
Gaining	29	0.58 *a*	0.00	0.19	0.50	1.00	1.40
Holding	13	0.20 *b*	-0.25	-0.03	0.00	0.38	1.10
Losing	10	0.10 *b*	-0.30	-0.30	-0.03	0.50	0.90
Not S Deficient Supplemented							
Gaining	89	0.69 *a*	-0.20	0.50	0.70	0.96	1.50
Holding	121	0.33 *b*	-0.25	0.10	0.25	0.50	1.60
Losing	71	0.10 *c*	-0.40	-0.10	0.10	0.25	1.20
S Deficient Not Supplemented							
Gaining	22	0.68 *a*	0.05	0.30	0.70	1.00	1.30
Holding	26	0.39 *b*	-0.14	0.15	0.30	0.60	1.10
Losing	9	0.29 *b*	-0.30	-0.13	0.00	0.55	1.50
Not S Deficient Not Supplemented							
Gaining	127	0.81 *a*	0.05	0.50	0.75	1.00	2.90
Holding	135	0.41 *b*	-0.19	0.15	0.31	0.65	2.40
Losing	54	0.18 *c*	-0.38	-0.10	0.13	0.40	1.40

4.2.3.3 Grazing management and diet selection

4.2.3.3.1 Grazing system

The comparison of results from the three grazing systems, cells, rotational and continuous, showed there was a consistently lower range, or less variation, from the cell paddocks than from the other two systems for the NIRS parameters digestibility, crude protein and faecal nitrogen (see Appendix E, Fig. 19). This may be due to cell systems being located on more uniform country and with more even pastures, or from the cell system creating this uniform pasture, compared with a wider variation in pastures in the traditionally larger paddocks of rotational and continuous systems.

DMD%

Across all seasons predicted DMD% was significantly higher for rotational grazing than cell and continuous grazing (Table 22a), however, there was greater variation in rotational grazing (see Appendix E, Fig. 19), and quite a number of outliers in the upper quartile for continuous grazing. During dry season, predicted DMD% was significantly higher for rotational grazing compared to continuous grazing, however, DMD% did not differ significantly between cell and continuous grazing, and between cell and rotational grazing. During the wet season, predicted DMD% was significantly higher for rotational grazing, however it did not differ between cell and continuous grazing. This could be explained by the greater capacity for more selective grazing of pasture in the rotational grazing system.

Patch grazing can benefit animal production by improving diet quality and intake from longer access to short patches of high quality feed (Houliston, Ash and Mott 1996 – Table 2, Wilmshurst, Fryxell and Hudson 1995, cited in Ash *et al.* 2003).

CP%

F.NIRS predicted CP% was significantly higher in the rotational grazing system across all seasons (Table 22a), and during both the dry season (Table 22b) and the wet season (Table 22c). Predicted CP% did not differ between cell and continuous grazing during the dry season

(Table 22b), however, it was significantly higher in the continuous grazing system across all seasons (Table 22a) and the wet season (Table 22c).

DMD:CP ratio

Predicted DMD:CP ratio was significantly higher in the cell grazing system than the other two systems across all seasons (Table 22a) and during the wet season (Table 22c), reflecting the lower crude protein values in the cell grazing system, however, it did not differ significantly from continuous grazing during the dry season (Table 22b). 50% of the results in cell grazing had a DMD:CP ratio that was near 10 which indicates that it was unlikely that there would be a response to supplementing nitrogen. In contrast, there were less than 25% of samples for the rotational and continuous grazing systems that were close to a DMD:CP ratio of 10. There were fewer results approaching the ratio of 10 from the three systems in the wet season, but the cell grazing system also had the highest proportion of results above this level.

FN%

The faecal nitrogen values closely followed the crude protein results, with the continuous grazing and cell grazing systems having lowest and the rotation system having the highest values (Table 22a, 22b, 22c). The cells and continuous systems had similar results over all samples, but the continuous was higher during the wet season, again reflecting the capacity for better pasture selection during the growing season in the larger paddocks of the continuous system.

Non-grass %

Across all seasons highest predicted non-grass % occurred in continuous grazing while cell and rotational grazing didn’t differ significantly from each other. This difference was most pronounced in the wet season (Table 22c). In the dry season there was a wider range of non-grass than in the wet season in the cells, and the mean non-grass proportion was higher than in the rotation system during the dry season.

Table 22a - Effect of grazing system on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) across all seasons

Grazing System	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Cell	44	53.9 *b*	46.0	51.5	54.0	57.0	63.0
Rotational	321	56.9 *a*	43.0	51.0	56.0	61.0	81.0
Continuous	1016	54.6 *b*	40.0	51.0	54.0	58.5	75.0
CP (%)							
Cell	44	6.0 *c*	3.8	4.9	5.9	6.8	11.8
Rotational	324	8.7 *a*	2.5	5.7	7.8	11.0	20.1
Continuous	1026	7.1 *b*	2.3	5.1	6.3	8.5	21.1
DMD:CP ratio							
Cell	44	9.4 *a*	5.3	8.1	9.4	10.9	13.2
Rotational	321	7.3 *c*	3.8	5.5	7.1	9.0	19.2
Continuous	1013	8.6 *b*	2.8	6.7	8.3	10.0	21.6
FN (%)							
Cell	44	1.30 *b*	0.79	1.16	1.30	1.40	2.06
Rotational	321	1.49 *a*	0.82	1.21	1.41	1.70	2.55
Continuous	1029	1.36 *b*	0.80	1.13	1.27	1.53	2.74
NG (%)							
Cell	45	15.5 *b*	0.0	6.0	15.0	23.0	45.0
Rotational	321	18.7 *b*	0.0	9.0	15.0	27.0	75.0
Continuous	1031	21.2 *a*	0.0	12.0	20.0	28.0	100.0

Table 22b - Effect of grazing system on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) for dry seasons

Grazing System	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Cell	16	53.2 *ab*	48.0	50.0	53.0	56.0	58.0
Rotational	183	55.4 *a*	43.0	50.0	54.0	59.0	81.0
Continuous	522	52.8 *b*	40.0	50.0	53.0	55.0	75.0
CP (%)							
Cell	16	5.4 *b*	3.9	4.5	5.0	6.3	7.6
Rotational	184	8.3 *a*	2.8	5.3	7.2	10.8	20.1
Continuous	530	6.2 *b*	2.5	4.9	5.8	7.0	21.1
DMD:CP ratio							
Cell	16	10.1 *a*	7.6	8.7	10.0	11.2	12.8
Rotational	183	7.7 *b*	3.8	5.7	7.4	9.4	15.5
Continuous	522	9.2 *a*	2.8	7.8	8.9	10.4	18.8
FN (%)							
Cell	16	1.19 *b*	1.00	1.12	1.18	1.28	1.45
Rotational	183	1.44 *a*	0.82	1.17	1.35	1.61	2.55
Continuous	531	1.24 *b*	0.81	1.10	1.20	1.33	2.48
NG (%)							
Cell	17	17.9 *a*	0.0	5.3	20.0	26.3	45.0
Rotational	183	19.0 *a*	0.0	9.0	15.0	28.0	68.0
Continuous	531	20.7 *a*	0.0	12.0	20.0	28.0	72.0

Table 22c - Effect of grazing system on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) for wet seasons

Grazing System	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
Cell	28	54.4 *b*	46.0	52.0	54.0	57.0	63.0
Rotational	138	58.9 *a*	43.0	55.0	58.0	62.0	80.0
Continuous	494	56.6 *b*	40.0	52.0	57.0	61.0	75.0
CP (%)							
Cell	28	6.4 *c*	3.8	5.1	6.2	6.9	11.8
Rotational	140	9.3 *a*	2.5	7.2	8.8	11.4	17.9
Continuous	496	8.0 *b*	2.3	5.6	7.8	10.1	17.8
DMD:CP ratio							
Cell	28	9.0 *a*	5.3	7.7	9.2	10.5	13.2
Rotational	138	6.9 *c*	4.1	5.4	6.5	7.8	19.2
Continuous	491	7.9 *b*	3.5	5.9	7.3	9.2	21.6
FN (%)							
Cell	28	1.35 *b*	0.79	1.21	1.36	1.45	2.06
Rotational	138	1.56 *a*	0.96	1.31	1.54	1.76	2.47
Continuous	498	1.48 *b*	0.80	1.20	1.46	1.69	2.74
NG (%)							
Cell	28	14.1 *b*	0.0	6.0	14.0	20.0	35.0
Rotational	138	18.3 *b*	0.0	9.0	15.0	25.0	75.0
Continuous	500	21.7 *a*	0.0	11.5	20.0	29.0	100.0

4.2.3.3.2 Diet selection

Diet quality appeared to be affected similarly by forbs and legumes. Predicted DMD%, CP%, faecal N% and non-grass % all increased when there were either forbs or legumes in the diet (Table 23). Browse on the other hand, had the opposite effect with a decrease in the means for CP% and DMD% when browse was present in the diet. However, the population was skewed to the right for CP%, with a large number of outliers (see Appendix E, Fig. 20). This would have been due to the high CP% content in a number of browse species. As expected, the non-grass % increased when forbs or browse were present in the diet (Table 23). There was a large number of outliers at the Upper quartile (see Appendix E, Fig. 20), which is difficult to explain due to the fact that browse cannot be distinguished from C3 forbs in the diet.

Table 23 - Effect of forbs, legumes and browse on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%)

Forbs / Legumes / Browse	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%) – Forbs							
Absent	731	54.6 *b*	40.0	50.0	54.0	58.0	81.0
Present	618	55.8 *a*	40.0	51.0	55.0	60.0	74.0
DMD (%) – Legumes							
Absent	648	54.7 *b*	40.0	51.0	54.0	58.0	75.0
Present	701	55.6 *a*	40.0	51.0	55.0	60.0	81.0
DMD (%) – Browse							
Absent	481	56.9 *a*	40.0	52.0	56.0	61.0	81.0
Present	910	54.2 *b*	40.0	50.0	54.0	58.0	74.0
CP (%) – Forbs							
Absent	738	7.1 *b*	2.3	4.9	6.1	8.6	21.1
Present	624	7.8 *a*	2.9	5.7	7.2	9.3	17.5
CP (%) – Legumes							
Absent	655	6.9 *b*	2.5	5.0	6.3	8.0	17.8
Present	707	7.9 *a*	2.3	5.4	7.1	9.6	21.1
CP (%) – Browse							
Absent	487	8.0 *a*	2.8	5.5	7.1	10.1	21.1
Present	917	7.1 *b*	2.3	5.1	6.4	8.5	20.9
DMD:CP – Forbs							
Absent	729	8.7 *a*	2.8	6.5	8.6	10.4	21.6
Present	617	7.8 *b*	3.8	6.3	7.6	9.2	15.8
DMD:CP – Legumes							
Absent	646	8.7 *a*	3.5	7.0	8.4	10.2	21.6
Present	700	7.9 *b*	2.8	6.0	7.6	9.4	20.4
DMD:CP – Browse							
Absent	480	8.0 *b*	3.6	6.0	7.8	9.5	16.6
Present	908	8.5 *a*	2.8	6.7	8.2	9.9	21.6
FN (%) – Forbs							
Absent	738	1.36 *b*	0.79	1.12	1.28	1.54	2.74
Present	624	1.42 *a*	0.84	1.18	1.35	1.60	2.55
FN (%) – Legumes							
Absent	657	1.32 *b*	0.79	1.11	1.25	1.47	2.40
Present	705	1.45 *a*	0.80	1.19	1.38	1.64	2.74
FN (%) –Browse							
Absent	487	1.45 *a*	0.81	1.17	1.36	1.66	2.55
Present	917	1.35 *b*	0.79	1.14	1.28	1.50	2.74
NG (%) – Forbs							
Absent	740	19.0 *b*	0.0	9.0	17.0	26.0	100.0
Present	625	22.6 *a*	0.0	13.0	21.0	29.3	80.0
NG (%) – Legumes							
Absent	661	20.0 *a*	0.0	10.0	18.0	28.0	100.0
Present	704	21.2 *a*	0.0	12.0	20.0	28.0	72.0
NG (%) – Browse							
Absent	489	17.9 *b*	0.0	9.0	16.0	25.0	80.0
Present	918	21.8 *a*	0.0	12.0	20.0	29.0	100.0

4.2.3.3.3 Pasture damage

All seasons

The effects of the wet and dry seasons were analysed. The groupings for the dry season were May to November and the groupings for the wet season were December to April.

In regions that were susceptible to frost, frost with rain and frost alone appeared to have the biggest impact on pasture damage, as shown by the lower DMD%, CP% and FN% predictions compared with other means of pasture damage, however, predicted CP% for frost and frost and rain did not differ significantly from rain (Table 24a). The timing of sampling and quantity of rainfall will have a big impact on the effect of rainfall on predicted DMD%, CP% and FN%. Often, there is damage immediately following rain, particularly when there is little standing feed and it takes several weeks for diet quality to improve.

DMD:CP ratio was most affected by other means of damage, which generally included prolonged drought (Table 24a).

Predicted non-grass % was lowest when there was frost damage, however, this was not significantly different to damage by frost and rain (Table 24a).

Table 24a - Effect of pasture damage on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) across all seasons

Pasture Damage	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
None	1078	55.4 *a*	40.0	51.0	55.0	59.0	80.0
Rain	50	55.8 *a*	48.0	51.0	54.0	59.0	81.0
Frost	100	51.9 *b*	44.0	49.0	51.0	54.5	69.0
Frost & Rain	29	52.3 *b*	44.0	48.0	53.0	55.0	67.0
Other	92	55.5 *a*	40.0	51.0	55.0	60.0	71.0
CP (%)							
None	1090	7.5 *a*	2.3	5.3	6.9	9.2	21.1
Rain	51	7.2 *ab*	3.6	5.2	6.0	8.8	20.1
Frost	100	6.4 *b*	3.6	5.0	5.6	6.8	20.9
Frost & Rain	29	6.3 *b*	3.3	4.3	5.1	6.8	17.5
Other	92	7.8 *a*	3.2	5.9	7.0	9.7	16.3
DMD:CP							
None	1075	8.2 *bc*	3.5	6.3	7.8	9.7	21.6
Rain	50	8.7 *ab*	4.0	6.5	9.1	10.2	14.7
Frost	100	8.7 *ab*	2.8	7.5	8.9	9.9	13.8
Frost & Rain	29	9.7 *a*	3.8	7.9	9.4	11.7	15.1
Other	92	7.8 *c*	4.1	6.2	7.9	8.9	15.0
FN (%)							
None	1088	1.41 *a*	0.80	1.16	1.34	1.58	2.74
Rain	53	1.33 *ab*	0.79	1.10	1.19	1.51	2.47
Frost	100	1.25 *b*	0.81	1.13	1.21	1.34	2.31
Frost & Rain	29	1.25 *b*	0.91	0.99	1.04	1.30	2.48
Other	92	1.40 *a*	0.92	1.19	1.33	1.60	2.30
NG (%)							
None	807	21.6 *a*	0.0	19.0	21.0	25.0	41.0
Rain	37	21.9 *a*	13.0	18.8	22.0	25.0	36.0
Frost	97	19.0 *b*	0.3	16.8	19.0	21.3	28.0
Frost & Rain	19	20.6 *ab*	15.0	17.0	20.0	24.8	27.0
Other	68	22.1 *a*	0.5	19.0	22.0	25.0	36.0

Dry season
Only predicted DMD% was affected by pasture damage, with frost reducing predicted DMD% more than rain and no damage, but not significantly more than frost and rain and other means of damage (Table 24b).

Table 24b - Effect of pasture damage on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) for dry seasons

Pasture Damage	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
None	524	53.8 *a*	40.0	50.0	53.0	57.0	75.0
Rain	28	54.4 *a*	49.0	51.0	53.0	55.0	81.0
Frost	94	51.8 *b*	44.0	49.0	51.0	54.0	69.0
Frost & Rain	16	52.8 *ab*	46.0	48.0	53.0	54.5	67.0
Other	33	53.5 *ab*	43.0	49.8	52.0	57.3	71.0
CP (%)							
None	532	6.8 *a*	2.5	5.0	6.1	7.6	21.1
Rain	29	6.4 *a*	3.7	5.1	5.6	6.8	20.1
Frost	94	6.4 *a*	3.6	5.0	5.6	6.8	20.9
Frost & Rain	16	6.8 *a*	3.3	4.6	5.3	6.5	17.5
Other	33	7.3 *a*	4.0	5.3	6.4	7.8	16.3
DMD:CP							
None	524	8.8 *a*	3.6	7.2	8.7	10.4	18.8
Rain	28	9.4 *a*	4.0	8.2	9.4	10.3	13.8
Frost	94	8.8 *a*	2.8	7.8	8.9	10.0	13.8
Frost & Rain	16	9.3 *a*	3.8	8.0	9.2	11.3	13.9
Other	33	8.1 *a*	4.4	6.7	8.1	9.0	11.9
FN (%)							
None	531	1.30 *a*	0.82	1.12	1.23	1.40	2.55
Rain	30	1.26 *a*	0.91	1.10	1.19	1.31	2.47
Frost	94	1.24 *a*	0.81	1.11	1.20	1.34	2.31
Frost & Rain	16	1.26 *a*	0.91	1.00	1.03	1.30	2.48
Other	33	1.31 *a*	0.93	1.12	1.25	1.38	1.93
NG (%)							
None	532	20.5 *a*	0.0	11.0	20.0	28.0	68.0
Rain	30	24.3 *a*	2.0	16.0	24.5	34.0	40.0
Frost	94	19.5 *a*	0.0	10.0	18.0	26.0	72.0
Frost & Rain	16	20.8 *a*	2.0	9.5	19.0	23.0	62.0
Other	33	17.1 *a*	2.0	8.0	17.0	26.0	45.0

Wet season
During the wet season, in regions that are susceptible to frost, predicted DMD% and FN% were most significantly affected by frost and rain damage which had the lowest mean predicted DMD% and FN%, however, it was not significantly different to frost damage in the case of DMD% and frost damage and rain damage in the case of FN% (Table 24c).

Predicted CP% was most affected by frost and rain damage ($P \leq 0.10$), however, again, this was not significantly lower than predicted CP% for pasture that had frost damage (Table 24c).

Table 24c - Effect of pasture damage on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) for wet seasons

Pasture Damage	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
None	554	57.0 *a*	40.0	53.0	57.0	61.0	80.0
Rain	22	57.7 *a*	48.0	54.0	56.5	62.0	76.0
Frost	6	52.8 *ab*	48.0	50.0	52.5	57.0	57.0
Frost & Rain	13	51.8 *b*	44.0	47.0	53.0	55.0	65.0
Other	59	56.5 *a*	40.0	53.0	57.0	60.0	71.0
CP (%)							
None	558	8.3 *a†*	2.3	5.8	7.9	10.3	17.9
Rain	22	8.3 *a*	3.6	5.7	8.2	10.8	16.6
Frost	6	8.0 *ab*	4.8	5.9	8.2	10.1	10.6
Frost & Rain	13	5.8 *b*	3.6	4.2	4.4	6.9	13.0
Other	59	8.1 *a*	3.2	6.0	7.7	9.9	15.1
DMD:CP							
None	551	7.7 *b*	3.5	5.9	7.2	8.9	21.6
Rain	22	7.9 *b*	4.6	5.9	6.6	9.5	14.7
Frost	6	7.1 *b*	5.4	5.6	6.6	8.1	10.4
Frost & Rain	13	10.2 *a*	5.0	7.9	10.7	12.5	15.1
Other	59	7.7 *b*	4.1	6.1	7.4	8.9	15.0
FN (%)							
None	557	1.50 *a*	0.80	1.25	1.47	1.70	2.74
Rain	23	1.43 *ab*	0.79	1.05	1.49	1.70	2.20
Frost	6	1.48 *ab*	1.17	1.29	1.49	1.64	1.79
Frost & Rain	13	1.22 *b*	0.92	0.98	1.10	1.37	1.98
Other	59	1.46 *a*	0.92	1.22	1.40	1.65	2.30
NG (%)							
None	559	21.1 *a*	0.0	10.0	19.0	28.0	100.0
Rain	23	21.7 *a*	0.0	13.3	18.0	30.8	59.0
Frost	6	28.3 *a*	11.0	17.0	30.0	38.0	44.0
Frost & Rain	13	21.6 *a*	8.0	15.0	21.0	29.3	35.0
Other	59	18.0 *a*	0.0	9.0	15.0	23.8	88.0

† Pairwise testing performed at P=0.10.

4.2.3.3.4 Pasture species

All seasons

Predicted DMD% was highest when there was sown pasture present although it was not significantly different to forbs and sown legumes (Table 25a). Predicted DMD% was lowest when there was wiregrass in the paddock. Predicted CP% was highest for sown legumes while DMD:CP ratio was lowest with sown legumes. FN% was highest when there were sown legumes, but this was not significantly different to forbs and sown pasture (Table 25a). Predicted non-grass % was highest when forbs and native legumes were in the paddock but this was not significantly different to sown legumes. There would have been instances where some of these species were not recorded on the FDCS as they were only a minor component of the pasture. Their presence could have affected the NIRS results.

Table 25a - Effect of pasture species grouping on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) across all seasons

Pasture species groups	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
3P grasses	711	54.5 *cd*	40.0	51.0	54.0	58.0	75.0
Annuals	84	54.7 *cd*	46.0	51.0	54.0	58.5	66.0
Forbs	8	60.1 *ab*	52.0	54.0	60.0	66.0	69.0
Intermediate	195	53.7 *d*	42.0	50.0	53.0	56.0	67.0
Legumes (native)	33	55.4 *bcd*	50.0	53.0	55.0	57.0	64.0
Legumes (sown)	11	57.9 *abc*	49.0	51.3	57.0	64.0	68.0
Sown pasture	313	57.7 *a*	40.0	52.0	57.0	62.0	81.0
Wiregrass	28	50.3 *e*	41.0	44.0	48.5	55.5	70.0
CP (%)							
3P grasses	720	7.0 *c*	2.3	5.0	6.3	8.5	20.9
Annuals	86	7.1 *c*	3.9	5.3	6.7	8.3	14.5
Forbs	8	7.6 *bc*	5.0	5.8	6.9	9.9	10.9
Intermediate	194	7.0 *c*	3.2	5.3	6.8	8.1	14.1
Legumes (native)	35	6.8 *c*	4.0	5.2	6.0	8.0	13.0
Legumes (sown)	11	11.2 *a*	6.6	7.3	10.9	15.5	17.4
Sown pasture	314	8.7 *b*	3.3	5.8	7.9	10.9	21.1
Wiregrass	28	6.6 *c*	3.0	4.4	5.4	9.5	12.8
DMD:CP							
3P grasses	711	8.6 *a*	2.8	6.7	8.4	10.2	21.6
Annuals	83	8.3 *a*	4.1	7.1	8.0	9.5	13.3
Forbs	8	8.3 *ab*	6.0	6.9	8.4	9.9	10.4
Intermediate	194	8.3 *a*	4.6	6.8	7.9	9.3	16.6
Legumes (native)	33	9.0 *a*	4.8	7.4	9.2	10.4	13.3
Legumes (sown)	11	5.7 *c*	3.9	4.1	5.2	7.2	7.7
Sown pasture	312	7.5 *b*	3.6	5.6	7.2	9.2	15.8
Wiregrass	28	8.8 *a*	5.0	6.2	8.5	10.8	14.2
FN (%)							
3P grasses	720	1.32 *c*	0.79	1.10	1.25	1.49	2.74
Annuals	87	1.39 *c*	0.86	1.18	1.31	1.48	2.37
Forbs	8	1.40 *abc*	1.12	1.26	1.37	1.55	1.70
Intermediate	195	1.35 *c*	0.93	1.19	1.27	1.49	2.29
Legumes (native)	34	1.36 *c*	0.94	1.06	1.24	1.54	2.40
Legumes (sown)	11	1.65 *a*	1.16	1.45	1.55	2.00	2.23
Sown pasture	313	1.53 *ab*	0.80	1.24	1.46	1.76	2.55
Wiregrass	28	1.42 *bc*	0.95	1.19	1.36	1.69	2.02
NG (%)							
3P grasses	718	21.0 *d*	0.0	12.0	20.0	28.0	80.0
Annuals	89	26.0 *b*	5.0	19.0	24.0	31.0	55.0
Forbs	8	36.8 *a*	19.0	29.5	33.0	37.5	75.0
Intermediate	196	20.7 *cd*	0.0	12.5	20.0	27.0	59.0
Legumes (native)	35	33.2 *a*	6.0	25.0	31.0	37.0	63.0
Legumes (sown)	11	31.0 *ab*	6.0	14.3	31.0	45.8	55.0
Sown pasture	314	14.0 *e*	0.0	6.0	11.0	20.0	65.0
Wiregrass	28	25.6 *bc*	5.0	16.0	24.5	33.5	58.0

Dry season

Predicted DMD% was highest from the sown pastures species group (56.1%), however this was not significantly different to native and sown legumes, or forbs. Predicted DMD% was lowest when there was wiregrass in the paddock (45.8%) (Table 25b). Predicted CP% (10.7%) and FN% (1.69%) was highest from sown legume pastures, while DMD:CP ratio was lowest (6.0) with sown legume in the paddock, indicating there was no protein deficiency when these species were present. This contrasts with the DMD:CP ratio of 10.0 with wiregrass dominant pastures, indicating consistent protein deficiency in these pastures in the dry season. Predicted NG% was lowest with sown pastures (15.3%) reflecting the competitive ability of sown grasses, especially buffel grass (*Cenchrus ciliaris*) (Table 25b).

Table 25b - Effect of pasture species grouping on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) for dry seasons

Pasture species groups	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
3P grasses	367	52.9 *c*	40.0	50.0	53.0	56.0	72.0
Annuals	50	53.3 *bc*	46.0	50.0	52.5	56.0	62.0
Forbs	4	58.0 *abc*	52.0	52.0	55.5	64.0	69.0
Intermediate	102	51.4 *d*	43.0	50.0	51.0	53.0	62.0
Legumes (native)	19	54.3 *abc*	50.0	53.0	54.0	55.8	61.0
Legumes (sown)	8	56.8 *ab*	49.0	51.0	53.5	64.0	68.0
Sown pasture	162	56.1 *a*	44.0	50.0	55.0	60.0	81.0
Wiregrass	8	45.8 *e*	41.0	43.5	46.0	47.5	51.0
CP (%)							
3P grasses	372	6.3 *c*	2.5	4.9	5.8	7.3	20.9
Annuals	51	6.3 *c*	3.9	5.0	5.9	7.3	11.4
Forbs	4	6.9 *bc*	5.0	5.1	6.2	8.8	10.3
Intermediate	102	5.9 *c*	3.2	4.9	6.0	6.9	8.9
Legumes (native)	20	6.2 *c*	4.3	5.3	6.0	6.2	11.7
Legumes (sown)	8	10.7 *a*	6.6	7.0	7.8	16.1	17.4
Sown pasture	164	8.3 *b*	3.3	5.2	6.7	11.4	21.1
Wiregrass	8	4.8 *c*	3.0	3.7	5.0	5.7	7.0
DMD:CP							
3P grasses	367	9.1 *a*	2.8	7.5	9.0	10.4	18.8
Annuals	50	9.0 *a*	5.2	7.7	8.8	9.8	13.3
Forbs	4	8.8 *ab*	6.7	7.4	9.1	10.3	10.4
Intermediate	102	9.2 *a*	6.0	7.8	8.7	10.2	16.6
Legumes (native)	19	9.3 *a*	4.9	8.7	9.2	10.0	12.3
Legumes (sown)	8	6.0 *c*	3.9	4.0	6.8	7.3	7.7
Sown pasture	162	7.9 *b*	3.6	5.5	7.8	10.0	15.8
Wiregrass	8	10.0 *a*	7.3	8.1	9.5	11.9	13.7
FN (%)							
3P grasses	373	1.22 *c*	0.82	1.08	1.18	1.32	2.48
Annuals	51	1.28 *c*	0.86	1.16	1.27	1.37	1.73
Forbs	4	1.33 *bc*	1.12	1.14	1.26	1.53	1.70
Intermediate	103	1.22 *c*	1.02	1.15	1.20	1.29	1.61
Legumes (native)	19	1.25 *c*	0.99	1.13	1.24	1.31	1.77
Legumes (sown)	8	1.69 *a*	1.20	1.45	1.52	2.06	2.23
Sown pasture	163	1.47 *b*	0.81	1.18	1.37	1.67	2.55
Wiregrass	8	1.33 *bc*	1.17	1.22	1.27	1.46	1.56
NG (%)							
3P grasses	371	21.0 *bc*	0.0	12.0	20.0	28.0	72.0
Annuals	52	26.1 *a*	8.0	19.0	24.5	30.5	55.0
Forbs	4	32.5 *ab*	29.0	29.5	31.5	35.5	38.0
Intermediate	103	18.4 *c*	0.0	11.0	18.0	25.0	45.0
Legumes (native)	20	30.5 *a*	6.0	25.0	30.5	36.5	57.0
Legumes (sown)	8	24.0 *abc*	6.0	10.0	22.5	38.0	45.0
Sown pasture	164	15.3 *d*	0.0	6.0	12.0	22.0	62.0
Wiregrass	8	25.3 *abc*	15.0	18.0	23.5	31.5	41.0

Wet season

Predicted DMD% was highest from forb dominant pastures (62.3%), although not significantly higher than the sown pastures or the native and sown legume pastures in the wet season (Table 25c). Mean DMD% was lowest for wiregrass pastures (52.2%). Predicted CP% was highest for sown legumes (12.4%), however this was not significantly different to sown pasture or forb dominant pastures. Sown legume pastures had the lowest DMD:CP ratio (4.9). 3P grasses (1.43%) and Intermediate species had the lowest predicted FN%. Predicted NG% was highest for sown legumes (49.7%), native legumes and forbs, while it was lowest for sown pastures (12.7%) in the wet season.

Table 25c - Effect of pasture species grouping on NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), DMD:CP ratio, faecal nitrogen (FN%) and non-grass (NG%) for wet seasons

Pasture species groups	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)							
3P grasses	344	56.3 *b*	40.0	52.0	56.0	61.0	75.0
Annuals	34	56.8 *b*	49.0	52.0	58.0	61.0	66.0
Forbs	4	62.3 *ab*	56.0	58.5	63.0	66.0	67.0
Intermediate	93	56.1 *b*	42.0	52.0	56.0	59.5	67.0
Legumes (native)	14	56.9 *ab*	51.0	54.0	56.0	60.0	64.0
Legumes (sown)	3	61.0 *ab*	57.0	58.3	62.0	63.5	64.0
Sown pasture	151	59.3 *a*	40.0	55.0	59.0	63.8	80.0
Wiregrass	20	52.2 *c*	42.0	46.0	50.0	59.0	70.0
CP (%)							
3P grasses	348	7.8 *c*	2.3	5.5	7.4	10.0	17.8
Annuals	35	8.3 *bc*	3.9	6.0	7.6	10.4	14.5
Forbs	4	8.3 *abc*	6.4	6.4	8.0	10.2	10.9
Intermediate	92	8.2 *c*	3.3	6.8	8.1	9.4	14.1
Legumes (native)	15	7.5 *c*	4.0	5.0	7.9	9.0	13.0
Legumes (sown)	3	12.4 *a*	10.9	11.3	12.6	13.5	13.8
Sown pasture	150	9.2 *ab*	3.5	6.5	8.7	10.9	17.9
Wiregrass	20	7.3 *c*	3.1	4.7	5.7	10.8	12.8
DMD:CP							
3P grasses	344	8.1 *a*	3.5	5.9	7.6	9.4	21.6
Annuals	33	7.3 *abc*	4.1	5.7	7.5	8.3	12.6
Forbs	4	7.8 *abc*	6.0	6.5	7.9	9.1	9.5
Intermediate	92	7.3 *bc*	4.6	6.0	7.1	8.0	15.2
Legumes (native)	14	8.7 *a*	4.8	6.6	7.5	11.2	13.3
Legumes (sown)	3	4.9 *c*	4.6	4.7	4.9	5.2	5.2
Sown pasture	150	7.1 *c*	4.1	5.7	6.7	8.1	14.6
Wiregrass	20	8.3 *ab*	5.0	5.5	8.2	10.7	14.2
FN (%)							
3P grasses	347	1.43 *b*	0.79	1.15	1.42	1.64	2.74
Annuals	36	1.54 *ab*	0.98	1.30	1.46	1.80	2.37
Forbs	4	1.46 *ab*	1.37	1.37	1.40	1.55	1.67
Intermediate	92	1.50 *b*	0.93	1.27	1.49	1.68	2.29
Legumes (native)	15	1.49 *ab*	0.94	1.02	1.48	1.96	2.40
Legumes (sown)	3	1.55 *ab*	1.16	1.29	1.66	1.79	1.83
Sown pasture	150	1.60 *a*	0.80	1.35	1.58	1.80	2.47
Wiregrass	20	1.46 *ab*	0.95	1.14	1.40	1.79	2.02
NG (%)							
3P grasses	347	20.9 *c*	0.0	12.0	19.0	28.0	80.0
Annuals	37	26.0 *b*	5.0	18.5	23.0	34.3	52.0
Forbs	4	41.0 *a*	19.0	26.0	35.0	56.0	75.0
Intermediate	93	23.3 *bc*	0.0	15.0	24.0	30.0	59.0
Legumes (native)	15	36.7 *a*	20.0	23.5	34.0	52.5	63.0
Legumes (sown)	3	49.7 *a*	46.0	46.5	48.0	53.3	55.0
Sown pasture	150	12.7 *d*	0.0	5.0	10.0	17.0	65.0
Wiregrass	20	25.8 *bc*	5.0	15.0	25.0	33.5	58.0

4.2.3.3.5 Species grouping and land system

Aristida/Bothriochloa

Predicted DMD% was highest when there were annuals in the paddock (57.2%), but it was not significantly different to sown pasture (Table 26). Predicted DMD% was lowest in wiregrass pastures (50.4%), but this was not significantly different to 3P grass dominant pastures. Forb dominant pastures had the highest CP levels (9.5%), while there were no differences in predicted CP% between the other species groups.

Bluegrass downs

There was significant difference in predicted DMD% between the pasture species groups on Bluegrass downs with highest levels of 57.9% in sown legume pastures (Table 26). Predicted CP% was highest where there were sown legumes in the paddock (11.2%), but this was not significantly different to where there was sown pasture in the diet. Wiregrass was not dominant in any of the Bluegrass downs sites.

Mitchell grass

Predicted DMD% was highest where forbs (58.5%) were dominant in the pastures and where 3P grasses, Mitchell grass (56.1%) was dominant (Table 26). Predicted CP% was highest where there was sown pasture (12.1%) in the paddock. There was significant difference in CP between the other pasture species groups.

Table 26 - Effect of pasture species grouping on NIRS predictions of dry matter digestibility (DMD%) and crude protein (CP%) for Aristida/Bothriochloa, Bluegrass downs and Mitchell grass land systems

Pasture species groups	N	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%)–Aristida/Bothriochloa							
3P grasses	85	51.3 *bc*	40.0	47.0	52.0	55.0	64.0
Annuals	17	57.2 *a*	48.0	52.3	59.0	61.3	66.0
Forbs							
Intermediate	122	53.8 *b*	42.0	51.0	53.0	57.0	67.0
Legumes (native)							
Legumes (sown)							
Sown pasture	46	54.4 *ab*	46.0	50.0	54.0	59.0	70.0
Wiregrass	27	50.4 *c*	41.0	44.0	49.0	56.8	70.0
CP (%)–Aristida/Bothriochloa							
3P grasses	85	6.5 *b*	2.9	4.9	5.8	7.8	12.9
Annuals	17	9.5 *a*	3.9	6.8	9.3	11.9	14.5
Forbs							
Intermediate	122	7.4 *b*	4.0	6.0	7.1	8.4	13.4
Legumes (native)							
Legumes (sown)							
Sown pasture	46	6.6 *b*	3.5	5.3	6.0	7.3	13.9
Wiregrass	27	6.6 *b*	3.0	4.3	5.3	9.6	12.8
DMD (%)–Bluegrass downs							
3P grasses	98	55.5 *a*	44.0	51.0	56.0	59.0	71.0
Annuals	4	56.8 *a*	53.0	53.5	55.5	60.0	63.0
Forbs	3	54.3 *a*	52.0	52.0	52.0	57.3	59.0
Intermediate	14	54.4 *a*	48.0	52.0	53.0	57.0	66.0
Legumes (native)	19	56.2 *a*	51.0	53.0	55.0	59.8	64.0
Legumes (sown)	11	57.9 *a*	49.0	51.3	57.0	64.0	68.0
Sown pasture	19	56.3 *a*	45.0	50.5	55.0	62.8	75.0
Wiregrass							
CP (%)–Bluegrass downs							
3P grasses	99	7.3 *c*	2.3	5.1	6.8	9.2	14.6
Annuals	4	7.7 *bc*	4.9	5.8	7.1	9.7	11.8
Forbs	3	5.8 *bc*	5.0	5.0	5.1	6.8	7.3
Intermediate	14	6.1 *c*	3.2	4.1	4.9	7.7	14.1
Legumes (native)	21	7.7 *bc*	4.3	5.9	6.4	9.6	13.0
Legumes (sown)	11	11.2 *a*	6.6	7.3	10.9	15.5	17.4
Sown pasture	19	9.6 *ab*	4.1	6.9	8.0	12.9	21.1
Wiregrass							
DMD (%)–Mitchell grass							
3P grasses	312	56.1 *a*	40.0	53.0	55.0	59.0	72.0
Annuals	63	54.0 *b*	46.0	50.3	53.0	57.0	65.0
Forbs	2	58.5 *ab*	56.0	56.0	58.5	61.0	61.0
Intermediate	21	54.6 *ab*	47.0	50.0	53.0	59.5	65.0
Legumes (native)	14	54.4 *ab*	50.0	54.0	55.0	56.0	57.0
Legumes (sown)							
Sown pasture	2	60.5 *ab*	58.0	58.0	60.5	63.0	63.0
Wiregrass							
CP (%)–Mitchell grass							
3P grasses	317	7.1 *b*	2.5	5.1	6.3	8.3	20.9
Annuals	65	6.4 *b*	3.9	5.1	6.0	7.5	12.0
Forbs	2	6.4 *b*	6.4	6.4	6.4	6.4	6.4
Intermediate	21	7.2 *b*	4.4	5.2	6.2	8.6	12.0
Legumes (native)	14	5.4 *b*	4.0	4.7	5.2	5.9	7.9
Legumes (sown)							
Sown pasture	2	12.1 *a*	7.6	7.6	12.1	16.6	16.6
Wiregrass							

4.2.3.3.6 Browse species palatability

There was no difference in DMD% predictions between low palatability and high palatability browse species in the dry season (51.6%) or the wet season (53.2%) (Table 27). A list of high and low palatability browse species is shown in Appendix C, Table 8.

Predicted CP% was significantly higher in the dry season for samples where there were high palatability browse species present (6.7%) than from low palatability browse species (5.8%). There was no significant difference during the wet season (6.9% CP from low palatability browse). During the dry season, the distribution for CP% prediction for samples with high palatability browse was skewed (see Appendix E, Fig. 24). A number of browse species have high CP%, however, it is usually associated with a low digestibility. The protein level for some of these species will be similar during both the wet or dry seasons.

The NIRS predictions for non-grass % for samples with high palatability browse species were significantly higher (24.6%) than those for low palatability browse during the dry season (16.2%) (Table 27), however, they were not significantly different during the wet season (22.5% for high palatability species). During the dry season the NG% would be from the browse species, while during the wet season the NG is more likely to be from forb species.

Table 27 - Effect of palatability of browse species on the NIRS predictions of dry matter digestibility (DMD%), crude protein (CP%), non-grass (NG%) and average daily gain (ADG kg/hd/d) for the dry and wet seasons

Palatability of browse	n	Mean	Min	Lower quartile	Median	Upper quartile	Max
DMD (%) – dry season							
Low palatability	67	50.9 *A*	43.0	49.0	51.0	53.0	60.0
High palatability	31	51.6 *A*	45.0	49.0	52.0	54.0	61.0
DMD (%) – wet season							
Low palatability	24	53.2 *A*	48.0	50.5	52.5	54.5	62.0
High palatability	11	52.0 *A*	44.0	49.0	50.0	56.5	62.0
CP (%) – dry season							
Low palatability	67	5.8 *B*	3.5	4.9	5.7	6.6	9.2
High palatability	31	6.7 *A*	4.3	4.9	5.3	7.2	20.9
CP (%) – wet season							
Low palatability	24	6.9 *A*	3.5	5.7	6.9	8.1	10.7
High palatability	11	6.1 *A*	3.4	4.7	6.2	7.1	9.4
NG (%) – dry season							
Low palatability	67	16.2 *B*	0.0	9.0	15.0	20.8	41.0
High palatability	31	24.6 *A*	0.0	18.0	23.0	30.0	68.0
NG (%) – wet season							
Low palatability	24	21.7 *A*	2.0	12.5	22.0	27.0	54.0
High palatability	11	22.5 *A*	5.0	15.5	19.0	30.0	41.0
ADG (kg/hd/d) – dry season							
Low palatability	64	0.25 *A*	-0.40	0.04	0.30	0.50	0.70
High palatability	31	0.30 *A*	0.00	0.10	0.15	0.25	2.40
ADG (kg/hd/d) – wet season							
Low palatability	24	0.51 *A*	-0.05	0.35	0.52	0.70	0.83
High palatability	9	0.72 *A*	-0.10	0.26	0.50	0.98	2.60

4.3 Relationships between NIRS variables

Relationships between F.NIRS results were plotted and analysed by regression analysis to determine if there were any consistent correlations.

4.3.1 Predicted crude protein to dry matter digestibility relationship

There is a moderately positive relationship between NIRS predicted CP% and DMD%. Figure 1 shows the plotted CP and DMD data with the fitted linear regression line. The R^2 indicates that 64.5% variation in CP% about the mean is explained by variations in DMD%.

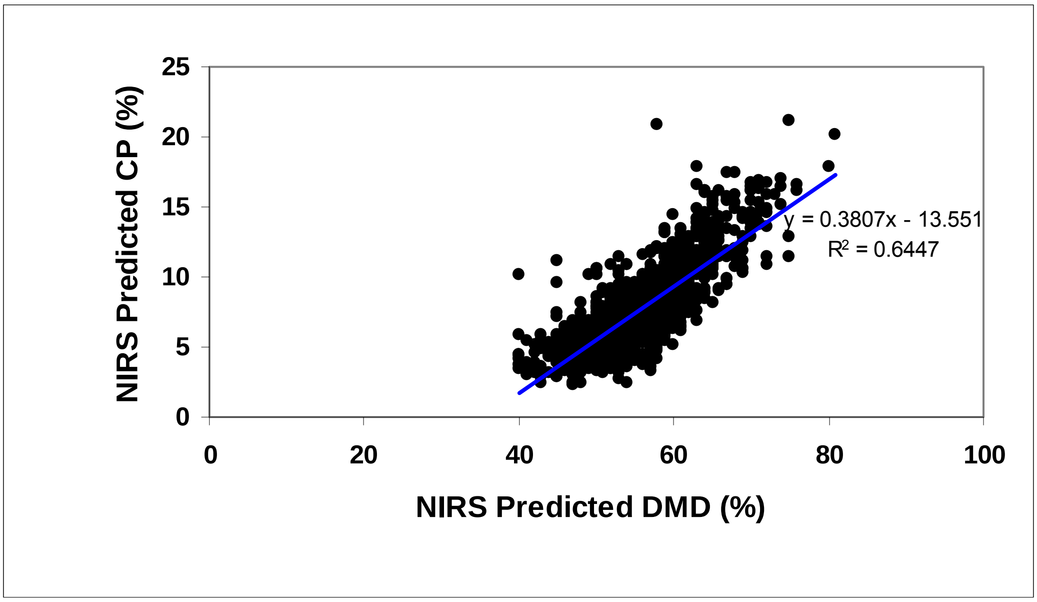


Figure 1 - Relationship between NIRS predicted dry matter digestibility (DMD%) and predicted crude protein (CP%) with the fitted linear regression line

4.3.2 Predicted non-grass to dry matter digestibility relationship

There was no correlation with NIRS predicted non-grass % and DMD%. Figure 2 shows the plotted data and fitted linear regression and the R^2, which indicates negligible variation (0.37%) in non-grass values about the mean is explained by variations in NIRS predicted DMD%.

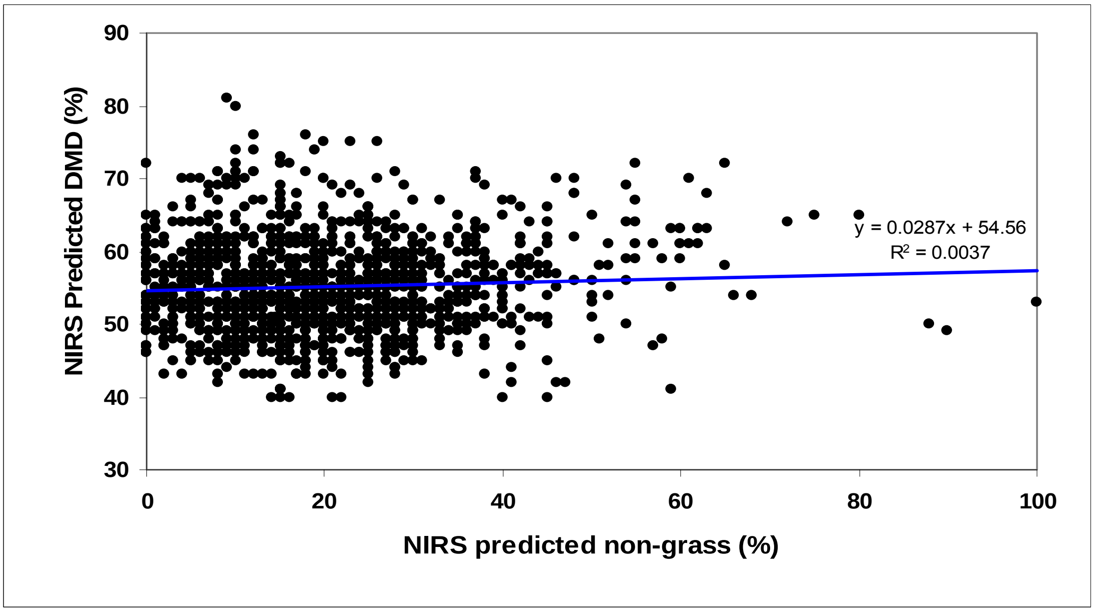


Figure 2 - Relationship between NIRS predicted non-grass % and predicted dry matter digestibility (DMD%)

4.3.3 Predicted non-grass to crude protein relationship

There is negligible correlation (R2=0.032) between NIRS predicted non-grass % and predicted dietary crude protein (CP%) (Figure 3).

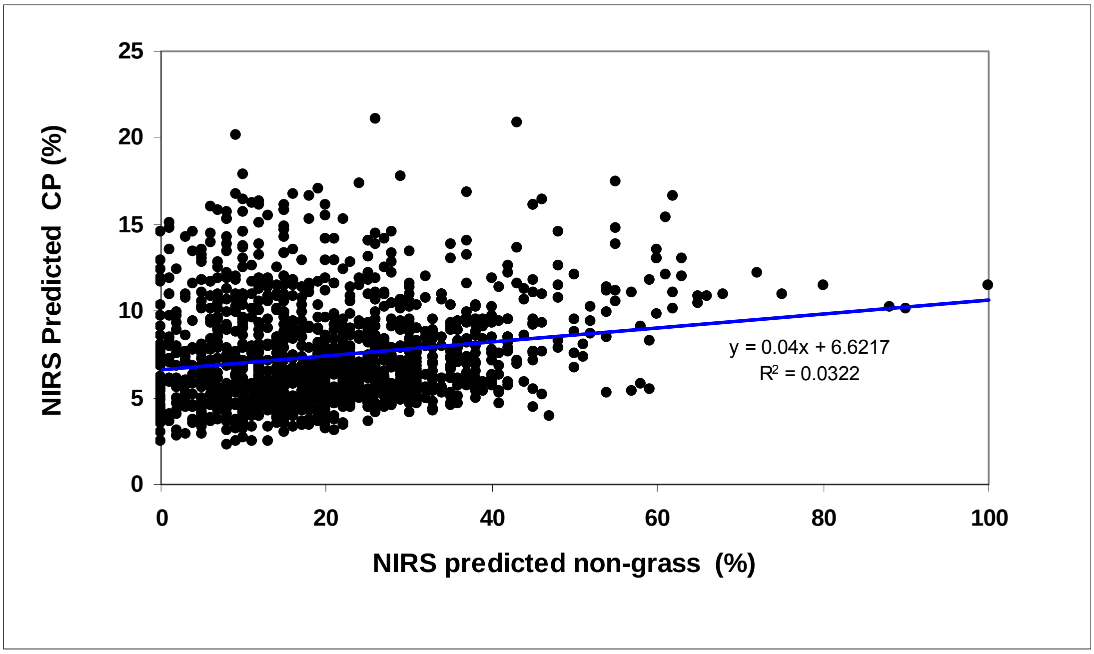


Figure 3 - Relationship between NIRS predicted non-grass % to predicted crude protein (CP%)

4.3.4 Predicted non-grass % to average daily liveweight gain relationship

There is no relationship between NIRS predicted non-grass % and predicted average daily liveweight gain (ADG kg/hd/d) of dry cattle (Figure 4).

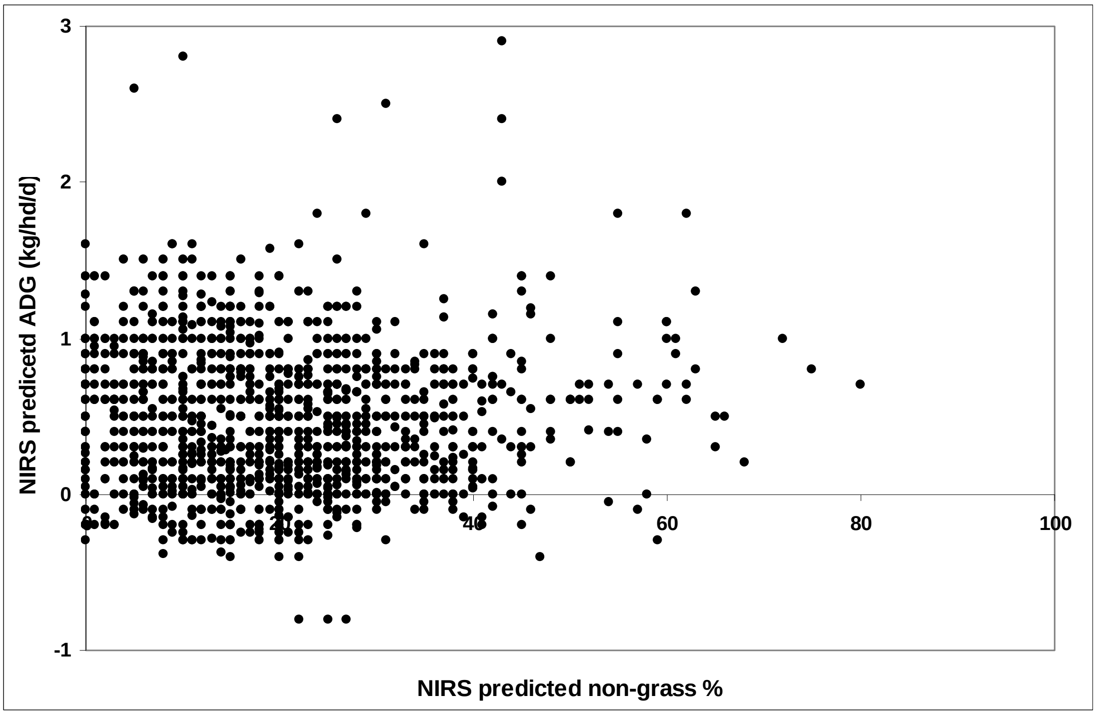


Figure 4 - Relationship between the NIRS predicted non-grass % and the predicted average daily liveweight gain (ADG kg/hd/d)

5 Success in achieving objectives

5.1 Develop a system of regional 'specialists' to assist in the uptake and understanding of NIRS technology

This included the development and delivery of a workshop for regional specialists and included:

- role of faecal NIRS;
- interpretation of results;
- monitoring animal performance;
- diet composition/selection;
- practical supplementation; and
- land types/pasture composition identification and monitoring;

The project team received initial training at the start of the project on the development of the NIRS technology and how it has been adapted to tropical pastures. A framework for the field data collection sheet, and a database to collate the information, were developed.
Further training was provided on the interpretation of the results.

The project team consisted of:

- Désirée Jackson, Project leader and NIRS Regional Specialist, QPIF Longreach
- David Smith, NIRS Regional Specialist, QPIF Charters Towers
- Trevor Hall, NIRS Regional Specialist, QPIF Toowoomba
- Bernadette Lyttle, NIRS Regional Specialist, QPIF Barcaldine
- Felicity Hamlyn-Hill, NIRS Regional Specialist, QPIF Charters Towers
- Russ Tyler, NIRS Regional Specialist, QPIF Gayndah

- Ross Dodt, NIRS Regional Specialist, QPIF Mackay
- Michael Jeffery, NIRS Regional Specialist, QPIF Charleville
- Alistair Brown, project survey Co-ordination, QPIF Roma
- David Reid, Biometrician, QPIF Rockhampton

5.1.1 Role of faecal NIRS

The role of the regional specialists was to provide producers with technical advice on the F.NIRS technology, to interpret and report on results, and to raise awareness of the technology to producers not directly involved in the project.

This was achieved through the introduction of the NIRS technology at numerous BeefUp and Meat Profit Day forums, field days, and meetings with established producer groups (Appendix I).

In addition, further understanding of the NIRS technology was able to be obtained by attending a Nutrition EDGE workshop. At this workshop, producers developed skills that enhanced their understanding of NIRS through training in pasture quality assessment, understanding the relationships between protein, energy and phosphorus, animal nutrient requirements and appropriate feeding strategies.

Three NIRS Fact sheets were developed to:

- Explain the NIRS technology (Appendix B-1);
- Provide instructions on the collection of samples for NIRS analysis (Appendix B-1);
- Provide instructions on sun-drying faecal samples for NIRS analysis (Appendix B-1).

QPIF NIRS fact sheets were available to those producers who wished to gain more of an understanding of the technology.

The use of faecal NIRS technology in conjunction with phosphorus analysis using wet chemistry will be incorporated into the production of the new books on phosphorus management of cattle in northern Australia, and weaner management.

5.1.2 Interpretation of results

The project team received initial training from David Coates (CSIRO) on the NIRS technology and interpretation of results. Initially, the project team relayed results back to producer co-operators then took on the role of interpretation of the results in consultation with David Coates.

There was ongoing training with David Coates (CSIRO) and Rob Dixon (QPIF) on interpreting NIRS results as new research updates on the development of the NIRS technology became available.

A number of project team members continued with the role of interpreting results when the NIRS technology went commercial, just prior to Symbio Alliance taking on the faecal NIRS analysis and reporting service. These NIRS specialists included:

- Désirée Jackson, Longreach
- Dave Smith, Charters towers
- Trevor Hall, Roma
- Russ Tyler, Gayndah
- Felicity Hamlyn-Hill, Charters Towers

The F.NIRS technology was commercialized in 2006. Symbio Alliance currently provides a commercial faecal NIRS service including an interpretation and reporting service. Alternatively, producers can get their NIRS analyses done through Symbio Alliance and seek an interpretation and report through private providers.

5.1.3 Field data collection sheet

The background information provided by producers on their pastures, cattle and management was critical to the interpretation of the NIRS results. Animal weights, condition score, stage of production and an assessment of whether producers thought their cattle were gaining, holding or losing weight, were recorded for each faecal sample collected (Appendix B-1). Producers were encouraged to sample regularly to monitor changes in diet quality and how these related to changes in animal productivity, condition score and whether they were losing or gaining weight.

Producers were urged to take digital photographs of the pasture and cattle that were representative of the paddock that the faecal samples were collected from. This provided a photo record of changing trends in pasture and cattle condition and productivity that could be related back to information recorded on the field data collection sheet and changes in diet quality.

There was a strong commitment by producers to get NIRS analyses done at critical times (eg. to determine whether a urea-based lick was required or when animals visually started showing rapid weight loss). It was difficult to increase the adoption of regular diet quality monitoring every 6-8 weeks. Only a small proportion of producer co-operators in the project valued the effectiveness of ongoing monitoring to gauge changes in diet quality. Regular monitoring allows for early recognition of the need to make adjustments to management such as upgrading from nitrogen-based supplements to energy-based supplements, sale of stock prior to onset of weight loss, paddock movements, etc.

5.1.4 Diet composition

It was critical that producers provided a comprehensive list of pasture species and that the NIRS specialist had a good local knowledge of the land systems, to interpret the results, particularly if there was a large non-grass component in the diet.

On some land systems, there was very little herbage in the diet, so the non-grass component was largely comprised of browse. On other land systems where productivity on pastures was relatively good and there was little browse, the non-grass component was likely to be primarily herbage, and the diet quality was higher. In paddocks where there were mixed land systems of productive country and more marginal country, it was more difficult to determine whether the non-grass component was comprised of browse or herbage.

During the wet season on land systems that tend to grow herbage, the non-grass component was comprised of a large proportion of herbage and this was reflected in the high diet quality. As the season deteriorated, the level of herbage in the overall diet declined and this was evident in the decline in diet quality. There may also have been a lower non-grass level in the diet, unless there were browse species in the paddock and there was a simultaneous increase in consumption of browse.

5.1.5 Practical supplementation

The interpretation of diet quality results from NIRS analyses included a recommendation on whether there was likely be a response by the cattle from supplementing with nitrogen and to identify critical changes in diet quality such as when an animal went from being nitrogen-deficient to being energy-deficient.

The crude protein (CP) prediction, faecal nitrogen level and DMD:CP (dry matter digestibility:crude protein) ratio that was calculated from predicted dietary crude protein and digestibility were used to determine whether there was likely to be a response from supplementing cattle with nitrogen alone (eg. urea-based lick).

The balance between energy and protein calculated in the NIRS report was expressed as a DMD:CP (dry matter digestibility:crude protein) ratio. From the DMD:CP ratio, it was determined whether protein and energy were balanced and whether there was likely to be a response to supplementation with nitrogen. The predicted digestibility analysis was used to make a recommendation on whether cattle needed to be upgraded to an energy supplement, depending on what class of stock and stage of production they were at, taking into account other management considerations.

In addition, phosphorus analyses by wet chemistry were carried out in conjunction with the NIRS analysis and the phosphorus:nitrogen (P:N) ratio was calculated to determine whether phosphorus and nitrogen were in balance and whether a phosphorus supplement was required.

The project team members who were trained in NIRS interpretation had to familiarize themselves with the limitations of the NIRS technology on various land systems as interpretation of NIRS results for these land systems was less straight forward as outlined in 5.1.4. Diets that had a high browse content, or a mixture of both very nutritious herbage and less nutritious browse were more difficult to interpret. This required the NIRS specialist to have a good local knowledge of the land systems and producers to provide a comprehensive list of the browse and forb species on the submission form submitted with their faecal sample.

The limitations of the technology on some land systems were identified in the NIRS reports sent out to producers, particularly where there was a high C3 component, such as herbage, but particularly browse.

5.1.6 Land types/pasture composition identification and monitoring

There were 119 land types identified in the project on the properties involved in monitoring. These were grouped into 11 land systems. Producers received descriptions of the land systems, to determine which land systems were on their property.

Producers were provided with photo standards to make estimates of pasture yields. It is imperative that recommendations on supplementation take into account the amount of available pasture, to ensure that it is not going to limit production.

Field data collection sheets required information on grass and non-grass species, leaf:stem ratios and % green leaf. Those producers who attended a Nutrition EDGE workshop were skilled enough to complete these sections relatively easily.

This level of detail on pasture vastly improved the quality of the NIRS interpretation however, it was difficult to emphasize to producers the importance of providing comprehensive information on the submission form to ensure a quality interpretation of the NIRS results.

5.2 Develop communication networks among 'regional specialists' and those involved in the research aspects of the project

The project team met initially to receive training on the NIRS technology. The team also developed:

a.) a framework for NIRS monitoring on commercial properties across a range of land systems;

b.) a field data collection sheet for recording information that was vital to the interpretation of the NIRS results;

c.) NIRS technical information including the NIRS Producer booklet, NIRS Fact Sheets and the quarterly NIRS Co-operator Report.

The team had regular teleconferences and subsequent biannual meetings to:

a.) receive further training on interpretation and reporting of NIRS results;

b.) receive updates on the outcomes from the NIRS Task 1 and Task 2 project leaders;

c.) develop a framework for analysing the information and to plan extension activities to raise awareness and facilitate adoption of the F.NIRS technology.

The regional specialists were trained on the general principles of the NIRS technology. Regional specialists continue to assist with raising the level of awareness of the NIRS technology to producers. They also provide producers with NIRS Fact Sheets to assist with collecting and submitting faecal samples for NIRS analysis.

Those project team members who were trained in interpretation of NIRS results currently are available to provide producers with further comments on NIRS results and reports generated by the commercial provider, Symbio Alliance, and to assist producers with management decisions on supplementary feeding programs and other management decisions that address the deficiencies identified in the NIRS report.

5.3 Produce 'district' guidelines on the use of NIRS by land type and pasture community

Producers are supplied with an interpretation of their NIRS results as part of the current NIRS service provided by Symbio Alliance or alternatively they can seek a report from private providers. Producers who wish to seek further assistance with their NIRS report can contact their NIRS regional specialist in QPIF whom they can also get advice on appropriate supplementation programs or other pertinent advice such as selling and weaning.

131 producers representing 15 land systems across Queensland and seven land systems across the Northern Territory submitted faecal samples for F.NIRS analysis during the project. Data from 114 properties on 85 land types was grouped into 13 major land systems for statistical analysis. The seven regions monitored exceeded the five regions originally planned for the project. The trends in F.NIRS predictions as they related to pasture, animal, soil and rainfall parameters were identified, as were the limitations of F.NIRS on some of the land systems, in particular those with a high non-grass component from browse and forbs.

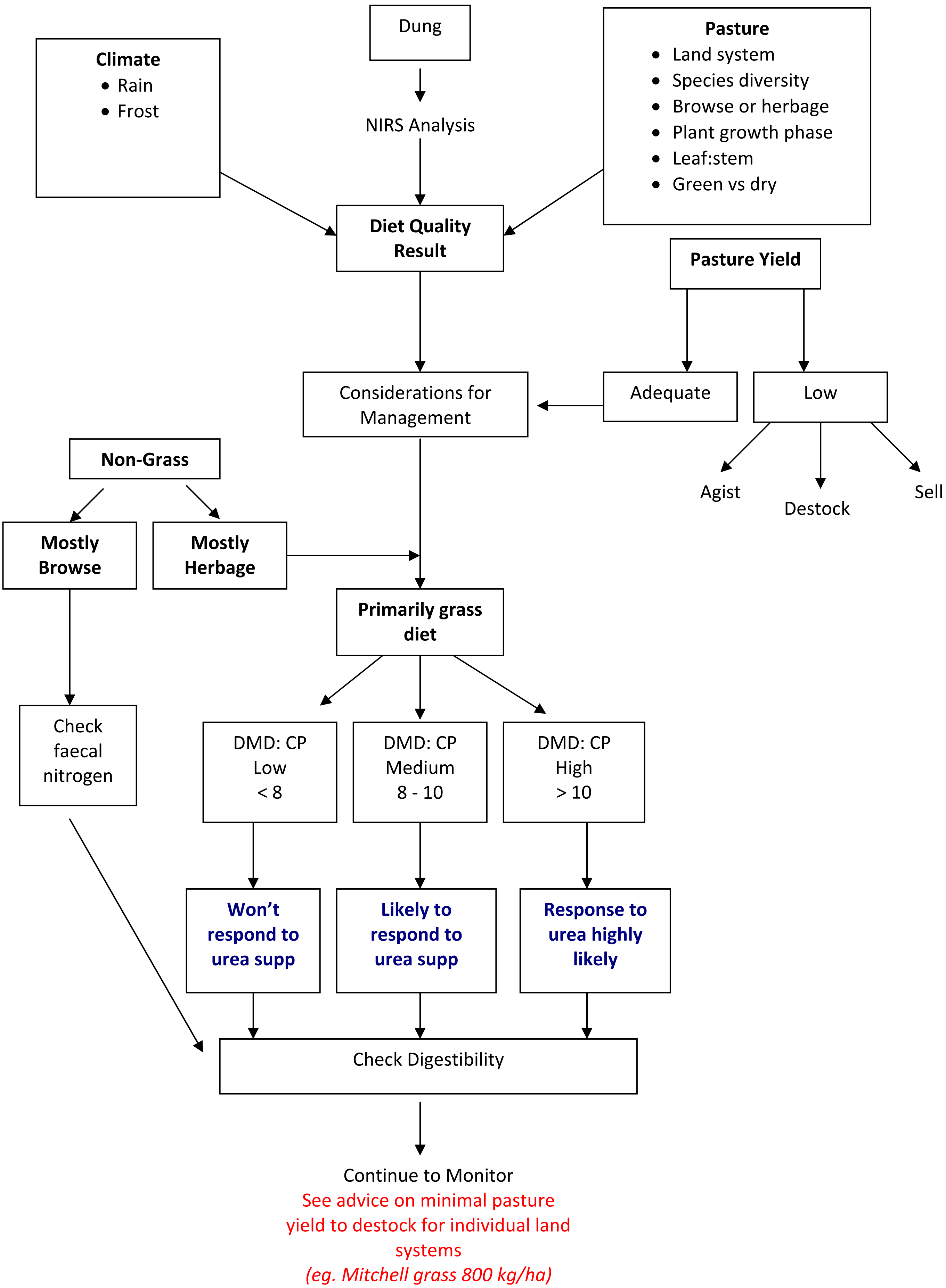
The various pasture, animal and seasonal effects on diet quality were analysed for each land system. The ranges and means for the diet quality variables for each of the major land systems are summarised in Appendix D.

There were only general trends identified for diet quality within each of the land systems, relating to rainfall, frost, season, pasture dynamics and grazing management. Consequently, the interpretation of the results is influenced by land system and pasture composition, particularly the C3 plants such as herbage and browse, as well as other pasture and animal factors, and current management. Consequently, specific guidelines for each district could not be developed. For example, two sets of results may report the same level of non-grass however, these will have very different implications for management if the non-grass component for one set of results is high in browse and the other is high in herbage.

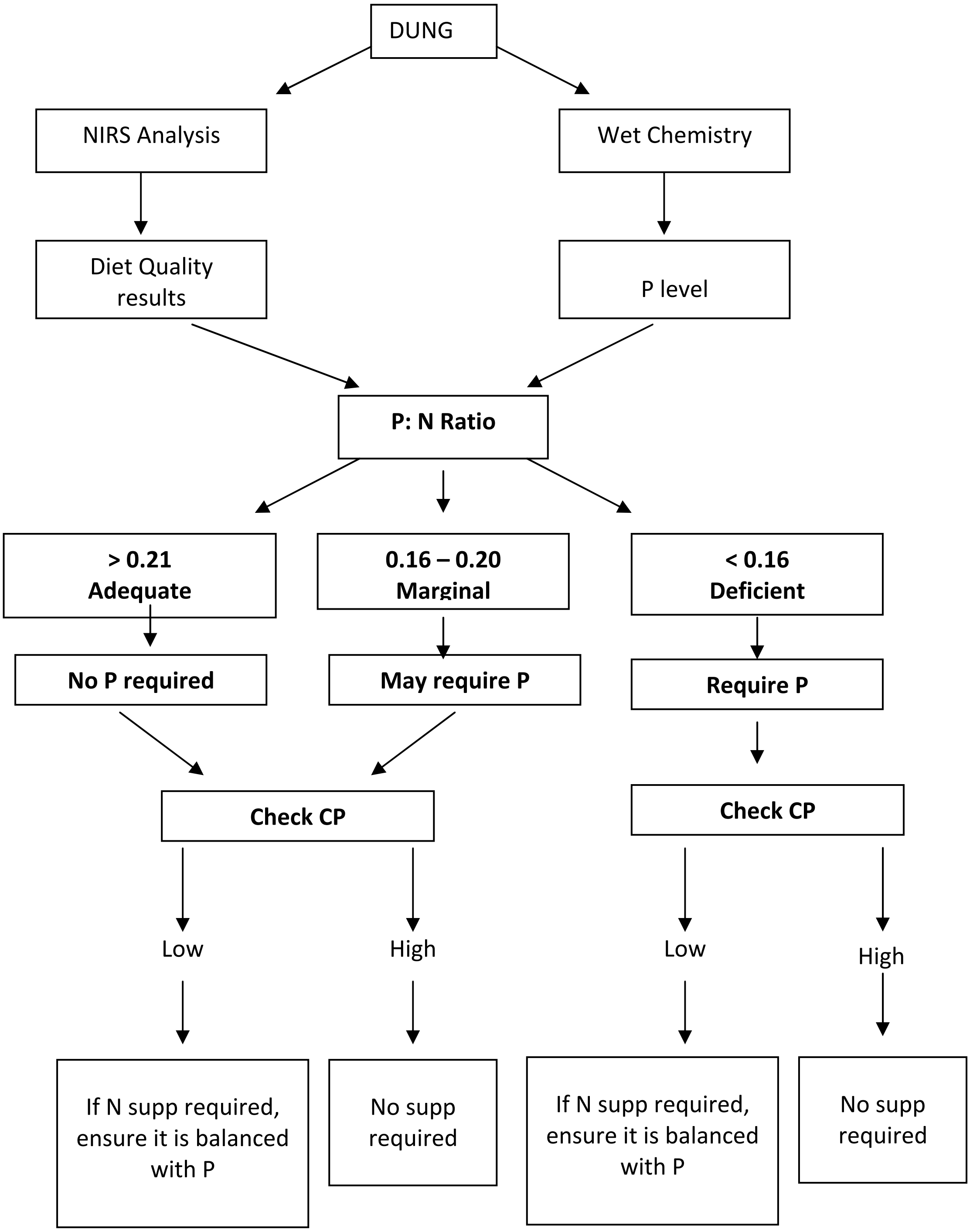
Further interpretation of the NIRS results with respect to digestibility and energy requires the assistance of an NIRS specialist because the DMD:CP (dry matter digestibility:crude protein) ratio can be affected by a number of factors, including the reliability of the CP result, which is influenced by the level of C3 species in the diet.

Decision flow charts have been developed to determine when to use non-protein nitrogen (eg. urea-based) supplements, when to supplement phosphorus and ensuring that phosphorus and nitrogen are in balance.

Using NIRS to Determine When to Use NPN Supplements



Phosphorus Analysis and Balancing Phosphorus with Protein



5.4 Develop reliable and practical field recording systems for use with NIRS

These included documentation of:

- body condition scoring of large groups of cattle (particularly breeder herds) and existing management; and
- pasture condition description with respect to pasture yield and apparent nutritional value (e.g. green leaf, stage of maturity, moisture stress, yield, presence of forbs and/or top feed, evidence of selection). This was conducted in association with the collection of fresh faecal samples.

A field data collection sheet was developed for producers to record information relating to the land systems, pasture and cattle from which they were collecting their faecal samples .

Producers received a series of condition score photo standards on a 1-9 scale to assist with recording animal condition scores. They recorded estimates of the percentages of breeders that fit into each of the condition score groups. This information was useful for tracking the trends in changes in condition score, to determine whether cattle were losing or gaining weight overall in a paddock.

Producers received photo standards for various pasture yields for their land system, to assist with making estimates of pasture yield for the paddocks from which they were sampling, and recording this information on their field data collection sheets. They also recorded: a.) growth phases of pasture; 2.) percentage of green leaf in grass and herbage; 3.) the leaf:stem ratio in grass; 4.) pasture species available to the stock for grazing; and 5.) browse species available to stock for grazing. This information was critical to the interpretation of the results.

6 Impact on meat and livestock industry – now & in five years time

88% of producer co-operators surveyed said that they would continue to use the NIRS service following the completion of the project. There were a number of ways producers indicated they would use F.NIRS technology, these included:

- Better understanding of pastures
- Selling livestock and agistment planning
- Moving stock between paddocks
- Drought management
- Commencing supplementary feeding – identification of when to begin nitrogen supplementation (on which land systems) through dietary CP% and DMD:CP ratio, and when to begin energy supplementation through analysis of DMD%
- Selecting appropriate supplements – protein vs. energy/protein supplements
- Modifying a supplement program – upgrading from energy to protein
- Breeder management decisions – timing of joining, controlled mating, weaning
- Weaner management decisions
- Aid for making management decisions at the end of the wet season
- Purchase of a new property
- Monitoring stock performance.

This project has generated interest in producers to seek more formal training on pasture management. Producers recognize the importance of pasture management to herd productivity, however, the uptake of formal pasture monitoring including measurements or composition estimates and keeping records has not been widespread. One of the major benefits producers identified from using the F.NIRS technology was to gain a better understanding of their pastures. A number of producers in all regions have attended an EDGE Grazing Land Management Workshop or a Stocktake workshop since the F.NIRS monitoring phase of the project was completed. Clearly, NIRS has identified a practical link between pasture monitoring and diet quality, and has provided producers with a tool to manage their pastures and to manipulate the nutritional management of their cattle.

F.NIRS has been embraced by scientists and extension officers, in accounting for diet quality in pasture experiments, and in providing more tailored advice to producers in the nutritional management of cattle. In recent years, NIRS technology has been further developed to predict diet quality of other grazing animals, such as dairy cattle (Decruyenaere *et al.* 2006), sheep (Li *et al.* 2007), goats (Landau *et al.* 2004), deer (Tolleson 2005) and antelope (Dörgeloh *et al.* 1998).

Estimates from economic modelling (Appendix L) in 2006 (F. Chudleigh) showed a return of $3.90 GM/AE/annum benefit by adopting F.NIRS technology. Currently, the adoption rate is estimated at 2%, but is expected to rise to 5% with continued technology publicity, promotion and results interpretation. With continued awareness and promotion of the practical herd nutritional management benefits from the technology, this could easily rise to 10%, representing approximately one million head of cattle across northern Australia.

The F.NIRS technology has been commercialized and the use of this service now extends to all parts of Queensland and the Northern Territory.

7 Conclusions and recommendations

F.NIRS proved to be a useful tool to help producers better understand and respond to seasonal changes in pasture and diet quality of grazing cattle. This information assisted producers to make management decisions regarding supplementary feeding, pasture management, adjusting stocking rates and herd numbers.

There are three main areas where NIRS results were inconsistent and research needs to be conducted in a controlled environment. These are: on mulga and spinifex land system diets; where C3 forb species (or non-grasses) form a major part of the diet; and where sown forages, legumes or other crops can be grazed in association with grass-based pastures.

The Mulga land systems covers some 19 million hectares alone in Queensland (or 12.5% of the State) and 150 million hectares across Australia (Sattler 1986; Johnson and Burrows 1994). This represents a major area where improvement the F.NIRS technology is needed because browse contributes significantly to the diet thus making it difficult to make an assessment of diet quality through objective visual assessment techniques.

A large C3 forb or legume component (i.e., non-grass component) in the diet from herbage or winter legumes results in underestimation of diet quality by F.NIRS with current equations. Further calibration is required to incorporate a larger C3 component in the diet and also to distinguish between high and low palatable browse species, and forbs, which make up the non-grass component. There has been limited NIRS evaluation of diets with a high proportion of sown crop forage or pasture species. This work is important in the sub-tropics of southern Queensland and northern New South Wales where winter rain can produce high quality and highly palatable forbs (herbage) and legumes at a time when summer grasses are mature, often frosted, and of below maintenance quality.

Data analysis from this work needs to be expanded to include analysis of FDCS qualitative assessment with quantitative results data.

The F.NIRS is an invaluable technology for assessing diet quality, however, it does not take into account feed intake, which has a significant impact on the nutrition and performance of cattle.

Further development of the ADG predictions for various classes of stock is necessary. At present, because predictions are based on a 300-kg medium frame steer, extrapolating the ADG prediction to other classes of cattle may involve significant error. Actual liveweight or growth rate information between sampling times was not available to accurately assess the daily liveweight gain predictions.

It is unwise to use NIRS results in isolation, but rather in conjunction with land type, objective pasture assessment and class and stage of reproduction of cattle. Training of producers, industry advisors and others involved in the interpretation of analyses is essential to ensure NIRS predictions are interpreted and used appropriately.

It is imperative that key pasture and cattle information included in the Field Data Collection Sheet that producers used to record paddock resource information and submit along with their samples is maintained in the commercialization of NIRS. The producer observations on the Field Data Collection Sheet includes pasture stage of growth phase, grass leaf:stem and grass green:dry leaf and pasture yield. This is necessary for an accurate interpretation of results where there is a lack of familiarity of the land systems and cattle production.

A formal training package for assessing key factors in the pasture which affect diet quality, as well as animal condition scoring should be developed and made available to producers. This will also contribute to increasing adoption of the F.NIRS technology.

Technical training in F.NIRS should be ongoing for beef extension officers, as they are key local contacts for producers in decision making and will be able to assist producers make the best nutritional management decisions from their F.NIRS results.

7.1 Acknowledgments

We gratefully acknowledge the funding supported provided by MLA and the support of QPIF to conduct this project.

Sincere thanks goes to all of the producer co-operators who were committed to collecting samples, completing field data collection sheets and providing feed-back over the duration of this project.

We would also like to thank Paul Telford, QPIF Longreach for his advice and assistance with the data analysis. David Coates (CSIRO) and Rob Dixon (DPIF) are also gratefully acknowledged for their input into the development of this project and provision of technical training to the NIRS Task 3 team.

We would finally like to acknowledge the generous support from Elders through the provision of 250 rain gauges, which were distributed to producer co-operators to measure rainfall in each of their monitor paddocks.

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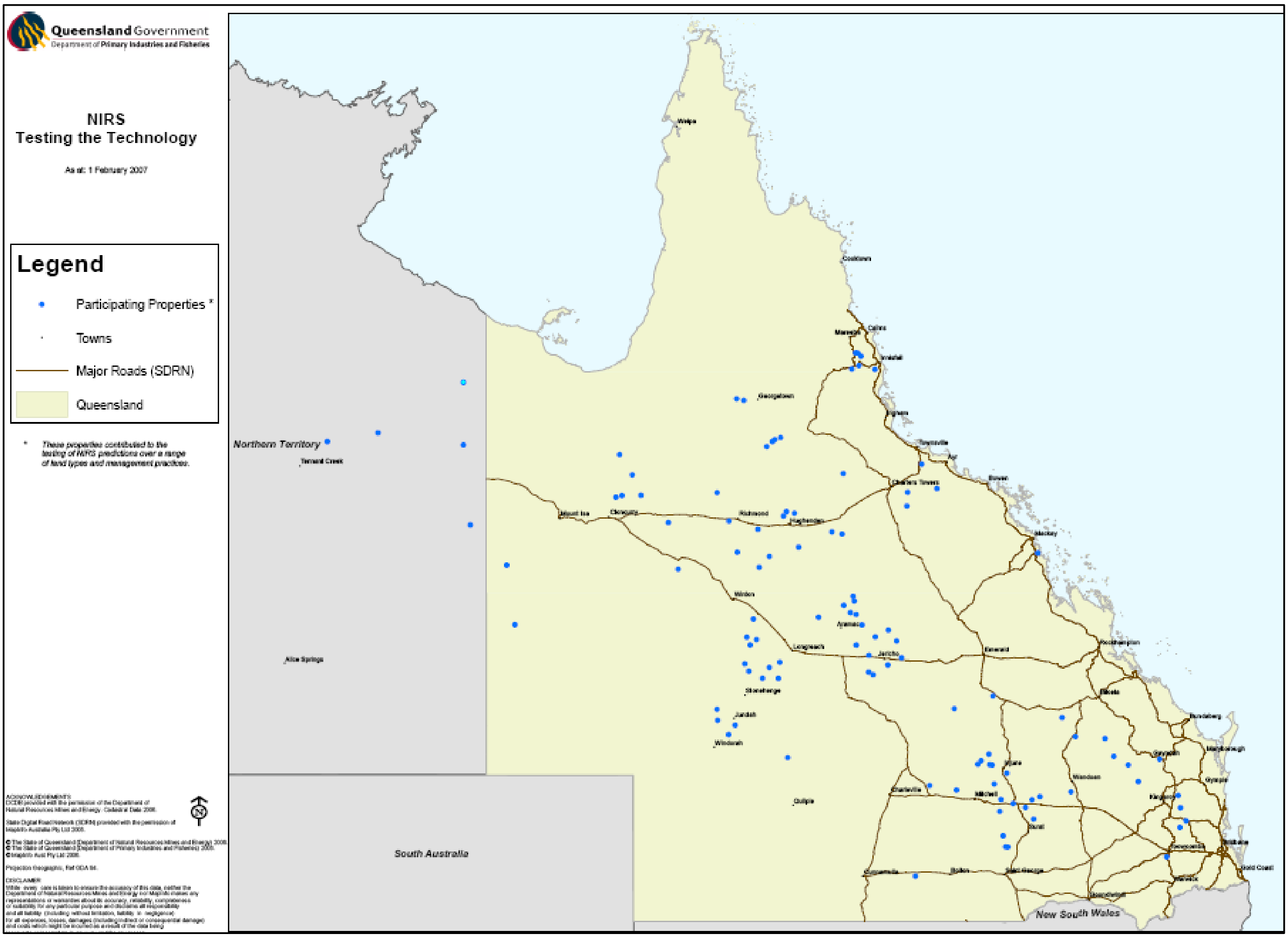
9 Appendices

9.1 Appendix A – Distribution of cooperating properties



Prepared by
John Arrowsmith
QPIF Brisbane

9.2 Appendix B-1 – NIRS Samples – Field Data Collection Sheet

NIRS Samples - Field Data Collection Sheet

(Email or fax the completed form to: CSIRO (4753 8600) and your NIRS Co-ordinator, and post the labelled sample to CSIRO, Townsville, Q 4810.

Office use only	
Sample No.	Date received

1. Sampling date	

2. Client details

Property to be sampled		**Property Number**	
Owner/Manager's Name			
Address			
Contact details	**Phone**	**Fax**	**Email**
DPI NIRS Co-ordinator			

3. Paddock Details

Paddock Name	**Area:** **ac/ha/km^2**		
Grazing System	☐ Continuous ☐ Rotational ☐ Cell ☐ Other:		
Mineral Deficiencies	☐ Phosphorus ☐ Salt ☐ Sulphur ☐ Unsure ☐ Other:		
Major Land Types			
Main Pasture species	1 2 3	1 2 3	1 2 3
Main Browse species	1 2 3	1 2 3	1 2 3
Rainfall last wet season	☐ above average	☐ average	☐ below average
Paddock history? (date)	Burnt: Destocked:	Flooded: Restocked:	

Description of cattle sampled

Breed(s):	**Number of head:**	**Mob Identifier:**
Class	☐ Weaners *(less than 12 mths)* ☐ Steers/heifers *(12mths+)* ☐ Maiden heifers ☐ First calf cows	☐ Breeders *(mixed ages)* ☐ Aged cows *(10 yrs +)* ☐ Bulls ☐ Mixed class *(male & female)*
Mating ***(date)***	☐ Continuous or Bulls in: Bulls Out:	
New cattle introduced	Breed ________________ Class ____________________ Number of head __________ Date introduced ____________	
Other stock in paddock	Species _______________ Class _____________________ Number of head __________ Date introduced ______________	

To help us from mismatching the pages please fill in the box to the right

Paddock	Date

Cattle Details (at time of sampling)

Weights (if available)	Max:			Min:			Average:		
General observations	☐ Gaining			☐ Holding			☐ Losing		
Condition Score (use photos & show range of percentages (no ticks)									
	1	2	3	4	5	6	7	8	9
Dry stock (%)	%	%	%	%	%	%	%	%	%
Wet stock (%)	%	%	%	%	%	%	%	%	%
Lactation (% wet)	☐ 0% ☐ less 25% ☐ 25-50% ☐ 51-75% ☐ >75%								
Pregnancy status *at preg testing only*	Date	Pregnant %				Empty %			
Weaning/mustering	*(since last sampling)* Date:								
Water availability	☐ Bore water ☐ Surface water ☐ Medicated water								

Pasture and Rainfall Details (at time of sampling)

Pasture Condition	Growth Phase *Grass only*	Green:dry leaf ratio *Grass*	 *Non-grass*	Leaf:stem ratio *Grass only*
Can tick more than 1 box to indicate different grass growth phases. *Tick 1 box only to indicate green:dry leaf ratio for grass and non-grass (leave non-grass blank if none present)* *Tick 1 box only for leaf:stem ratio*	☐ 1 ☐ 2 ☐ 3 ☐ 4	☐ 100 % ☐ 75 % ☐ 50 % ☐ 25 % ☐ 0 %	☐ 100 % ☐ 75 % ☐ 50 % ☐ 25 % ☐ 0 %	☐ 75 % ☐ 50 % ☐ 25 % ☐ 0 %
Pasture damage	☐ Frosted ☐ Rain-spoiled ☐ Fire ☐ Other:			
Pasture Yield	☐ less than 500 kg/ha ☐ 500 -1000 kg/ha ☐ 1001 - 2000 kg/ha		☐ 2001 – 3000 kg/ha ☐ 3001 – 4000 kg/ha ☐ > 4,000 kg/ha	

Rainfall in last month	Total Rainfall		No. of rain events		No. of rain events
		Less than 10mm		51-100 mm	
		10-20 mm		101-200 mm	
	mm	21-50 mm		201+ mm	

Legumes/forbs present *Tick the box(es) if present and note name if known*	☐ Legumes ☐ Forbs	*If browse, legumes or forbs are being grazed by cattle please make a note in section 8 comments*

Supplement Details (at time of sampling)

	Supplement	Date started	Date finished	Intake/hd/day
1				
2				

Any other comments on conditions, previous NIRS results

Figure 1 - Field Data Collection Sheet (FDCS) used by co-operators with each sample

Explanatory Notes for NIRS Field Data Collection Sheet

Paddock Details	
Grazing System	*Cross (x) which is appropriate. If your monitor paddock has a different system please list in 'Other'.*
Mineral Deficiencies	*Cross (x) which is appropriate if known. List any other deficiencies not listed under other.*
Land type	*List major land types in the monitor paddocks using the descriptions in the land type sheet if provided.*
Main pasture species	*List the main pasture species in the paddock for each land type (if known).*
Main Browse species	*List the main browse species in the paddock for each land type (if known).*
Rainfall last season	*Cross (x) which generally describes the previous season before the sampling began. Enter only once.*
Paddock history	*List the month and year (mm/yy) when the paddock was last burnt, flooded, destocked and restocked before the sampling commenced.*

Description of Cattle Sampled	
Breed	*e.g. Brahman, Brahman cross*
Number	*Number of head in the paddock*
Mob ID.	*Continuous grazing systems ignore this entry. For those who sample several paddocks we need to be able to identify if it is the same mob of cattle you are monitoring. Please give a brief descriptive name to the mob i.e., No2 steers or Breeders A.*
Class	*Cross (x) the class of animals in the monitor paddock.*
Mating Management	*Cross (x) box that describes the mating management in this paddock. If controlled mating list month that bulls go in and out of the paddock.*
New cattle introduced	*Document any new cattle, which have been transferred into the paddock during the monitoring program.*
Other stock in paddock	*Some paddocks may have a mix of species i.e., cattle and sheep. List the species other than cattle running in the paddock (except natives).*

Cattle Details (at time of sampling)	
Weights	*If cattle weights are available for the month please list the highest and lowest weight and the average for the paddock.*
General observations	*An indication of cattle performance – cross (x) a box.*
Condition Score	*Using the photo standards list the percentage of cattle that fall into the 9 categories.* ***If you are monitoring a paddock of breeders with wet and dry cattle - estimate condition scores for the wet cattle (add up to 100%) and again for the dry cattle (add up to 100%).***
Lactation Status	*An indication of the number of wet cattle in the mob. Cross (x) the most appropriate box.*
Pregnancy status fill out this section at preg testing only	*If a pregnancy test occurs during the month of sampling indicate the date, and % pregnant and empty.*

Weaning/mustering	*If the cattle are mustered, and in particular weaned during the sampling month -indicate the date.*
Water availability	*What water is available during the sampling month (may cross (x) more than one box e.g. bore water and surface water).*

Pasture and Rainfall Details (at time of sampling)	
Pasture Condition ***Can tick more than 1 box to indicate different grass growth phases*** ***Tick 1 box only to indicate green:dry leaf ratio for grass and non-grass (leave non-grass blank if none present)*** ***Tick 1 box only for leaf:stem ratio***	*1. Growth phase (grass only) from photo sheet in your folder (may cross (x) more than one box).* *2. Green:dry leaf – an estimate of the percentage green leaf for grass and non grass (excluding browse).* *3. Leaf:stem (grass only) – estimate what percentage of the plant is leaf (by weight) i.e., 0% is no leaf and all stem, 75% is mostly leaf as in fresh new season growth. Think in terms of – 'on average the grass in the paddock is …% leaf by weight.*
Pasture damage	*If there has been some damage during the sampling month please note it here.*
Pasture Yield	*Refer to photo standards supplied and tick the appropriate box – once again think in terms of: 'on average I think the pasture yield is …. kg/ha (use your photo standards supplied). The categories are broad so don't agonise over a couple of hundred kg's.*
Rainfall (in last month)	*1. List the total rainfall the month* *2. List the number of rainfall events, which made up the total i.e., Total 100mm for the month. And it fell in two falls of 40mm and one fall of 20. Write 2 in the '21-50' category, and 1in the '10-20' category.*
Legumes/forbs present	*If there are legumes &/or forbs (herbage/weeds) present cross (x) the box. If you know what species they are list them on the right hand side of the box.*

Supplement Details (at time of sampling)	
Supplements	*List either the commercial name of supplement or the main components of your home brew mix.* *List the start and finish date as necessary.* *List the intake (if known) per head per day.*

Any Other Comments
List any comments on conditions, which may help with interpretation of the NIRS results. If you have observed cattle eating browse or legumes or forbs (herbage/weeds) you could note it in this section. *Could also note any comments on previous NIRS results. e.g. are they matching what you are seeing in the paddock.*

This information will be valuable in interpreting the NIRS results as it provides information that impacts on diet quality. The cattle information is useful in determining nutritional needs of different classes of cattle. Collation of this information in conjunction with the NIRS result will be entered in a database of information. This information will help ground truth NIRS results and assist the NIRS research team in progressing the effectiveness and application of NIRS technology.

Figure 2 - Explanation notes used by co-operators to complete the FDCS

Appendix B-2. Land type and land system descriptions

Land System description for Mitchell Grasslands in Western Queensland

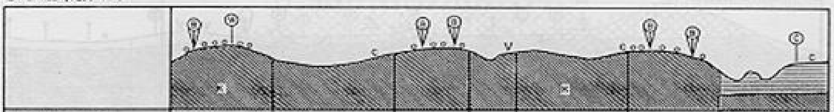
Land System Sheets for Mitchell Grasslands of Western Queensland

T2 Kentle Land System

Kentle Land System is a 'wooded downs'. That is ther is sufficient tree density to distinguish it from open or ashy downs. Tree densities range from scattered trees to small clumps of low open woodland. The tre density does nto appear to inhibit pasture growth to any extent. These wooded downs are valuable as they provide shade and shelter. The main occurrence is east of the Thomson river and adjacent to alluvia.

- **LANDFORM:** Flat to gently undulating plains, sloes <2%.
- **GEOLOGY:** Fresh, labile Cretaceous sediments.
- **SOILS:** Deep grey and brown cracking clays with dense gravel cover.
- **VEGETATION:** Mitchell grass, boree wooded open-tussock grassland. Occasionally noree, whitewood, boonaree grassy open-woodland.

T2 KENTLE (4 260 km^2)



Land Unit and / or Associated Land System	50	1	50	2	1	50	A3, W3
Site and / or special comment	21, 22, 35, 38, 51, 66, 101, 114, 164, 185, 188, 189	(as per Allaru L.S.)		91 92 152 214			
Est. % of Land System	70	20		<5			<5

Figure 3 - Example of a land system description used by co-operators

Appendix B-3. Photo standards of cattle condition scores (1-8) from the University of Arkansas

Body Condition Score 1 and 2

Condition Score 1 – Emaciated

- **Visible Bone structure**
  - Shoulder, ribs, back
  - Hooks – sharp to touch
  - Pins – sharp to touch
- **Muscling**
  - Very little
- **Fat Deposits**
  - Very little

Condition Score 2 – Very Thin

- **Visible Bone structure**
  - Spinous process easily seen
    - Sharp to touch
- **Muscling**
  - Some in hindquarters
- **Fat Deposits**
  - Very little

Body Condition Score 3 and 4

Body Condition 3 – Thin

- **Visible Bone structure**
  - Foreribs remain noticeable
  - Backbone visible
  - Spinous process
    - Palpate with little pressure
    - Less pronounced intervening space
- **Muscling**
  - Muscling apparent
- **Fat Deposits**
  - Beginning cover – loin, back, foreribs

Body Condition Score 4 – Borderline

- Visible Bone structure
  - Foreribs not noticeable
  - 12th and 13th ribs noticeable
  - Transverse process
    - Felt with slight pressure
- Muscling
  - Full but straight, not rounded
  - Fat Deposits – ribs becoming well-covered

Body Condition Score 5 and 6

Body Condition Score 5 – Moderate

- **Visible Bone structure**
  - 12th and 13th rib not visible except shrunk cattle
  - Transverse processes felt w/firm pressure
- **Muscling**
  - Full
- **Fat Deposits**
  - Area around tail head filled out but not mounded

Body Condition Score 6 – Good

- **Visible Bone structure**
  - No distinct structure
  - Transverse processes felt w/firm pressure
- **Muscling**
  - Hindquarters plump and full
- **Fat Deposits**
  - Sponginess over forerib
  - Sponginess around tail head

Body Condition Score 7 and 8

Body Condition Score 7 – Very Good

- Visible Bone structure
  - No distinct structure
  - Ends of spinous process felt w/very firm pressure
- Muscling
  - Hindquarters plump and full
- Fat Deposits
  - Abundant fat around tail head w/some patchiness

Body Condition Score 8 – Fat

- Visible Bone structure
  - No distinct structure to none
- Muscling
  - Hindquarters plump and full
- Fat Deposits
  - Thick and spongy
  - Animal appears smooth and blocky

Body Condition Score 9

Body Condition Score 9 – Very Fat

- **Visible Bone structure**
  - None
- **Muscling**
  - Hindquarters plump and full
- **Fat Deposits**
  - Tail head buried in fat

Figure 4 - Cattle condition score photo standards for scores 1-9 used by co-operators

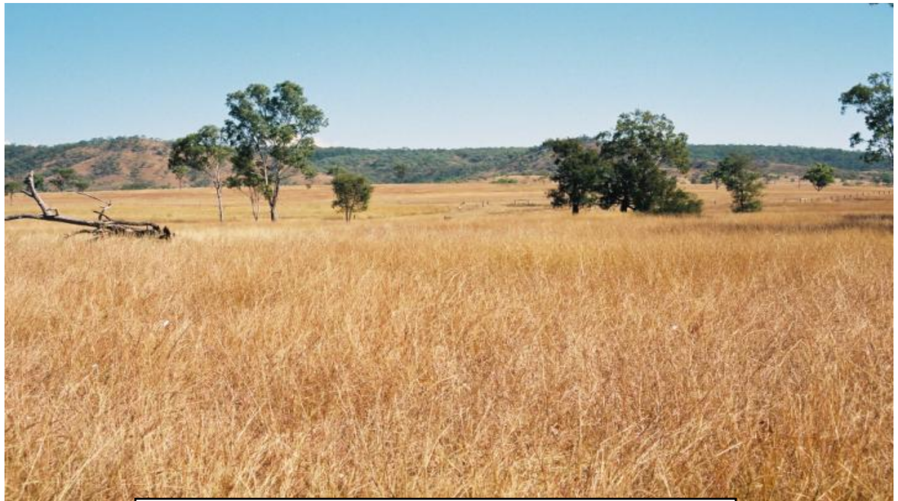
Appendix B-4. Pasture growth phase (1-4) photo standards for Mitchell grass country

Pasture growth phases

Phase 1 – leaf growth, early growing season

Phase 2 – green leaf & stem, mid-season pre-seeding

Phase 3 – green leaf & stem, flowering & maturing



Phase 4 – dry mature grass, hayed off

Figure 5 - Pasture growth phase (1-4) photo standards used by co-operators

Appendix B-5. Pasture dry matter yield photo standards

Mitchell grass

370 kg/ha

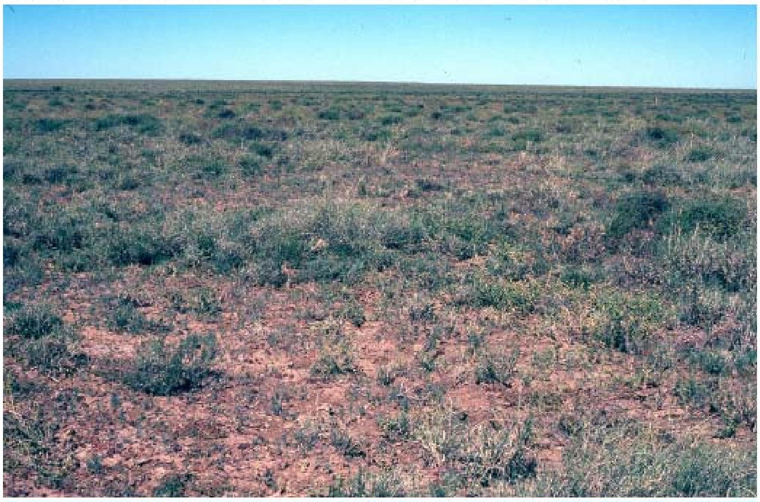
570 kg/ha

890 kg/ha

Queensland Government
Department of Primary Industries

Mitchell grass

980 kg/ha



1250 kg/ha

1480 kg/ha

Queensland Government
Department of Primary Industries

Mitchell grass

1530 kg/ha

1820 kg/ha

2430 kg/ha

Queensland Government
Department of Primary Industries

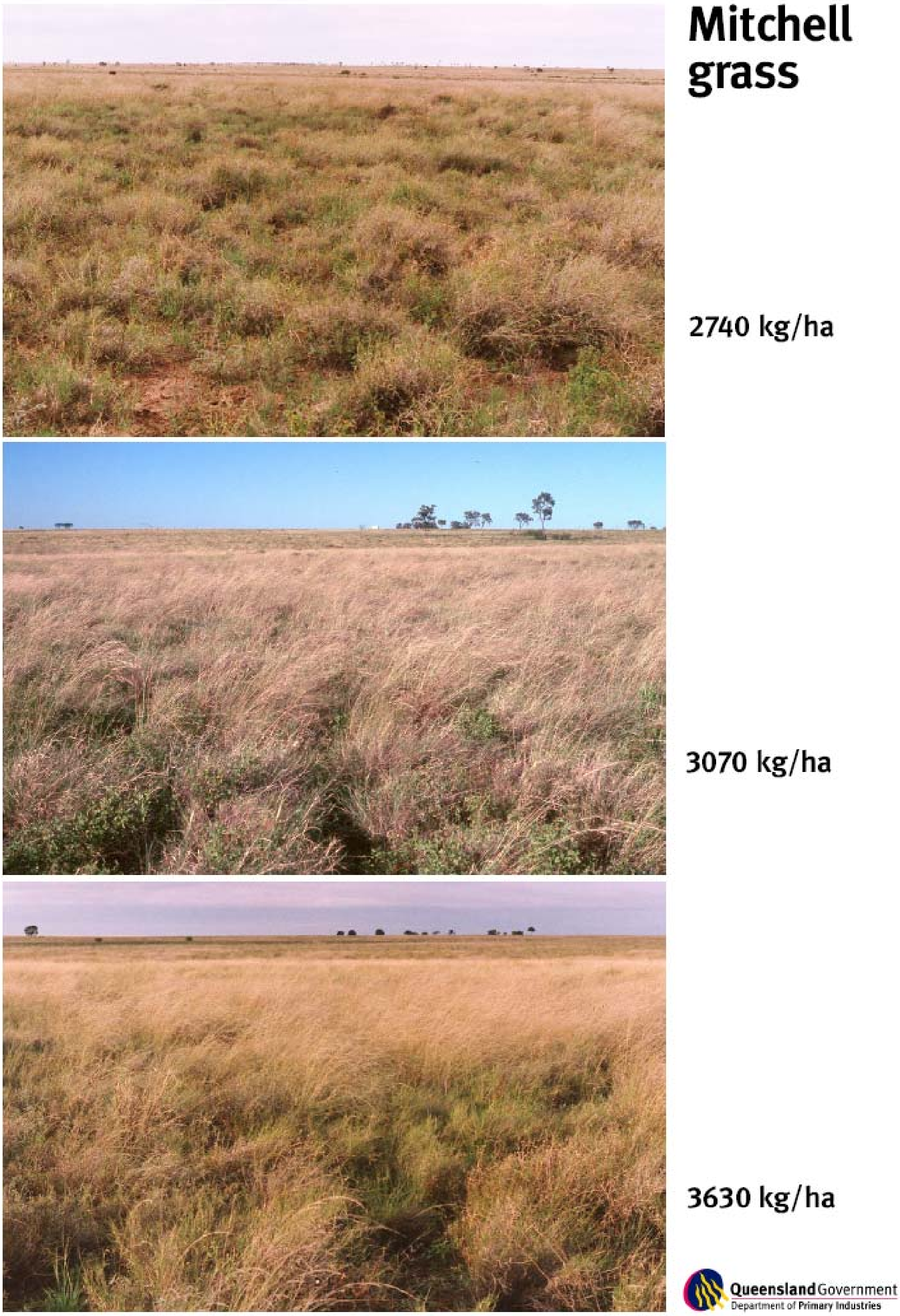


Figure 6 - Example of pasture dry matter yield photo standards for Mitchell grass

9.3 Appendix C – Land system pasture and browse categories

Table 1 - Land systems sampled in *Southern Qld (SQ)*

Land system	*Land type*	*Soil*
Aristida/Bothriochloa	Cypress pine (duplex soils)	Light
	Cypress pine (forest)	Light
	Iron bark on yellow earth	Light
	Narrow leaf Ironbark	Light
	Pine/Eucalypt	Light
	Poplar Box (clay)	Heavy
	Poplar Box (duplex soils)	Light
	Poplar Box with sandalwood	Light
	Poplar box woodland	Light
	Silver leaved ironbark	Light
Brigalow/Gidyea	Brigalow Belah scrub	Heavy
Bluegrass downs	Black soil downs	Heavy
	Bluegrass downs	Heavy
	Bluegrass downs (south east)	Heavy
	Qld bluegrass basalt	Heavy
Mitchell grass	Mitchell grass (Southern)	Heavy
Woodlands	Mountain Coolibah	Heavy
	Softwood scrub	Heavy
	Softwood vine scrub	Heavy

Table 2 - Land systems sampled in *South-east Qld (SEQ)*

Land system	*Land type*	*Soil*
Aristida/Bothriochloa	Ironbarks/spotted gum-duplex & loams	Light
	Silver leaved ironbark (granite)	Light
Black speargrass	Blue Gum flats	Heavy
	Ironbarks/bloodwoods-non cracking clay	Heavy
Woodland	Softwood scrub	Heavy

Table 3 - Land systems sampled in the *Desert Uplands (DU)*

Land system	*Land type*	*Soil*
Aristida/Bothriochloa	Gidyea/Eucalypt woodland	Light
	Gidyea/Eucalypt woodland (red sandy desert)	Light
	Silver leaved ironbark	Light
	Silver leaved ironbark (sandy duplex)	Light
Brigalow/Gidyea	Brigalow Belah scrub	Heavy
Spinifex	Alluvial plains – channels/streams (desert)	Light
Woodland	A2 Aramac	Light
	Redcliffe	Light

Table 4 - Land systems sampled in *north Qld (NQ)*

Land system	***Land type***	***Soil***
Aristida/Bothriochloa	Bauhinia/Beefwood low woodland (By)	Light
	Georgetown box (granite)	Light
	Gidyea lowlands on shale (By)	Light
	Gidyea/Eucalypt woodland (red sandy desert)	Light
	Grey Box on sandy loam - Desert Uplands	Light
	Ironbark/bloodwood ridges (granite)	Light
	Narrow leaf Ironbark	Light
	Silver leaved ironbark (sandy duplex)	Light
	Yellow jacket & Ironbark on red sand-Desert Uplands	Light
Black speargrass	Goldfields (CT)	Light
	Granite with alluvial river frontage	Light
	Metamorphic (Warrawee)	Light
	Mount Ravenswood (R)	Light
	Nulla Black Basalt	Heavy
	Poplar gum on flat plains	Heavy
	Poplar gum/bloodwood open forest	Light
Bluegrass downs	Alluvial plains - channel streams (brown/grey clays)	Heavy
	Bluegrass/Browntop plains (Bl)	Heavy
	Coolibah woodland on channels	Heavy
	Monstraven black soil downs	Heavy
Mitchell grass	Alluvial (other)	Heavy
	F3 Winton	Heavy
	Mitchell grass (Julia)	Heavy
	Mitchell grass (wd-Gidyea)	Heavy
	Mitchell grass/Bluebush channels	Heavy
	Rosella black basalt	Heavy
Rainforest derived (Atherton Tableland)	Brown loam (tablelands)	Heavy
	Malaan (Tablelands)	Heavy
	Red basalt (wet tropics)	Heavy
	Tableland Pin Gin	Heavy
Spinifex	Spinifex (hard) (Cn)	Light
	Spinifex/Silver box open woodland (Ko)	Light
Woodland	Leichhardt (Bloodwood/Ironbark mtns)	Light
	River frontage loam	Light
	Sandy loam forest (Bylong)	Light

Table 5 - Land systems sampled in *western Qld (WQ)*

Land system	*Land type*	*Soil*
Aristida/Bothriochloa	Alluvial plains (wooded)	light
	Dissected residuals	light
Bluegrass downs	Alluvial plains - channel streams (brown/grey clays)	heavy
Mitchell grass	Alluvial (other)	heavy
	F3 Winton	heavy
	Mitchell grass (Central)	heavy
	Mitchell grass (wd-Georgina)	heavy
	Mitchell grass (wd-Gidyea)	heavy
	Mitchell grass (wd-other)	heavy
	Mitchell grass/Bluebush channels	heavy
Mulga	Mulga (hard)	light
	Mulga (soft)	light
	Mulga (soft) (Central)	light
Woodland	Red Sand Ridges	light
	Simpson	light

Table 6 - Land systems sampled in the *Northern Territory (NT)*

Land system	*Land type*	*Soil*
Bluegrass downs	Coolibah Swamp (NT)	Heavy
	Dry Lake (NT)	Heavy
Mitchell grass	Barkly (NT)	Heavy
	Mitchell grass (Barkley Tablelands)	Heavy
Woodland	Wonorah (NT)	Light

Table 7 - Pasture species groupings

3P Grasses	*Intermediate grasses*	*Wiregrass*	*Annual grasses*	*Forbs*	*Legume (Native)*	*Legume (Sown)*	*Sown pasture grasses*
Black speargrass	Barb wire grass	Feather-top	Urochloa (annual)	Boggabri	Glycine	Butterfly pea	Bambatsi
Bluegrass	Bluegrass (Pitted)	Kerosene grass	Button grass	‘Herbage’ (winter forbs)	Psoralea	Glycine (Tinnaroo)	Buffel (Cloncurry)
Bluegrass (Desert)	Bottle-washer grass	White speargrass	Digitaria (summer grass)	Malvastrum	Sesbania Pea	Lablab	Buffel grass
Bluegrass (Forest)	Cane grass	Wiregrass	Flinders grass	‘Mixed weeds’		Medic	Green panic
Bluegrass (Qld)	Couch		Summer grass	Nut grass		Stylo (Seca, Verano)	Guinea grass
Golden beard grass	Digitaria			Pigweed			Indian couch
Kangaroo grass	Katoora			Sclerolaena			Jarra
Mitchell (Barley)	Lovegrass			Tar vine			Kikuyu
Mitchell (Bull)	Panic (native)			Tick weed			Pangola
Mitchell (Curly)	Paspalidium			Verbena (Mayne's pest)			Para grass
Mitchell (Hoop)	Spinifex (other)			Verbine			Rhodes grass
Mitchell grass	Spinifex (soft)						Sabi grass
Mulga Mitchell	Windmill grass						Setaria
Mulga Oats							Signal grass
Silky brown top							Sorghum (forage)
							Sorghum (silk)
							Sorghum (stubble)
							Tully grass
							Wheat stubble

Table 8 - Browse species relative palatability

High palatability	***Low palatability***
Bauhinia	Appletree
Belah	Beefwood
Blue bush	Bendee
Broom bush	Bloodwood
Cocky apple	Bootlace
Conkerberry	Boree
Corkwood	Breadfruit
Dead Finish	Brigalow
Dogwood	Cabbage Gum
Emu apple	Cattle Bush
Kurrajong	Currant bush
Lemon wood	Desert Oak
Leucaena	Eucalyptus (unidentified)
Mimosa	False sandalwood
Myall	Georgina gidyea
Myrtle	Gidyea
Queensland blue bush	Ghost gum
Supple Jack	Gundabluie
Wait-a-while	Gutta percha
Whitewood	Hop bush
Wilga	Ironbark
Yellow wood	Ironwood
	Lancewood
	Leopardwood
	Lignum
	Limebush
	Mulga
	Parkinsonia
	Poplar box
	Prickly acacia
	Quinine
	Red river gum
	Silver leaved ironbark
	Soap Bush
	Teatree (black)
	Teatree (other)
	Turkey bush
	Wattle (Acacia species)
	Wild orange

9.4 Appendix D – Summary of ranges for NIRS predictions for land systems across Queensland and the Northern Territory

It is important to note that:

- Although the NIRS prediction for one land system may be higher than for another, they may not necessarily be statistically different (further information on statistical differences is available within this Final Report);
- Some land systems have particularly high predictions for CP% (e.g. Mulga). This does not mean that all of this protein is available for absorption – in some cases it may be coming from browse species (such as in the case of Mulga, under drought conditions) that are high in CP% but have a low digestibility%.
- Sampling was carried out over a period of three years. There were a number of land systems that were droughted over the duration of the project so there were not adequate samples taken from some land systems when there was green feed.
- The number of samples must be borne in mind, particularly for those land systems where there were a small number of samples taken. On these land systems, the results may not be representative of what is typical for those particular land systems.

Table 1a. Dry season NIRS predictions of dry matter digestibility% (DMD%) on 11 land systems

	No. of Samples	Average DMD%	Typical DMD% Range	
Rainforest derived (rd)	**49**	**64.1**	**59.0**	**69.0**
Mulga (m)	10	60.8	57.0	63.0
Downs (d)	97	54.7	51.0	58.0
Mitchell grass (mg)	235	54.6	52.0	57.0
Brigalow/Gidyea (b)	47	53.8	51.3	56.0
Spinifex (sp)	12	51.2	49.5	53.0
Woodland (light) (w-l)	30	50.9	47.0	55.0
Aristida/Bothriochloa (ab)	134	50.6	48.0	53.0
Black speargrass (heavy) (bs-h)	51	50.5	48.0	52.0
Woodland (heavy) (w-h)	8	50.1	48.0	52.0
Black speargrass (light) (bs-l)	50	47.1	46.0	49.0

Table 1b. Dry season NIRS predictions of crude protein% (CP%) on 11 land systems

	No. of Samples	Average CP%	Typical CP% Range	
Rainforest derived (rd)	**50**	**12.7**	**10.9**	**14.9**
Mulga (m)	10	10.4	9.3	12.1
Downs (d)	98	7.4	5.1	8.0
Mitchell grass (mg)	241	6.5	5.1	7.2
Brigalow/Gidyea (b)	47	6.2	4.8	6.9
Black speargrass (heavy) (bs-h)	51	6.0	5.0	6.5
Aristida/Bothriochloa (ab)	134	5.9	5.0	6.9
Woodland (heavy) (w-h)	8	5.3	4.6	5.9
Woodland (light) (w-l)	30	5.2	3.7	6.7
Black speargrass (light) (bs-l)	51	4.9	4.1	6.0
Spinifex (sp)	12	4.8	3.9	5.4

Table 1c. Dry season NIRS predictions of non-grass% (NG%) on 11 land systems

	No. of Samples	Average non-grass%	Typical non-grass% Range	
Mulga (m)	**10**	**44.4**	**28.0**	**60.0**
Mitchell grass (mg)	242	25.1	17.0	31.0
Downs (d)	99	20.8	9.0	31.0
Aristida/Bothriochloa (ab)	133	18.9	12.0	25.0
Woodland (light) (w-l)	30	17.4	8.0	28.0
Woodland (heavy) (w-h)	8	15.3	6.5	23.5
Black speargrass (heavy) (bs-h)	51	15.2	8.3	21.8
Black speargrass (light) (bs-l)	50	15.2	7.0	25.0
Spinifex (sp)	13	15.1	13.3	15.3
Brigalow/Gidyea (b)	47	14.3	4.0	20.0
Rainforest derived (rd)	50	12.4	8.0	15.0

Table 2a. Wet season NIRS predictions of dry matter digestibility% (DMD%) on 11 land systems

	No. of Samples	Average	Typical Range	
Rainforest derived (rd)	**40**	**63.5**	**59.0**	**67.0**
Mulga (m)	10	61.8	60.0	65.0
Brigalow/Gidyea (b)	52	59.9	57.0	63.5
Woodland (heavy) (w-h)	15	57.4	53.5	59.8
Downs (d)	71	57.1	53.3	61.0
Mitchell grass (mg)	179	57.1	53.0	61.0
Black speargrass (heavy) (bs-h)	53	56.8	51.8	62.0
Spinifex (sp)	5	56.2	51.5	61.8
Woodland (light) (w-l)	25	55.6	50.0	60.3
Aristida/Bothriochloa (ab)	167	55.0	51.0	59.0
Black speargrass (light) (bs-l)	51	53.7	48.0	59.3

Table 2b. Wet season NIRS predictions of crude protein% (CP%) on 11 land systems

	No. of Samples	Average	Typical Range	
Rainforest derived (rd)	**40**	**11.9**	**9.6**	**14.3**
Mulga (m)	10	10.3	9.5	11.3
Black speargrass (heavy) (bs-h)	53	8.4	6.1	10.6
Brigalow/Gidyea (b)	52	8.3	6.8	9.9
Downs (d)	73	8.2	5.3	10.9
Aristida/Bothriochloa (ab)	167	8.0	5.9	10.2
Black speargrass (light) (bs-l)	50	8.0	5.5	9.5
Woodland (heavy) (w-h)	15	7.9	6.1	8.3
Woodland (light) (w-l)	28	7.8	5.5	10.1
Mitchell grass (mg)	180	7.5	5.1	9.3
Spinifex (sp)	4	5.5	3.8	7.1

Table 2c. Wet season NIRS predictions of non-grass% (NG%) on 11 land systems

	No. of Samples	Average	Typical Range	
Mulga (m)	**10**	**44.4**	**30.0**	**59.0**
Downs (d)	72	25.9	13.0	35.0
Mitchell grass (mg)	182	24.4	14.0	32.0
Aristida/Bothriochloa (ab)	168	22.4	12.5	29.0
Woodland (light) (w-l)	28	18.6	14.5	21.0
Black speargrass (light) (bs-l)	50	17.3	10.0	23.0
Black speargrass (heavy) (bs-h)	53	15.9	7.0	22.3
Brigalow/Gidyea (b)	52	13.4	4.5	18.0
Spinifex (sp)	5	12.6	8.8	15.8
Rainforest derived (rd)	39	9.4	5.3	13.0
Woodland (heavy) (w-h)	15	9.4	4.3	13.5

Table 3a. Effect of rainfall on NIRS predictions of dry matter digestibility% (DMD%) on the major land systems

Rainfall (mm)	No. of Samples	Average DMD%	Typical DMD% Range	
Aristida/Bothriochloa				
0 mm	49	52.0	49.0	54.3
< 25 mm	67	50.6	48.0	53.0
26 – 50 mm	37	52.5	48.0	56.3
51 – 75 mm	32	54.7	52.0	58.0
> 75 mm	52	57.8	54.0	61.0
Brigalow/Gidyea				
0 mm	15	55.0	53.0	58.0
< 25 mm	19	54.4	51.0	57.8
26 – 50 mm	15	58.3	52.8	64.0
51 – 75 mm	16	57.9	55.0	62.0
> 75 mm	17	60.2	55.5	64.3
Black speargrass (light)				
0 mm	23	47.0	45.3	49.0
< 25 mm	23	47.1	43.0	49.8
26 – 50 mm	15	51.5	47.3	54.8
51 – 75 mm	1	54.0	54.0	54.0
> 75 mm	19	59.9	55.3	62.8
Black speargrass (heavy)				
0 mm	23	52.4	49.3	54.8
< 25 mm	26	49.1	46.0	51.0
26 – 50 mm	15	53.4	49.0	60.0
51 – 75 mm	7	53.1	51.3	55.0
> 75 mm	25	60.4	55.8	65.0
Downs				
0 mm	32	53.9	51.0	55.5
< 25 mm	37	55.3	50.8	61.0
26 – 50 mm	14	53.4	48.0	57.0
51 – 75 mm	11	55.6	53.3	58.8
> 75 mm	26	60.9	57.0	64.0
Mitchell grass				
0 mm	85	56.9	54.0	59.0
< 25 mm	97	54.0	51.0	56.0
26 – 50 mm	24	55.7	51.0	60.0
51 – 75 mm	14	60.0	57.0	64.0
> 75 mm	39	60.9	56.5	65.0
Rainforest derived				
0 mm				

< 25 mm	16	60.6	57.0	63.5
26 – 50 mm	8	63.5	59.0	69.0
51 – 75 mm	9	65.9	58.8	71.3
> 75 mm	47	64.2	59.3	67.8
Woodland (light)				
0 mm	6	58.3	57.0	60.0
< 25 mm	12	51.8	51.5	54.5
26 – 50 mm	2	52.5	47.0	58.0
51 – 75 mm	1	56.0	56.0	56.0
> 75 mm	8	59.8	59.0	64.0
Woodland (heavy)				
0 mm	2	53.0	52.0	54.0
< 25 mm	5	49.4	47.8	51.3
26 – 50 mm	5	49.4	47.8	51.3
51 – 75 mm	3	53.7	51.3	55.8
> 75 mm	9	60.2	56.0	63.5

Table 3b. Effect of rainfall on NIRS predictions of crude protein% (CP%) on the major land systems

Rainfall (mm)	No. of Samples	Average CP%	Typical CP% Range	
Aristida/Bothriochloa				
0 mm	49	6.4	5.3	7.5
< 25 mm	67	6.1	5.2	6.7
26 – 50 mm	37	7.4	5.3	9.1
51 – 75 mm	32	7.1	5.8	8.4
> 75 mm	52	9.6	8.1	11.4
Brigalow/Gidyea				
0 mm	15	5.8	4.6	6.8
< 25 mm	19	6.5	5.4	7.1
26 – 50 mm	15	8.5	6.4	9.9
51 – 75 mm	16	8.1	6.7	9.7
> 75 mm	17	8.6	6.1	10.5
Black speargrass (light)				
0 mm	23	4.8	4.3	5.5
< 25 mm	23	5.0	4.0	6.1
26 – 50 mm	15	7.3	6.2	8.5
51 – 75 mm	1	7.1	7.1	7.1
> 75 mm	18	10.9	8.2	12.9
Black speargrass (heavy)				
0 mm	23	6.5	5.1	7.3
< 25 mm	26	5.4	5.0	6.0
26 – 50 mm	15	7.8	5.7	10.3
51 – 75 mm	7	6.5	5.8	6.8
> 75 mm	25	10.2	7.8	12.0
Downs				
0 mm	32	6.3	4.5	7.6
< 25 mm	38	7.7	4.9	9.8
26 – 50 mm	15	7.2	5.5	7.9
51 – 75 mm	11	8.5	6.9	10.6
> 75 mm	27	11.4	9.4	12.9
Mitchell grass				
0 mm	88	7.1	5.3	8.1
< 25 mm	100	5.8	4.6	6.4
26 – 50 mm	24	7.9	5.5	9.2
51 – 75 mm	15	9.4	7.0	11.6

> 75 mm	38	11.2	9.1	12.2
Rainforest derived				
0 mm				
< 25 mm	16	10.7	8.8	12.2
26 – 50 mm	8	11.7	10.1	13.6
51 – 75 mm	9	13.3	10.1	15.4
> 75 mm	48	12.7	10.8	14.8
Woodland (light)				
0 mm	8	7.8	7.0	8.8
< 25 mm	12	5.7	5.0	6.9
26 – 50 mm	3	7.2	5.9	8.5
51 – 75 mm	1	7.2	7.2	7.2
> 75 mm	8	11.2	10.2	11.7
Woodland (heavy)				
0 mm	2	5.3	4.4	6.1
< 25 mm	5	5.4	4.7	6.0
26 – 50 mm				
51 – 75 mm	3	6.7	5.8	7.5
> 75 mm	9	8.9	6.8	10.5

Table 4a. Effect of rainfall on NIRS predictions of dry matter digestibility% (DMD%) on light and heavy soils

Rainfall (mm)	No. of Samples	Average DMD%	Typical DMD% Range	
Light soils				
0 mm	158	55.4	52.0	58.0
< 25 mm	205	54.1	51.0	57.0
26 – 50 mm	80	56.4	50.0	61.0
51 – 75 mm	66	58.2	55.0	61.0
> 75 mm	166	61.7	57.0	65.0
Heavy soils				
0 mm	84	51.6	47.0	55.0
< 25 mm	103	50.1	47.0	53.0
26 – 50 mm	57	52.7	48.0	56.3
51 – 75 mm	28	54.3	52.0	57.0
> 75 mm	78	58.4	54.0	62.0

Table 4b. Effect of rainfall on NIRS predictions of crude protein% (CP %) on light and heavy soils

Rainfall (mm)	No. of Samples	Average CP%	Typical CP% Range	
Light soils				
0 mm	161	6.7	5.1	7.8
< 25 mm	209	6.6	4.9	7.4
26 – 50 mm	81	8.3	5.8	10.3
51 – 75 mm	67	8.8	6.7	10.5
> 75 mm	167	11.1	8.8	13.2
Heavy soils				
0 mm	86	6.4	4.9	7.5
< 25 mm	103	5.9	4.8	6.7
26 – 50 mm	58	7.4	5.4	8.6
51 – 75 mm	28	7.1	6.0	8.4

> 75 mm	76	10.0	8.2	11.6

Table 4c. Effect of rainfall on NIRS predictions of non-grass% on light and heavy soils

Rainfall (mm)	No. of Samples	Average Non-grass%	Typical non-grass% Range	
Light soils				
0 mm	162	21.5	11.0	29.0
< 25 mm	208	19.2	9.0	26.0
26 – 50 mm	82	19.8	10.0	27.0
51 – 75 mm	67	18.8	6.3	26.0
> 75 mm	168	16.4	7.0	21.5
Heavy soils				
0 mm	86	22.0	14.0	29.0
< 25 mm	104	23.5	14.0	28.5
26 – 50 mm	59	23.6	14.3	30.0
51 – 75 mm	28	20.8	9.0	30.5
> 75 mm	78	14.2	7.0	21.0

Table 5a. Effect of pasture yield on the NIRS prediction of non-grass% for Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass land systems

Yield (kg/ha)	No. of Samples	Average Non-grass%	Typical non-grass% Range	
Aristida/Bothriochloa				
< 500 kg/ha	11	45.6	22.5	80.3
500 – 1000 kg/ha	40	27.0	18.0	33.0
1001 – 2000 kg/ha	75	21.4	14.3	27.8
2001 – 3000 kg/ha	89	19.5	12.0	27.0
3001 – 4000 kg/ha	50	16.2	7.0	25.0
> 4000 kg/ha	7	15.9	4.5	24.8
Black speargrass (light)				
< 500 kg/ha	3	22.3	16.3	28.3
500 – 1000 kg/ha	18	22.7	15.0	30.0
1001 – 2000 kg/ha	39	18.0	11.0	24.8
2001 – 3000 kg/ha	28	12.5	5.5	19.0
3001 – 4000 kg/ha	12	8.1	0.0	11.5
> 4000 kg/ha				
Mitchell grass				
< 500 kg/ha	7	32.1	17.3	49.8
500 – 1000 kg/ha	66	24.5	14.0	30.0
1001 – 2000 kg/ha	224	24.6	16.0	32.0
2001 – 3000 kg/ha	77	24.1	15.5	31.0
3001 – 4000 kg/ha	29	26.3	13.8	31.0
> 4000 kg/ha	3	34.7	21.8	47.3

Table 5b. Effect of grass green:dry leaf ratio (%) on the NIRS prediction of non-grass% (NG%) for Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass land systems

Grass green:dry leaf ratio (%)	No. of Samples	Average Non-grass%	Typical non-grass% Range	
Aristida/Bothriochloa				
0%	56	23.2	15.0	31.5
25%	70	23.5	15.0	30.0
50%	80	18.1	9.5	27.0
75%	48	18.4	9.5	27.0
100%	15	19.0	13.5	27.5
Black speargrass (light)				
0%	32	16.2	10.5	23.5
25%	23	19.9	13.3	27.8
50%	11	14.2	1.5	24.8
75%	13	18.2	8.5	27.0
100%	21	12.2	6.8	17.3
Mitchell grass				
0%	198	24.3	16.0	31.0
25%	116	24.8	16.5	31.0
50%	43	26.2	14.3	36.8
75%	31	26.7	17.5	36.8
100%	19	23.2	10.0	30.0

Table 5c. Effect of grass leaf:stem ratio (%) on the NIRS prediction of non-grass% for Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass land systems

Grass leaf:stem ratio (%)	No. of Samples	Average Non-grass%	Typical non-grass% Range	
Aristida/Bothriochloa				
0%	14	17.9	5.0	27.0
25%	80	20.1	15.0	28.0
50%	122	22.2	12.0	30.0
75%	50	18.3	12.0	26.0
Black speargrass (light)				
0%	3	25.7	23.8	27.5
25%	26	17.8	11.0	24.0
50%	50	13.2	6.0	20.0
75%	13	15.8	9.8	19.0
Mitchell grass				
0%	13	24.9	15.8	30.0
25%	144	23.6	14.0	31.5
50%	163	24.3	16.0	31.0
75%	72	28.1	20.0	36.5

Table 6. Effect of observed non-grass green:dry leaf ratio (%) on NIRS predictions of dry matter digestibility (DMD%) for the major land systems

Non-grass green:dry leaf ratio (%)	No. of Samples	Average DMD%	Typical DMD% Range	
Aristida/Bothriochloa				
0%	24	50.0	48.5	51.5
25%	53	52.9	49.0	55.3
50%	60	53.0	50.0	56.0
75%	42	55.1	52.0	58.0
100%	33	58.6	57.0	62.0
Brigalow/Gidyea				
0%	22	54.1	52.0	57.0
25%	35	56.9	52.5	60.8
50%	6	57.3	55.0	59.0
75%	16	58.9	53.0	63.0
100%	17	59.8	55.8	64.0
Black speargrass (light)				
0%	14	49.7	46.0	55.0
25%	11	46.1	45.0	47.0
50%	8	48.8	47.0	50.0
75%	15	51.9	47.0	54.0
100%	28	53.8	48.0	61.0
Black speargrass (heavy)				
0%	12	48.8	46.5	50.0
25%	16	51.3	49.0	53.0
50%	8	50.6	49.0	52.0
75%	23	53.2	49.3	56.8
100%	25	59.3	53.8	64.3
Downs				
0%	10	55.6	53.0	59.0
25%	54	53.7	49.0	57.0
50%	31	56.4	52.0	61.8
75%	16	56.4	52.5	60.5
100%	9	60.2	56.3	64.5
Mitchell grass				
0%	112	53.3	51.0	55.0
25%	95	55.4	52.0	57.8
50%	43	56.5	54.0	59.8
75%	34	57.7	52.0	62.0
100%	24	61.8	59.0	65.0
Rainforest derived				
0%	3	61.0	59.0	63.5
25%	9	59.1	56.8	62.0
50%	10	61.7	58.0	63.0
75%	12	65.7	59.0	70.5
100%	29	67.5	63.5	71.0
Woodland (light)				
0%	6	49.7	47.0	51.0
25%	14	55.9	54.0	57.0
50%	6	53.7	53.0	56.0
75%	6	59.3	58.0	64.0
100%				
Woodland (heavy)				
0%	2	53.0	52.0	54.0
25%	2	48.5	48.0	49.0
50%	3	53.3	49.0	58.0
75%	5	51.0	47.8	53.5
100%	3	55.0	51.5	58.3

Table 7. Effect of observed non-grass green:dry leaf ratio (%) on NIRS predictions of crude protein (CP%) for the major land systems

Non-grass green:dry leaf ratio (%)	No. of Samples	Average CP%	Typical CP% Range	
Aristida/Bothriochloa				
0%	24	5.4	5.0	6.0
25%	53	6.7	5.4	7.5
50%	60	7.0	6.2	8.1
75%	42	8.1	6.2	8.9
100%	33	9.6	7.8	11.7
Brigalow/Gidyea				
0%	22	5.5	4.8	5.7
25%	35	7.3	6.0	8.8
50%	6	8.6	7.3	9.5
75%	16	8.4	6.9	9.2
100%	17	8.4	6.7	10.3
Black speargrass (light)				
0%	14	5.1	4.1	6.1
25%	11	4.2	3.6	4.7
50%	8	5.0	3.6	5.9
75%	15	7.8	6.0	7.4
100%	28	8.3	5.7	10.9
Black speargrass (heavy)				
0%	12	5.3	4.9	5.7
25%	16	6.3	5.3	7.1
50%	8	5.6	5.1	6.2
75%	23	7.0	5.9	7.8
100%	25	10.2	8.0	12.1
Downs				
0%	10	6.3	4.9	7.6
25%	54	6.8	5.0	7.6
50%	31	9.2	7.0	11.5
75%	18	9.6	7.8	11.2
100%	9	11.0	7.7	13.5
Mitchell grass				
0%	115	5.8	4.7	6.3
25%	98	6.8	5.4	8.0
50%	44	7.0	5.8	7.9
75%	34	8.5	5.9	9.9
100%	23	12.6	10.6	14.4
Rainforest derived				
0%	3	12.0	9.8	14.5
25%	9	10.3	8.7	12.4
50%	10	11.2	9.1	11.8
75%	13	12.2	10.5	13.2
100%	29	14.1	12.4	16.0
Woodland (light)				
0%	6	4.6	3.7	5.0
25%	17	6.4	5.0	7.3
50%	6	6.7	5.5	7.4
75%	6	9.3	8.9	11.0
100%				
Woodland (heavy)				
0%	2	5.3	4.4	6.1
25%	2	5.0	4.8	5.2
50%	3	6.3	5.2	7.4
75%	5	6.1	5.0	7.4
100%	3	6.9	6.4	7.5

Table 8. Effect of observed non-grass green:dry leaf ratio (%) on NIRS predictions of CP:FN ratio for the major land systems

Non-grass green:dry leaf ratio (%)	No. of Samples	Average CP:FN ratio	Typical CP:FN Range	
Aristida/Bothriochloa				
0%	25	4.5	4.2	5.0
25%	53	5.1	4.4	5.7
50%	60	5.4	4.8	6.1
75%	42	5.3	4.5	5.8
100%	33	5.8	5.4	6.2
Brigalow/Gidyea				
0%	22	4.5	4.0	4.8
25%	35	5.3	4.7	6.1
50%	6	5.5	4.7	5.8
75%	16	5.2	4.8	5.6
100%	17	5.4	5.2	6.0
Black speargrass (light)				
0%	14	3.7	3.2	4.0
25%	11	3.9	3.5	4.4
50%	8	3.8	3.2	4.3
75%	15	5.0	4.2	5.7
100%	28	5.0	4.2	5.7
Black speargrass (heavy)				
0%	12	4.5	4.2	4.9
25%	16	5.1	4.7	5.7
50%	8	4.7	4.4	5.1
75%	23	5.1	4.7	5.6
100%	25	6.2	5.4	7.1
Downs				
0%	10	4.4	3.6	4.9
25%	54	5.1	4.3	5.6
50%	31	5.8	4.7	6.6
75%	17	5.7	4.9	6.5
100%	9	5.8	5.2	6.4
Mitchell grass				
0%	116	4.9	4.3	5.5
25%	98	5.2	4.5	5.7
50%	45	5.1	4.6	5.7
75%	34	5.6	5.2	6.1
100%	23	6.5	6.0	7.0
Rainforest derived				
0%	3	6.6	6.1	7.1
25%	9	6.4	5.6	7.1
50%	10	6.6	6.1	7.3
75%	13	6.4	6.0	6.8
100%	28	7.4	6.7	8.1
Woodland (light)				
0%	6	3.8	3.4	3.9
25%	17	5.4	4.6	6.1
50%	6	5.1	4.9	5.8
75%	6	6.0	6.1	6.4
100%				
Woodland (heavy)				
0%	2	4.4	4.0	4.9
25%	2	4.2	4.1	4.4
50%	3	5.0	4.6	5.4
75%	5	4.8	4.2	5.4
100%	3	4.9	4.6	5.2

9.5 Appendix E – Summary analysis of results presented as box plots

The box plots are as defined by Tukey (1977) with the box spanning the inter-quartile range (the middle 50% of the data within the box) and the line in the box indicating the median. The ‘whiskers’ extend a distance of up to 1.5 times the inter-quartile range beyond the quartiles (or to the Min/Max values if these are less). Individual outliers beyond these are identified in green while extreme outliers (greater than 3 times the inter-quartile range beyond the quartiles) are identified in red. Summary statistics are also presented.

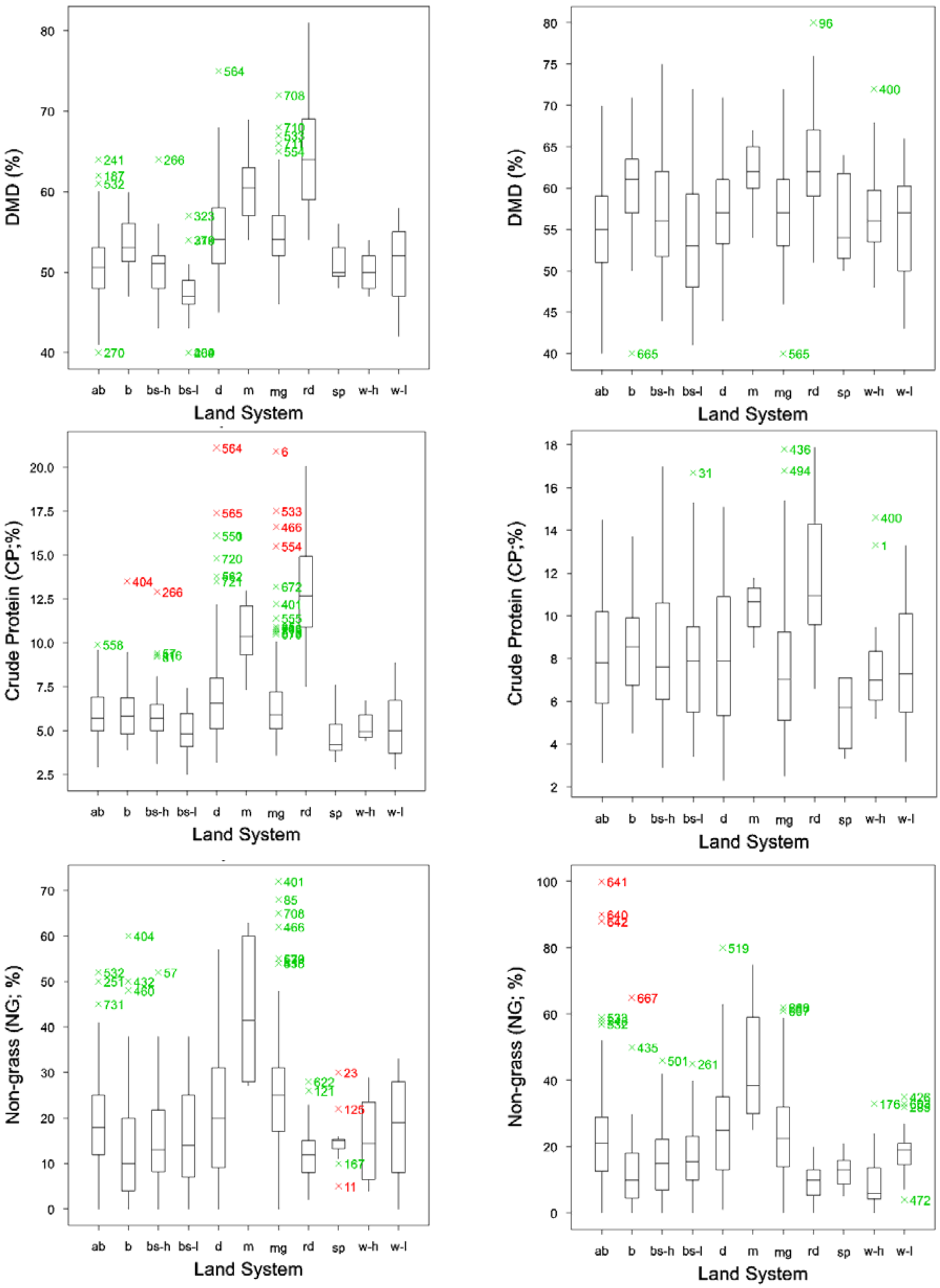


Figure 1. **NIRS predictions of DMD%, CP% and non-grass % for land systems in the dry season (left; n=747) and the wet season (right; n=682)**

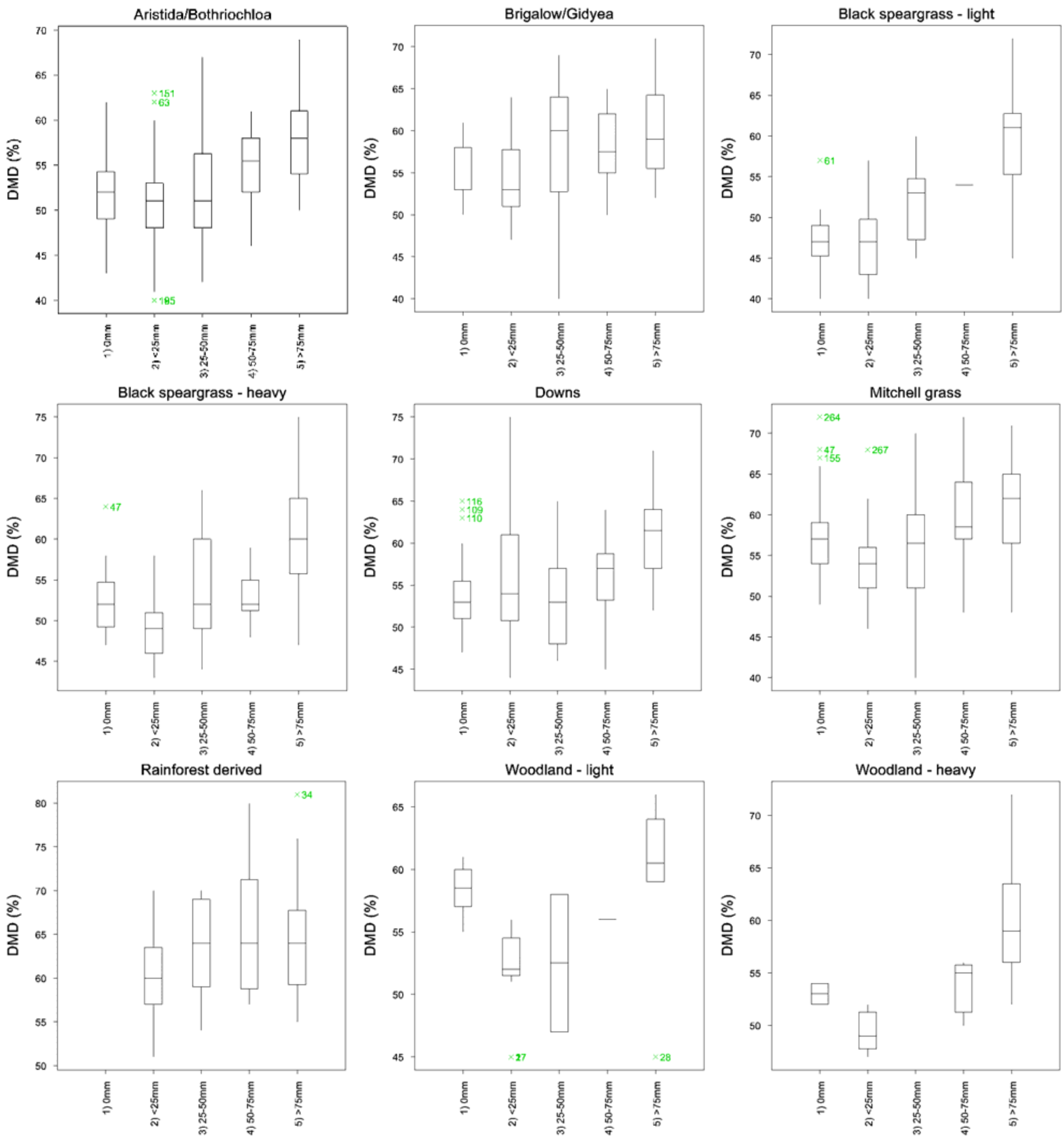


Figure 2. Effect of rainfall on NIRS predictions of DMD% for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

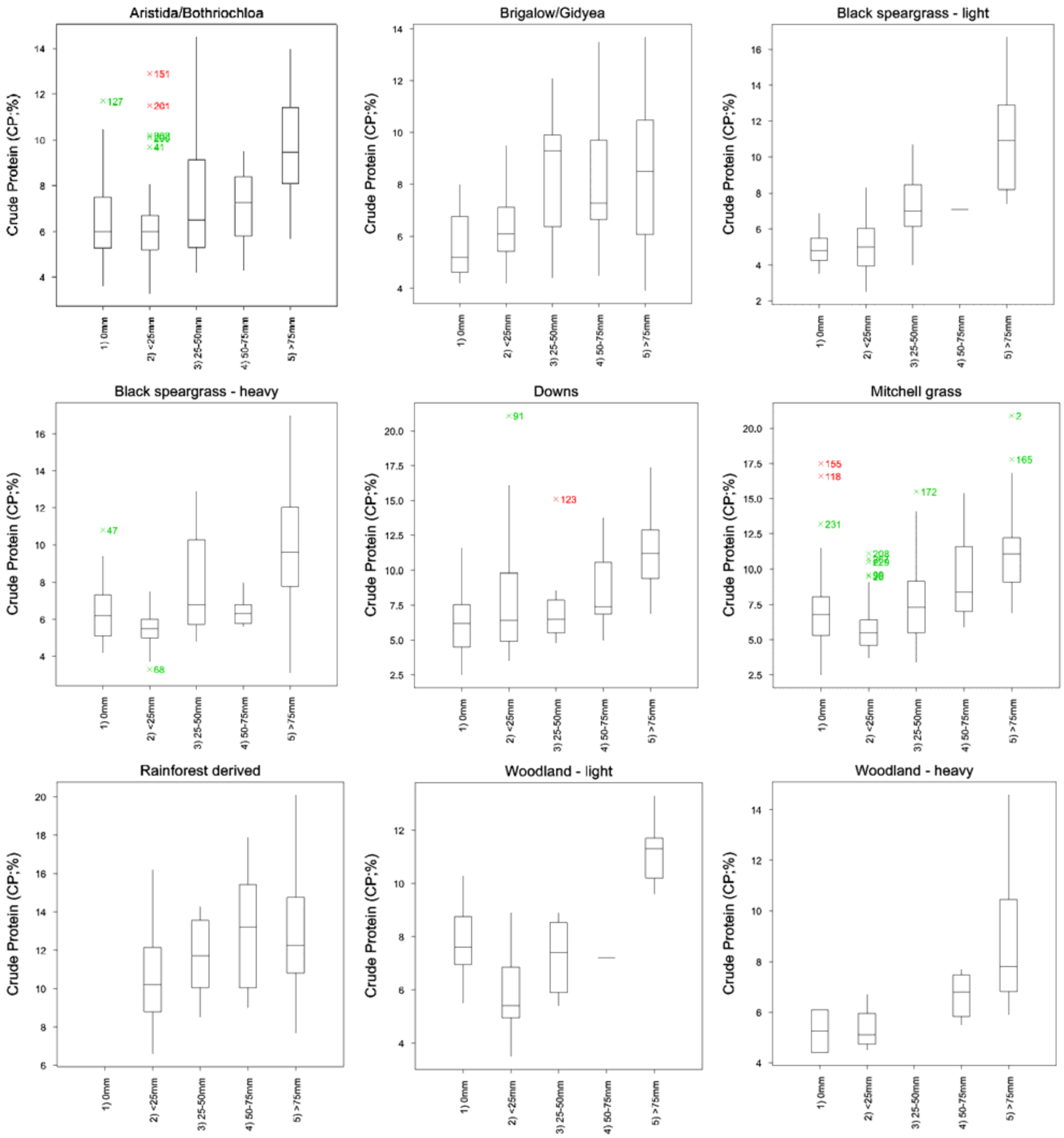


Figure 3. Effect of rainfall on NIRS predictions of CP% for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

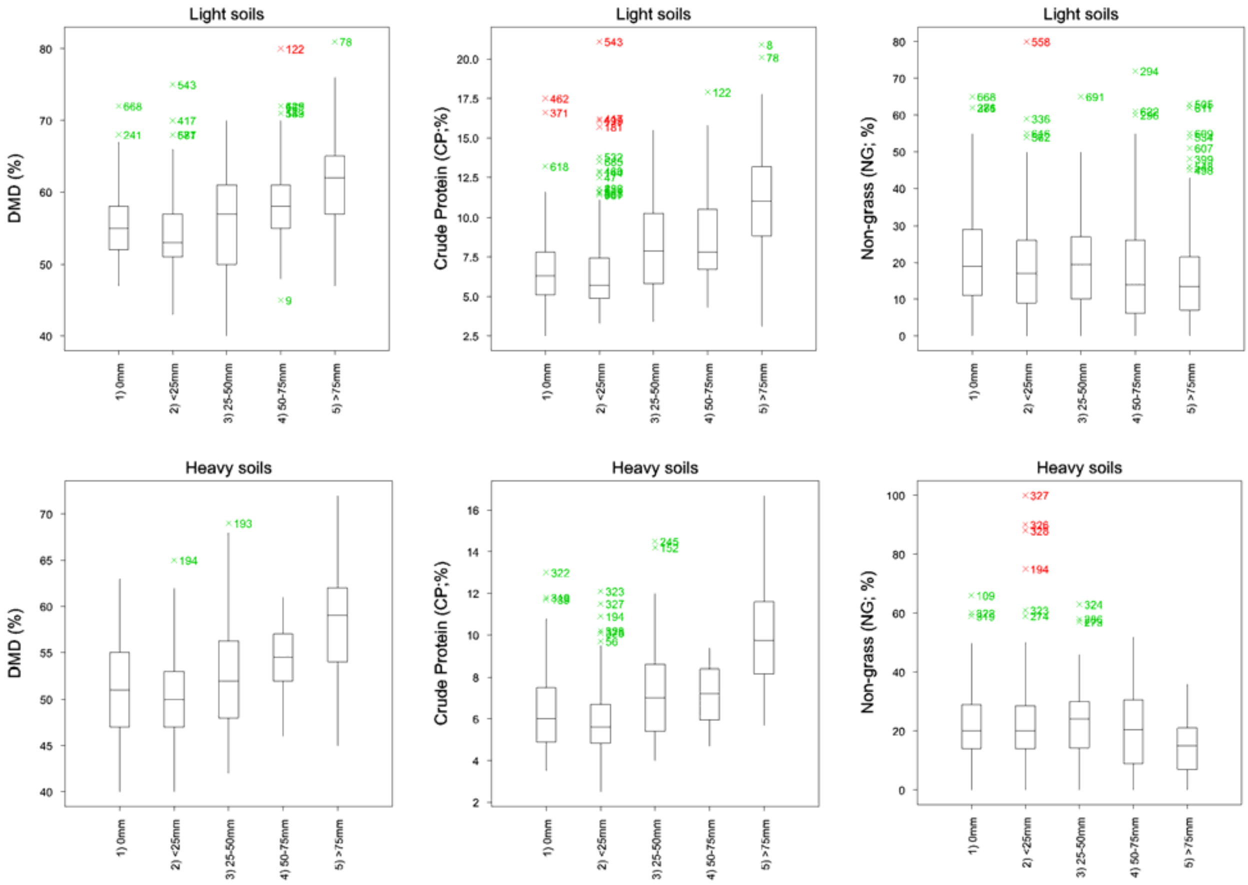


Figure 4. Effect of rainfall on NIRS predictions of DMD%, CP% and non-grass % for land systems with light (top; n=698) and heavy (bottom; n=360) soil

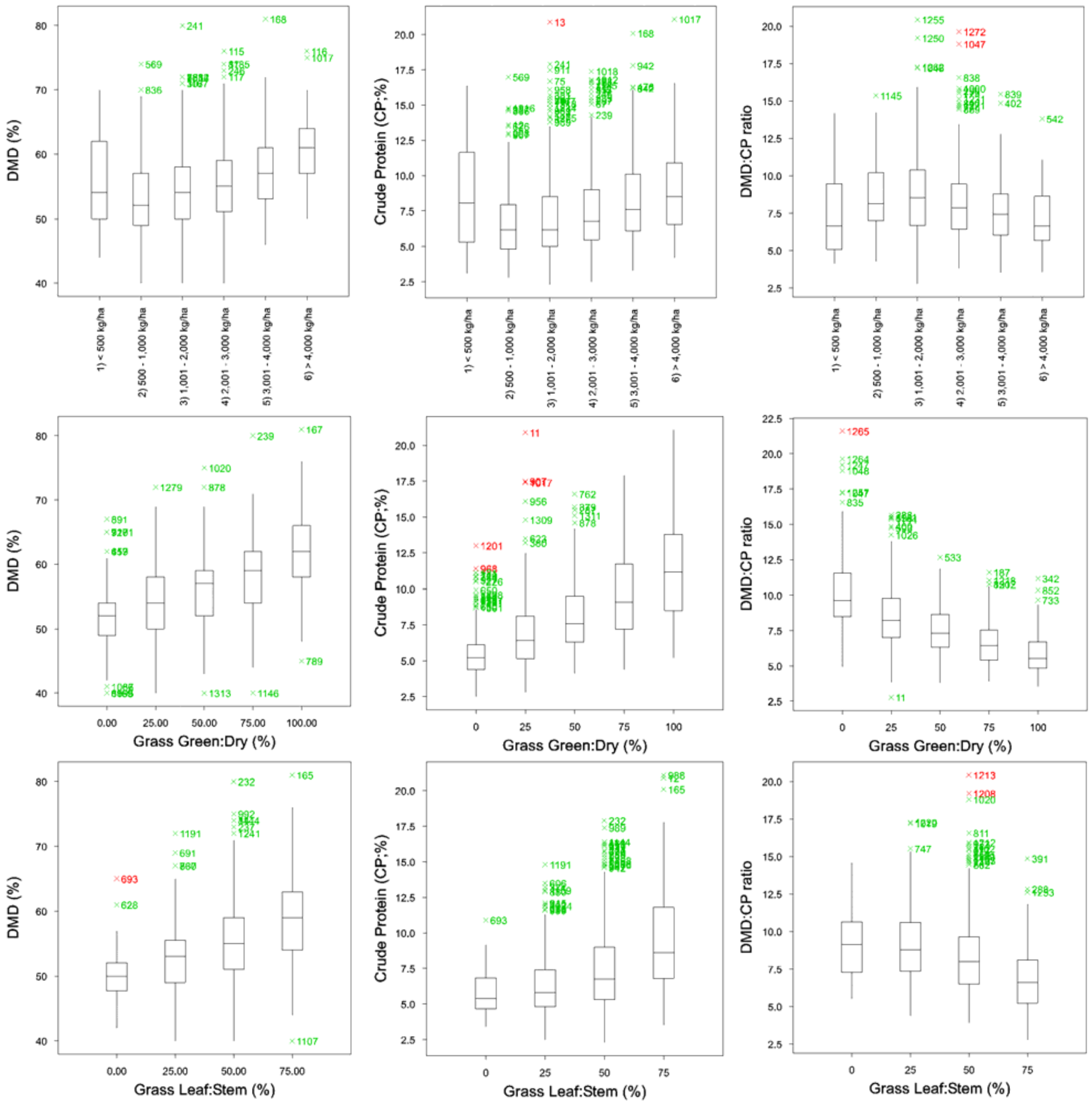


Figure 5. Effect of observed pasture yield (top row), grass green:dry leaf ratio (middle row) and grass leaf:stem ratio (bottom row) on NIRS predictions of DMD%, CP% and DMD:CP ratio

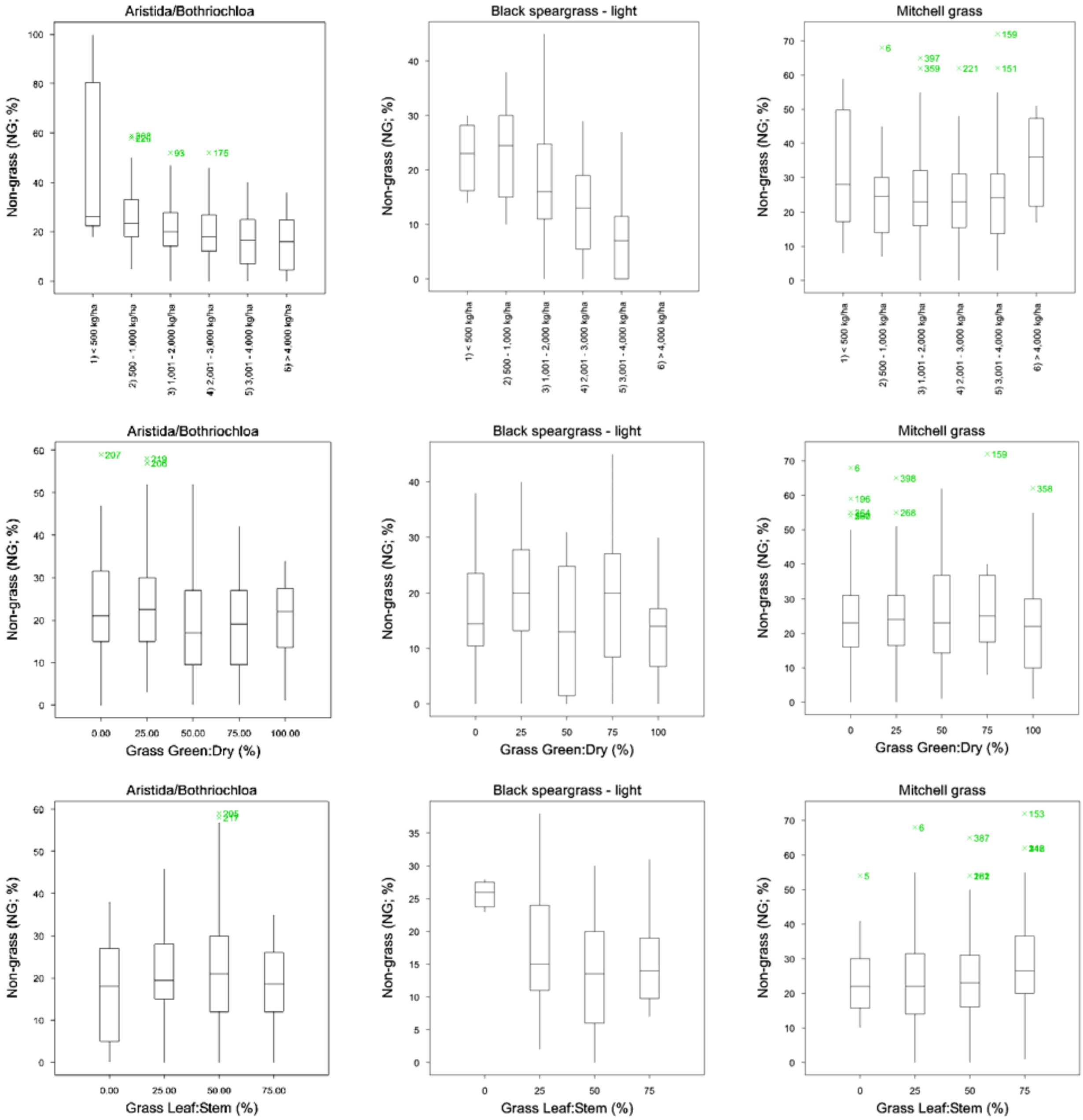


Figure 6. **Effect of observed pasture yield (top row), grass green:dry ratio (middle row) and grass leaf:stem ratio (bottom row) on the NIRS prediction of non-grass % for the three land systems of Aristida/Bothriochloa, Black speargrass (light) and Mitchell grass**

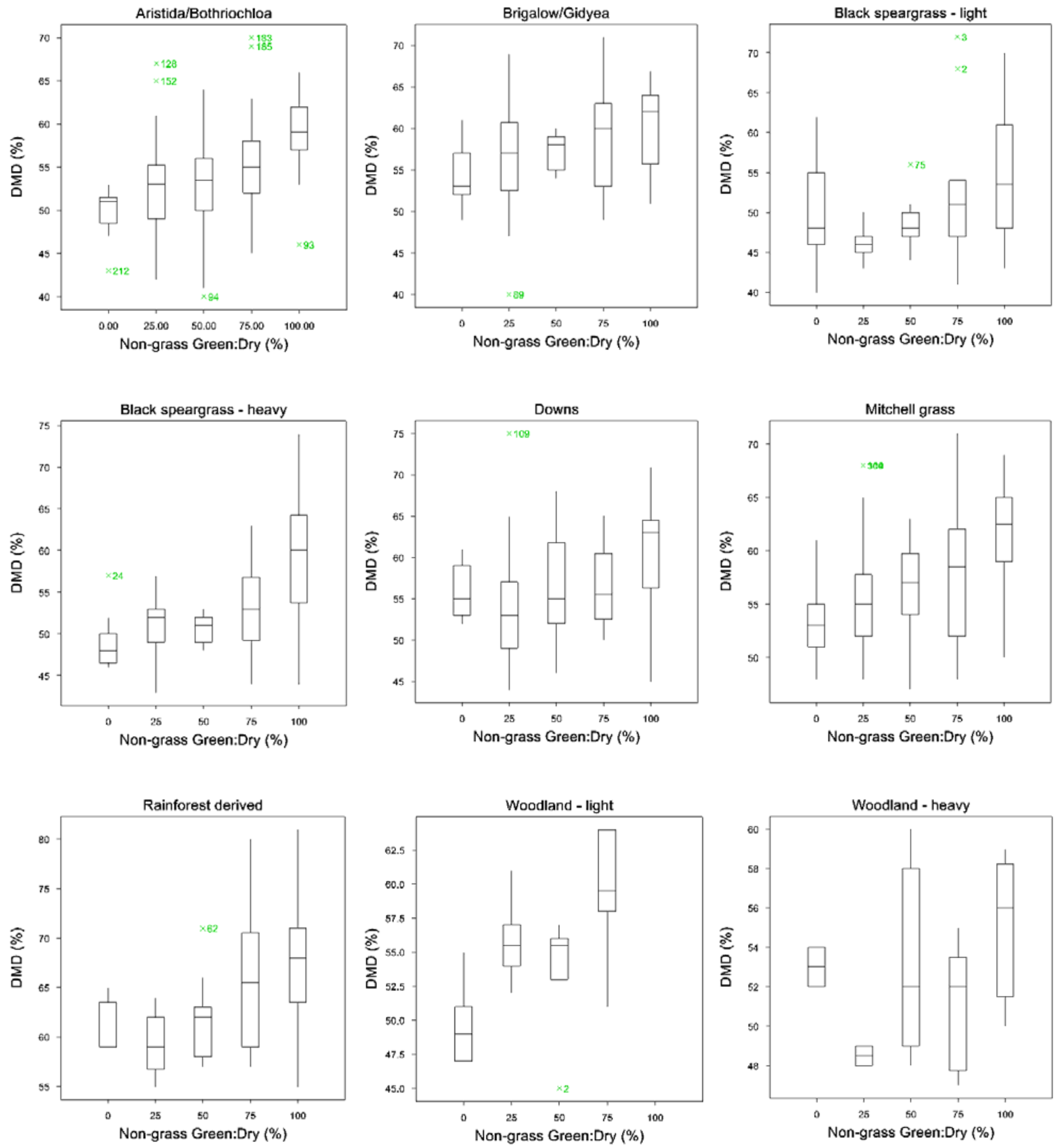


Figure 7. Effect of observed non-grass green:dry leaf ratio on NIRS predictions of DMD% for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

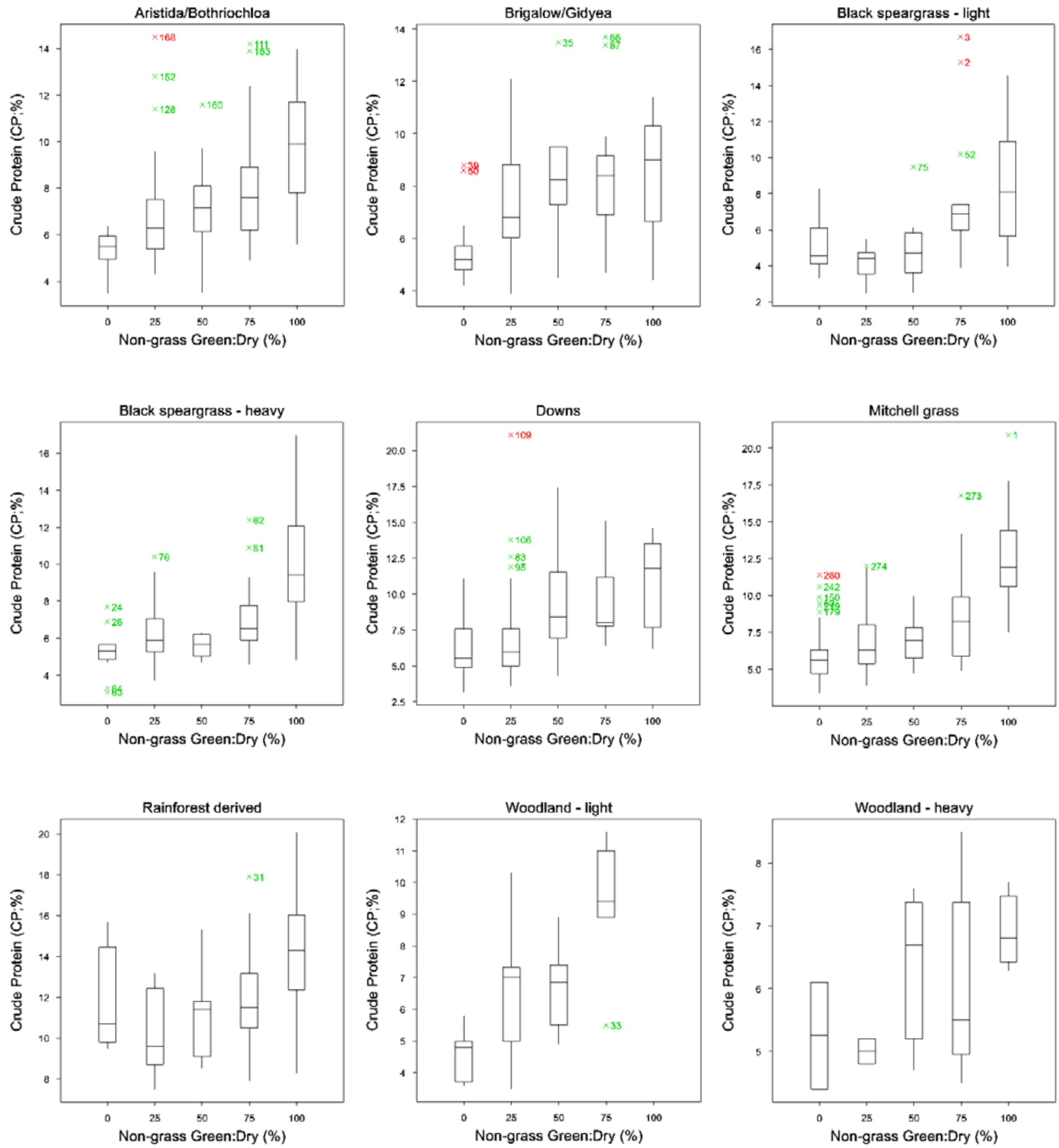


Figure 8. **Effect of observed non-grass green:dry leaf ratio on NIRS predictions of CP% for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)**

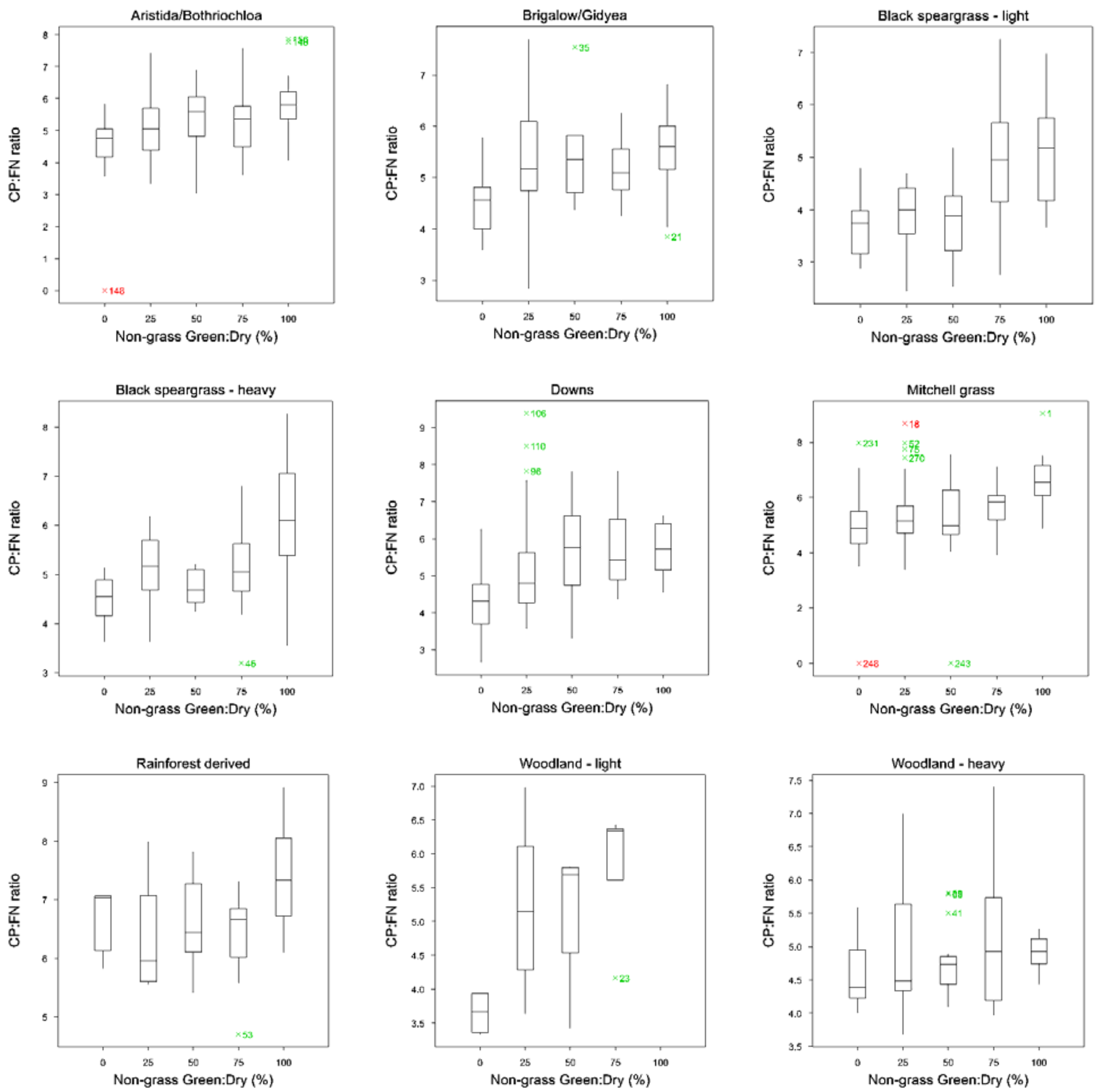


Figure 9. Relationship between the observed non-grass green:dry leaf ratio and the CP:FN ratio for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

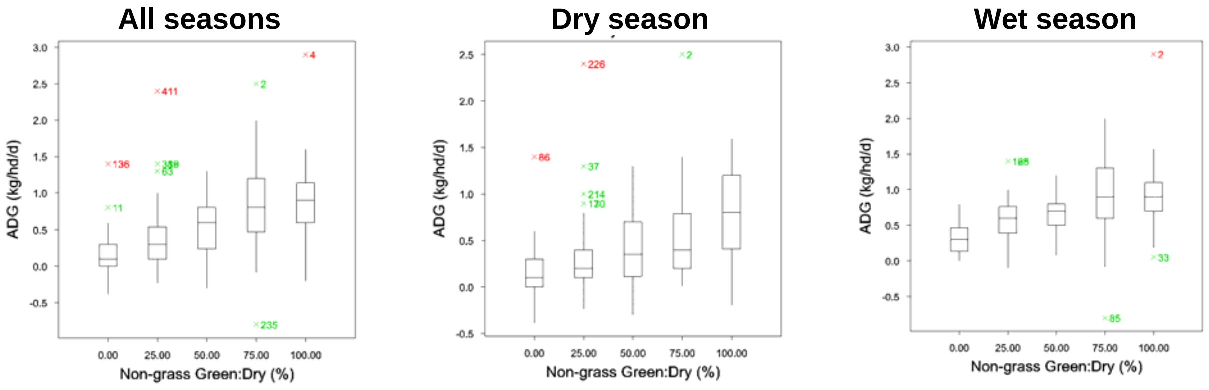


Figure 10. Effect of observed non-grass green:dry leaf ratio of the pasture on the NIRS prediction of ADG (kg/hd/d) of dry cattle across all seasons, the dry season and the wet season

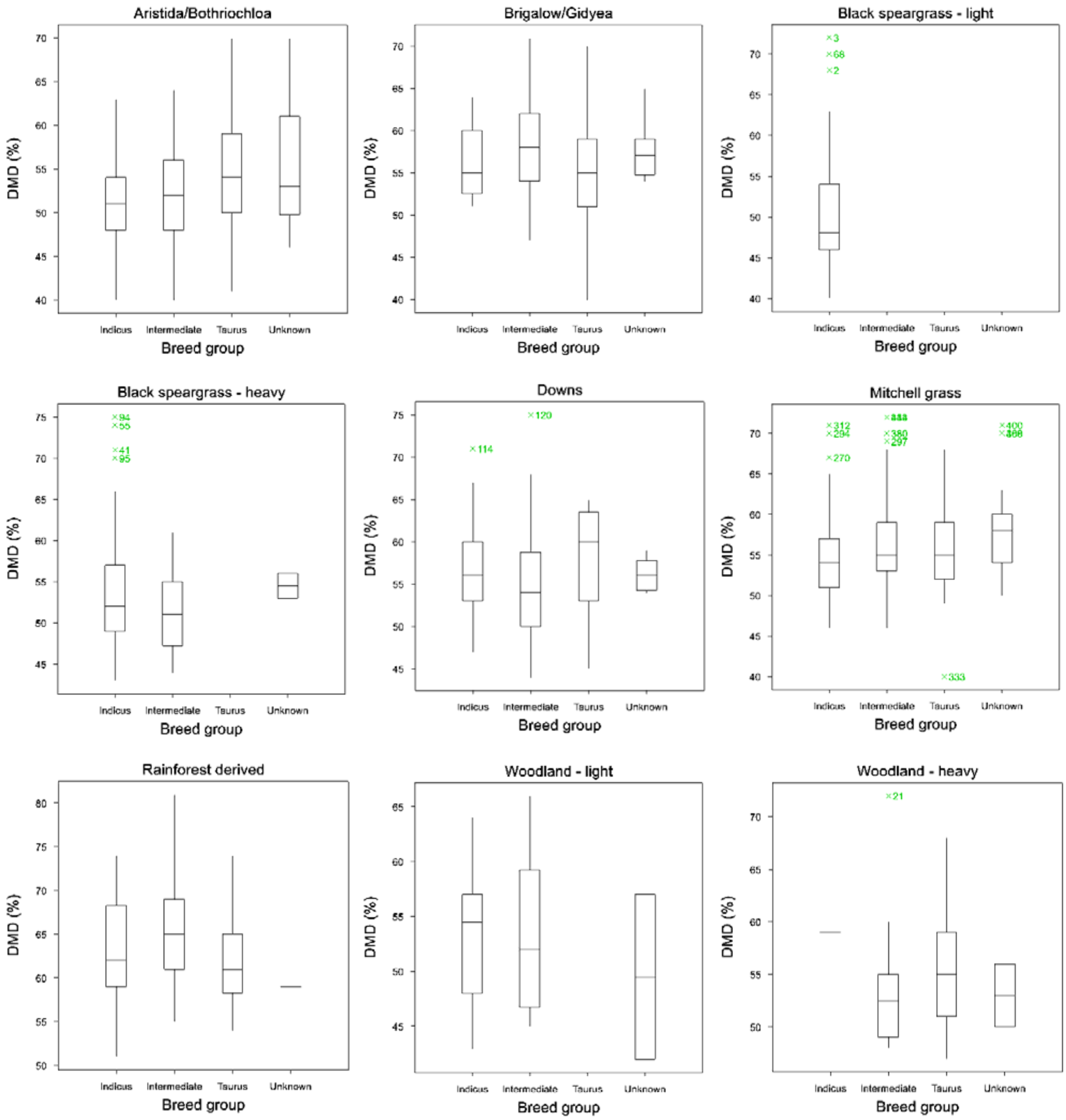


Figure 11. Effect of cattle breed grouping on NIRS predictions of DMD% for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

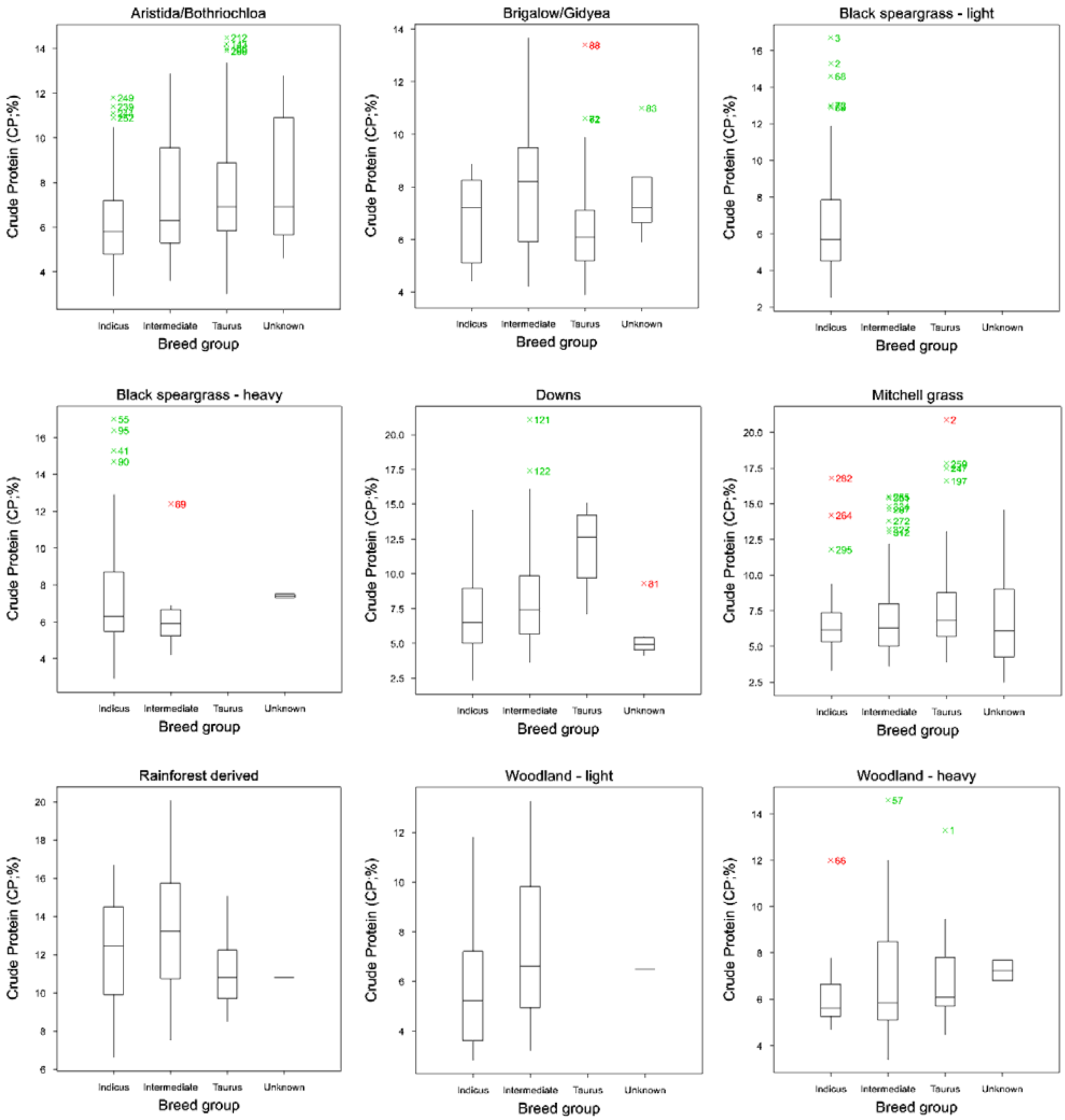


Figure 12. Effect of cattle breed grouping on NIRS predictions of CP% for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

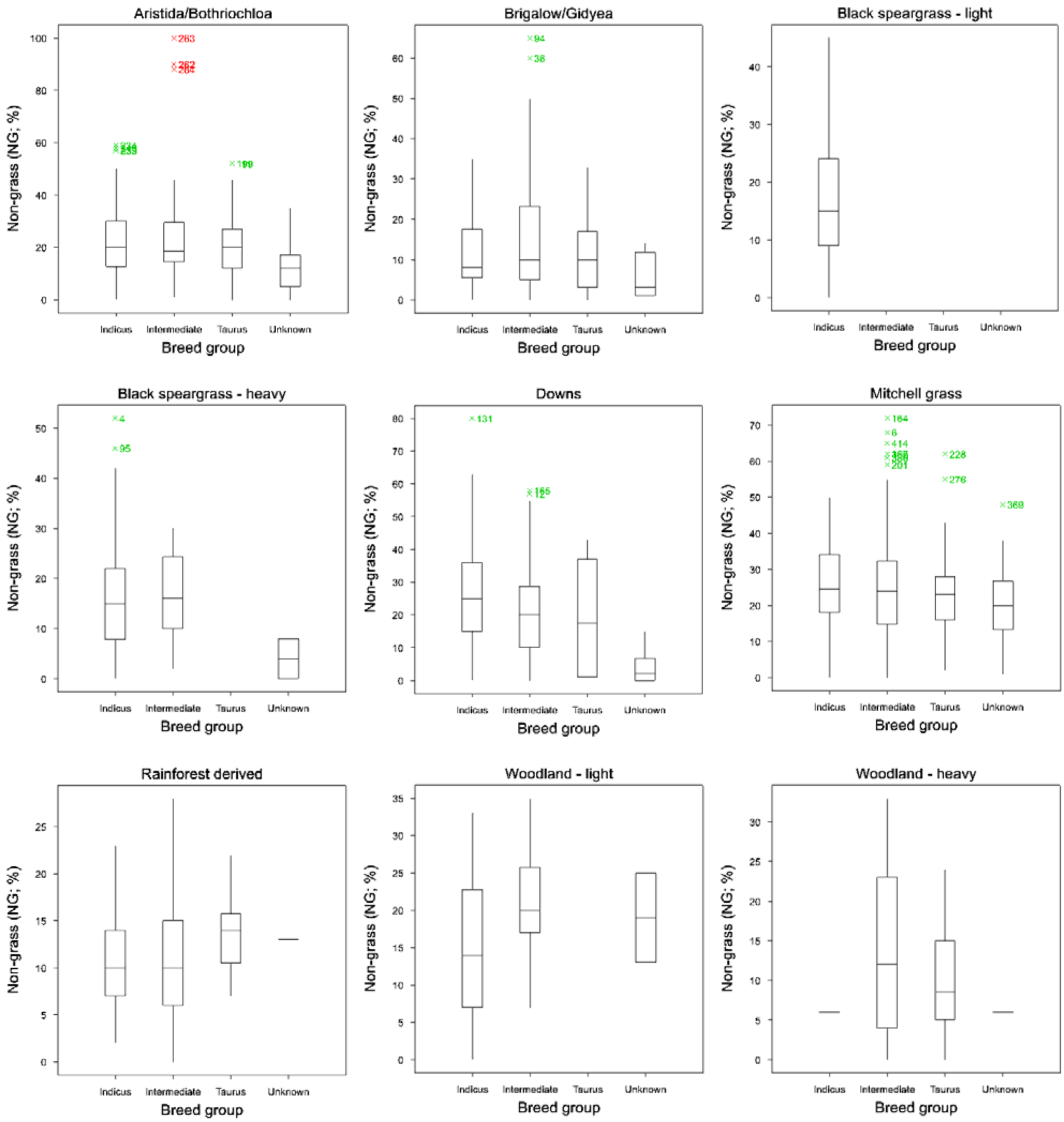


Figure 13. Effect of breed grouping on NIRS predictions of non-grass % for the land systems of Aristida/Bothriochloa (n=239), Brigalow/Gidyea (n=84), Black speargrass (light) (n=85), Black speargrass (heavy) (n=100), Bluegrass downs (n=124), Mitchell grass (n=271), Rainforest derived (n=81), Woodland (light) (n=32) and Woodland (heavy) (n=19)

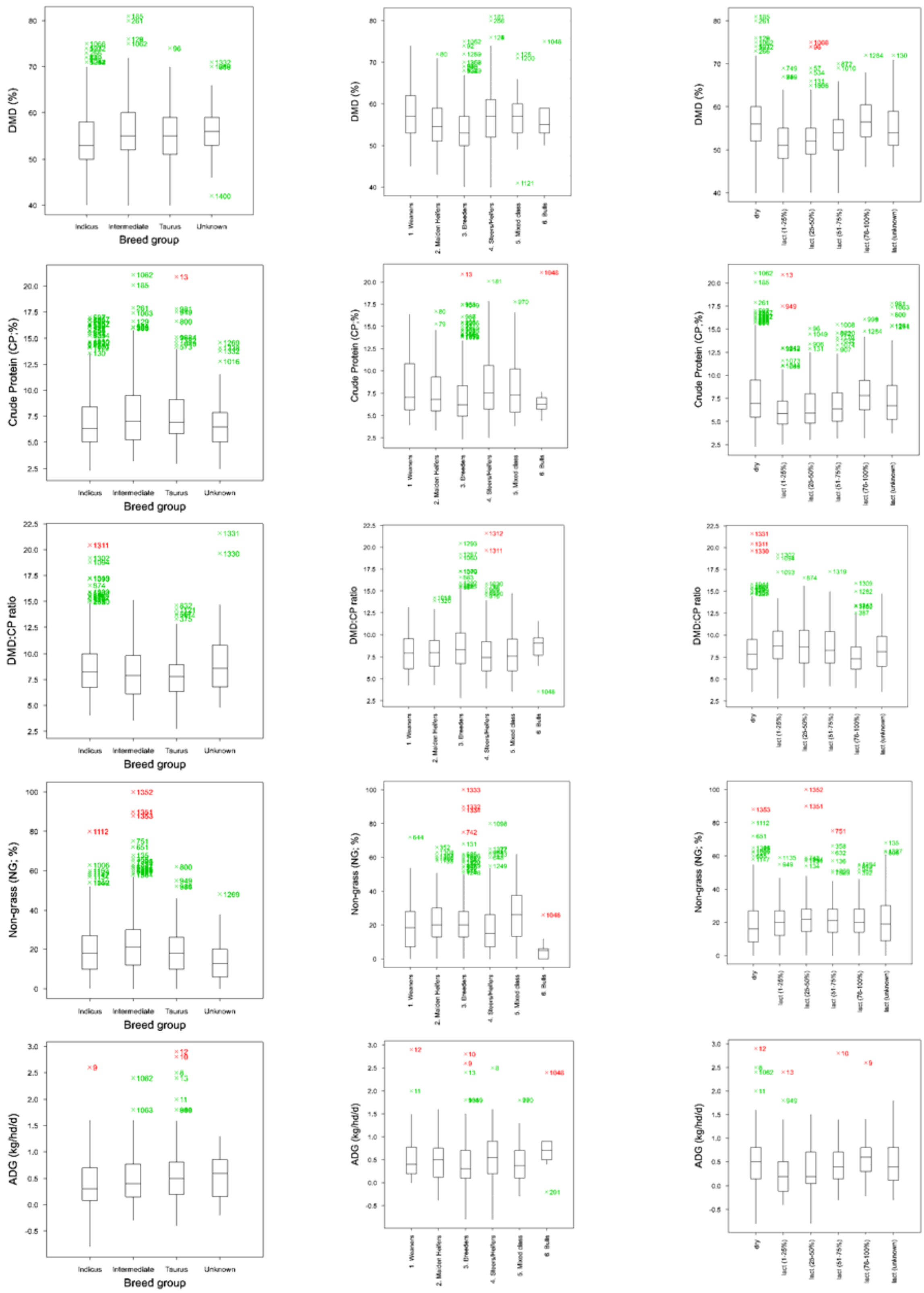


Figure 14. Effect of cattle breed (left), cattle class (middle) and lactation status of cattle (right) on the NIRS predictions of DMD%, CP%, DMD:CP ratio, non-grass % and average daily gain

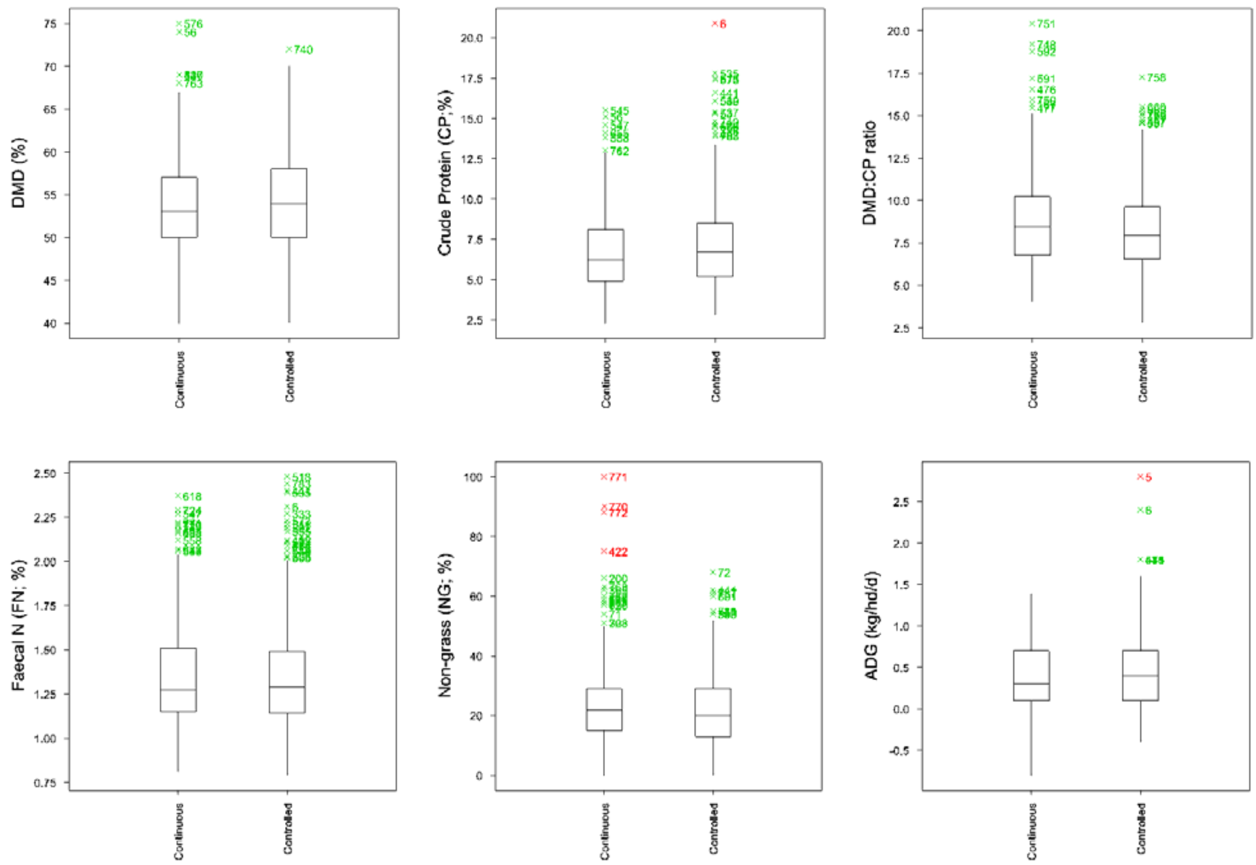


Figure 15. Effect of method of mating (for those with a mating type) on the NIRS predictions of DMD%, CP%, DMD:CP ratio, faecal nitrogen (FN%), non-grass % and average daily gain

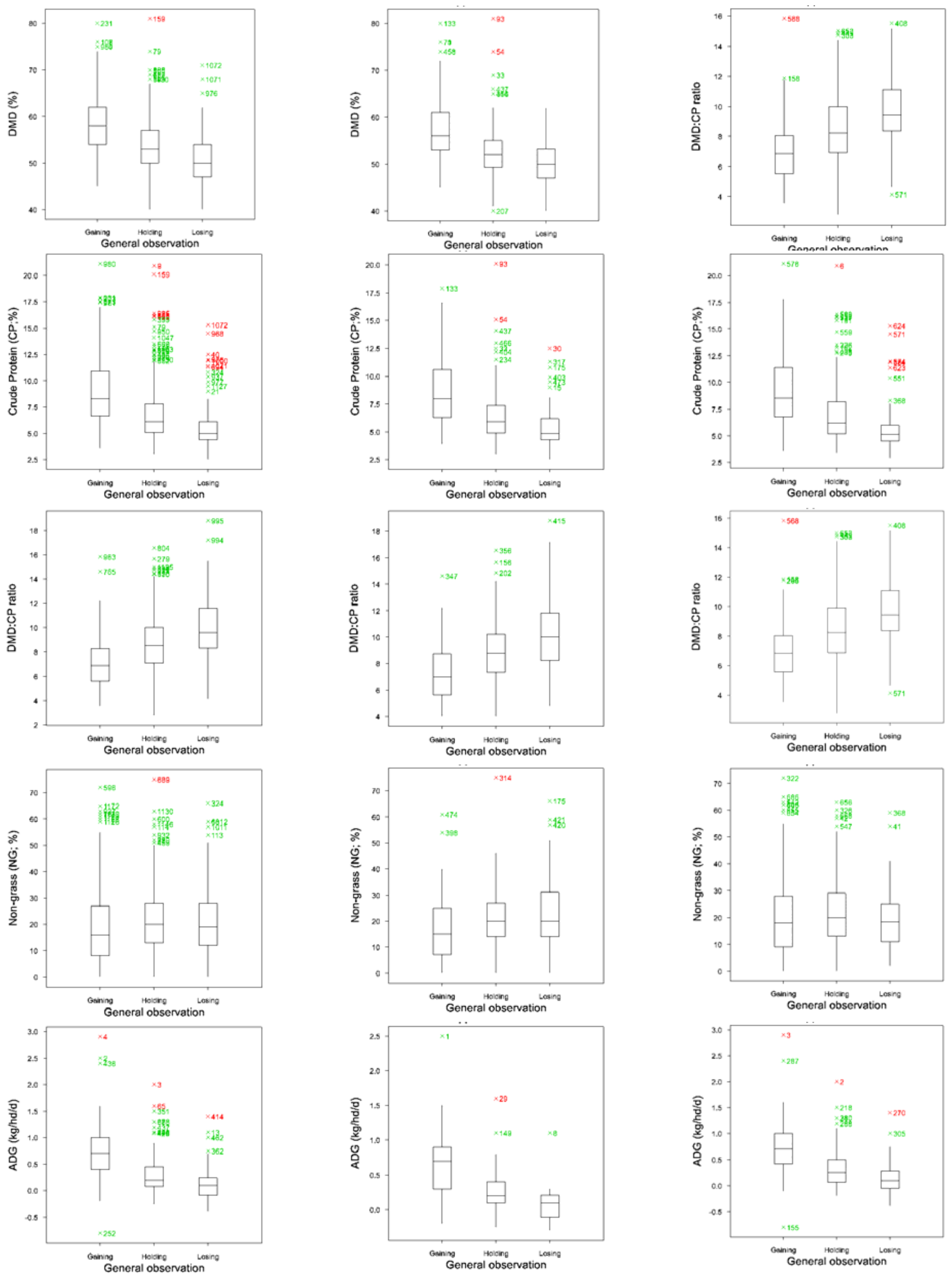


Figure 16. Relationship between the general observation of all cattle (left; n=1207), supplemented cattle (middle; n=517) and unsupplemented cattle (right; n=690) and NIRS diet predictions

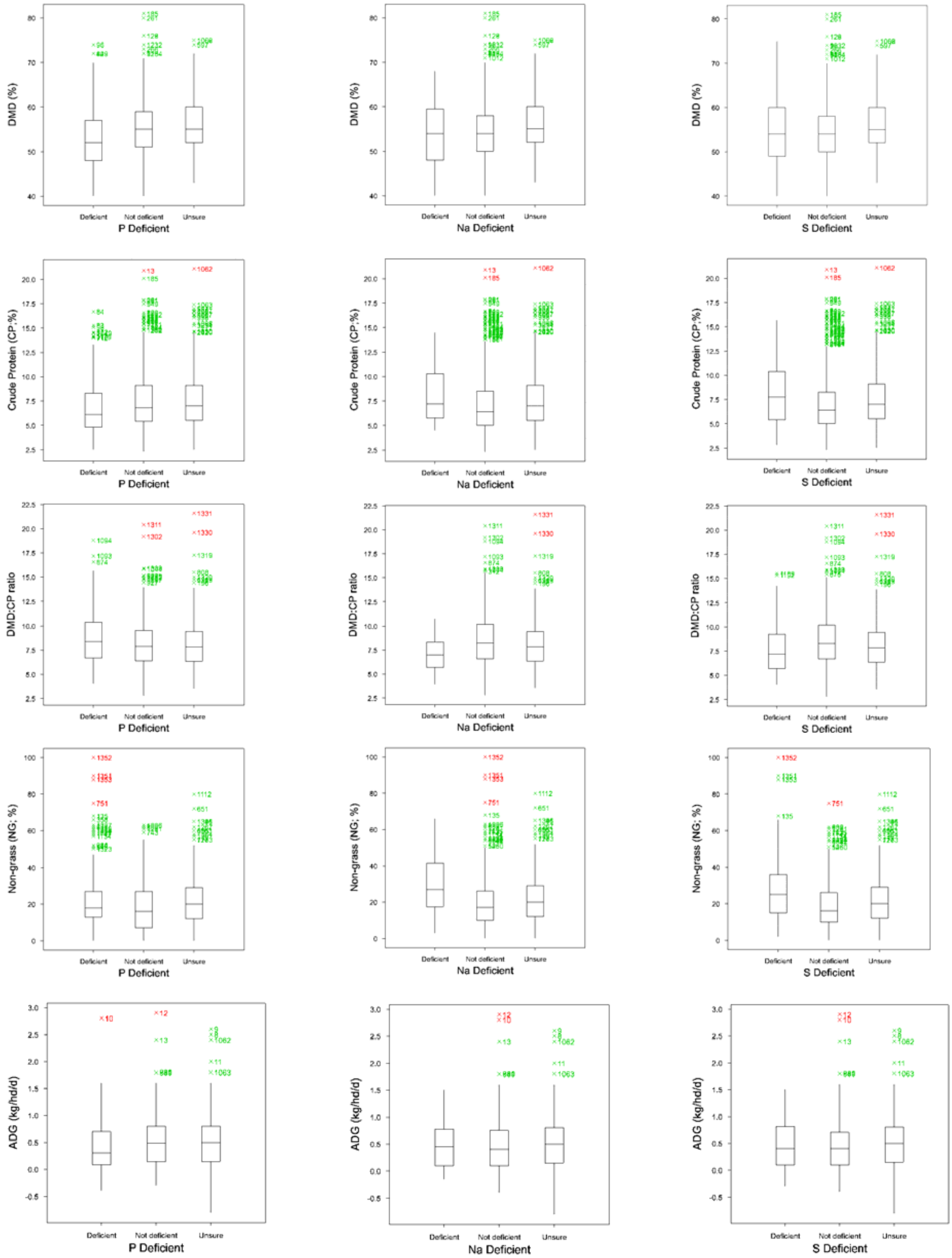


Figure 17. Effect of P deficiency (left), Na deficiency (middle) and S deficiency (right) on the NIRS predictions of DMD%, CP%, DMD:CP ratio, non-grass % and average daily gain (kg/hd/d)

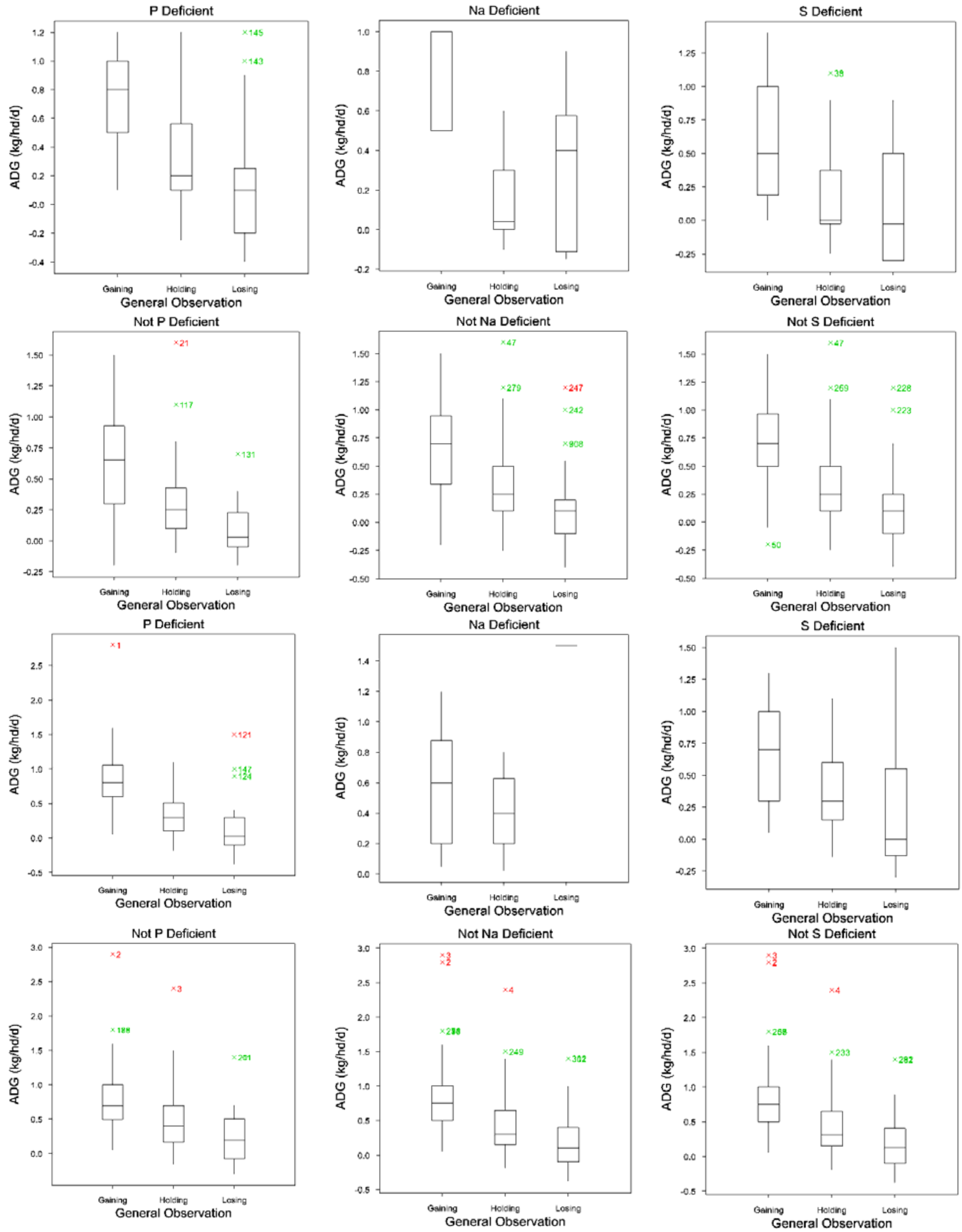


Figure 18. Effect of soil nutrition deficiencies on the relationship between the general observation and the NIRS prediction of average daily gain (kg/hd/d) with and without supplementation

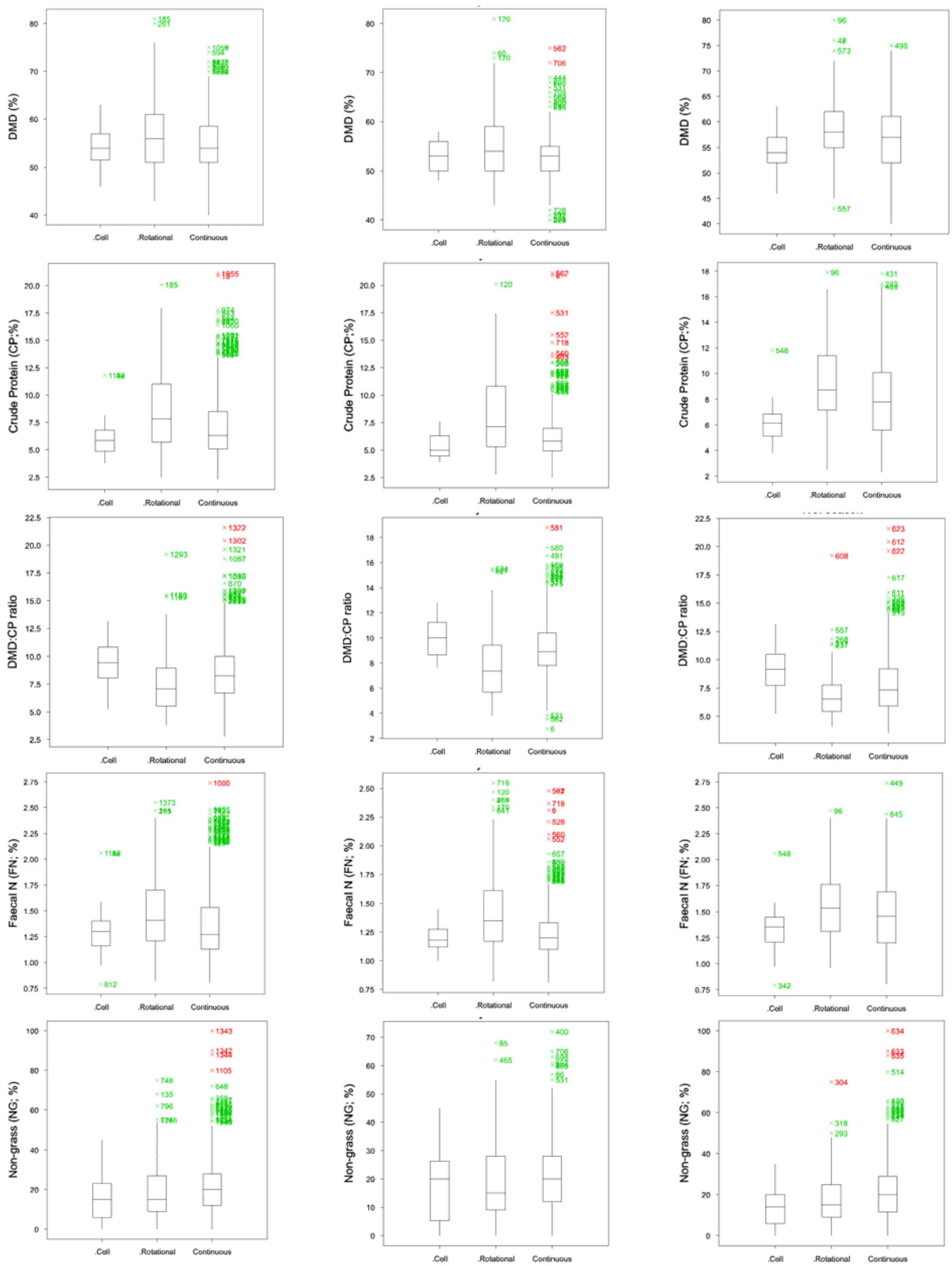


Figure 19. Effect of grazing system on NIRS predictions of DMD%, CP%, DMD:CP ratio, FN% and non-grass % across all (left; n=1419), dry (middle; n=745) and wet seasons (right; n=674)

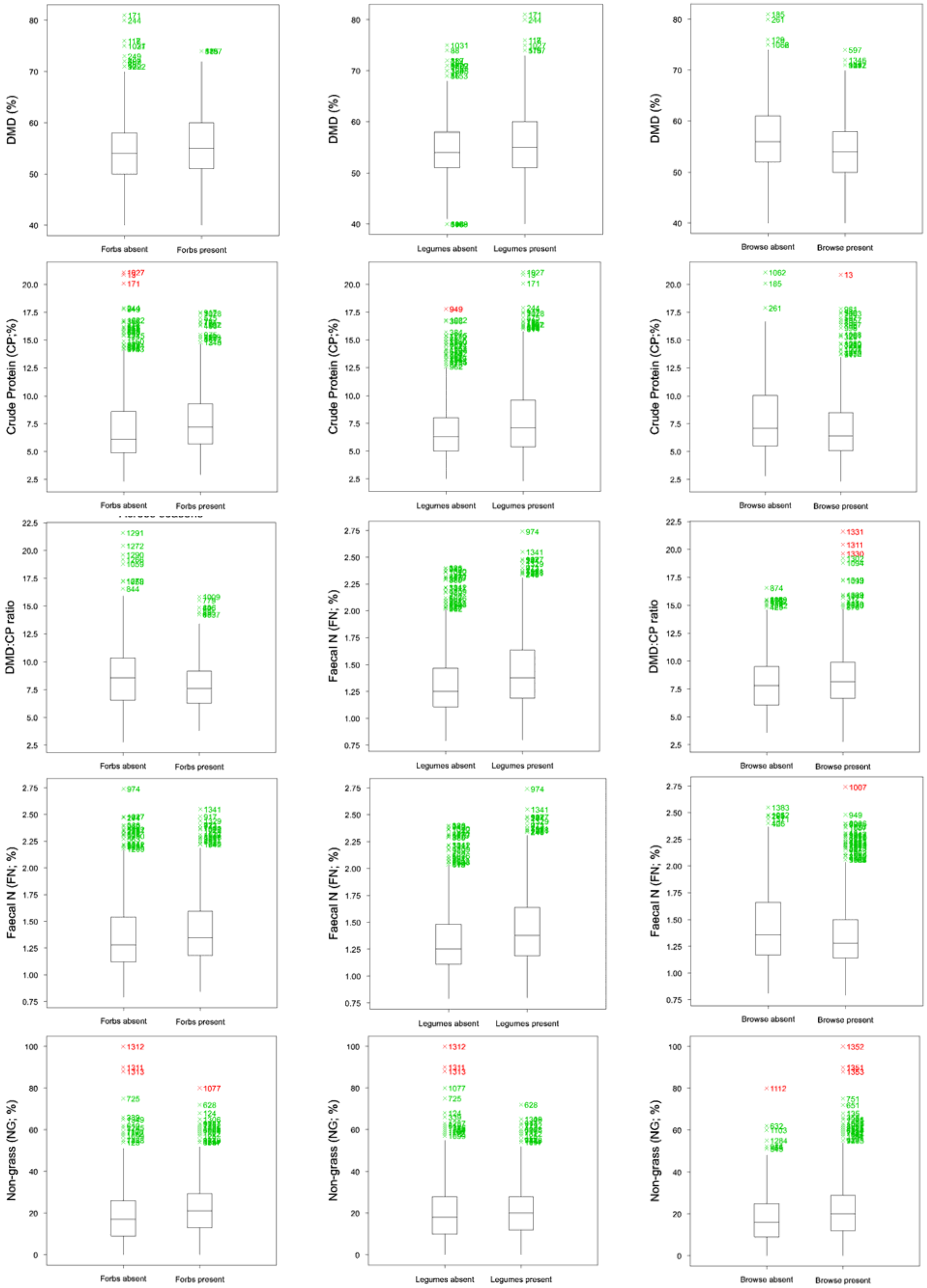


Figure 20. Effect of forbs (left), legumes (middle) and browse (right) on NIRS predictions of DMD%, CP%, DMD:CP ratio, FN% and non-grass %

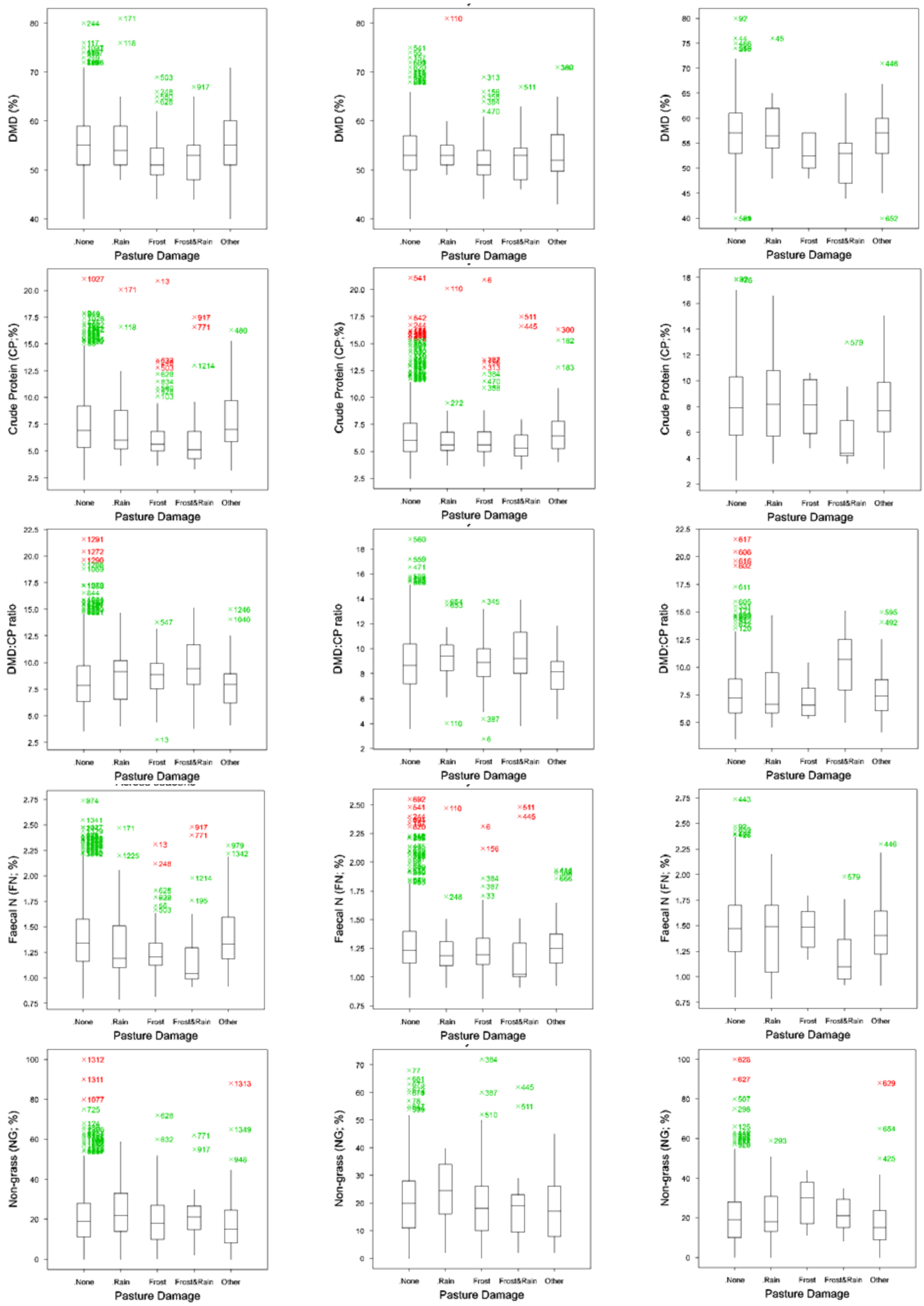


Figure 21. Effect of pasture damage on NIRS predictions of DMD%, CP%, DMD:CP ratio, FN% and non-grass % across all seasons (left), the dry season (middle) and the wet season (right)

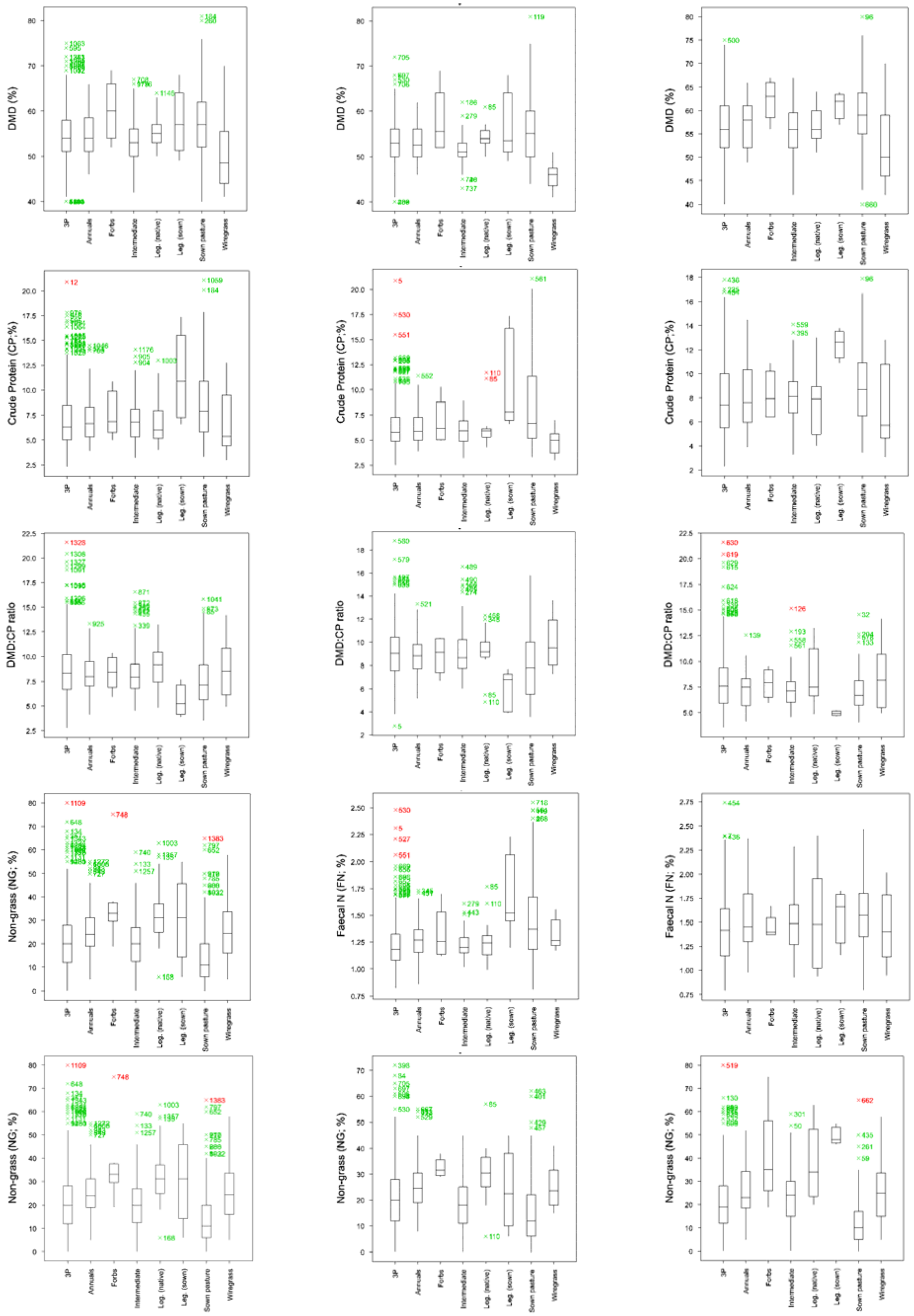


Figure 22. Effect of pasture grouping on NIRS predictions of DMD%, CP%, DMD:CP ratio, FN% and non-grass % across all seasons (left), the dry season (middle) and the wet season (right)

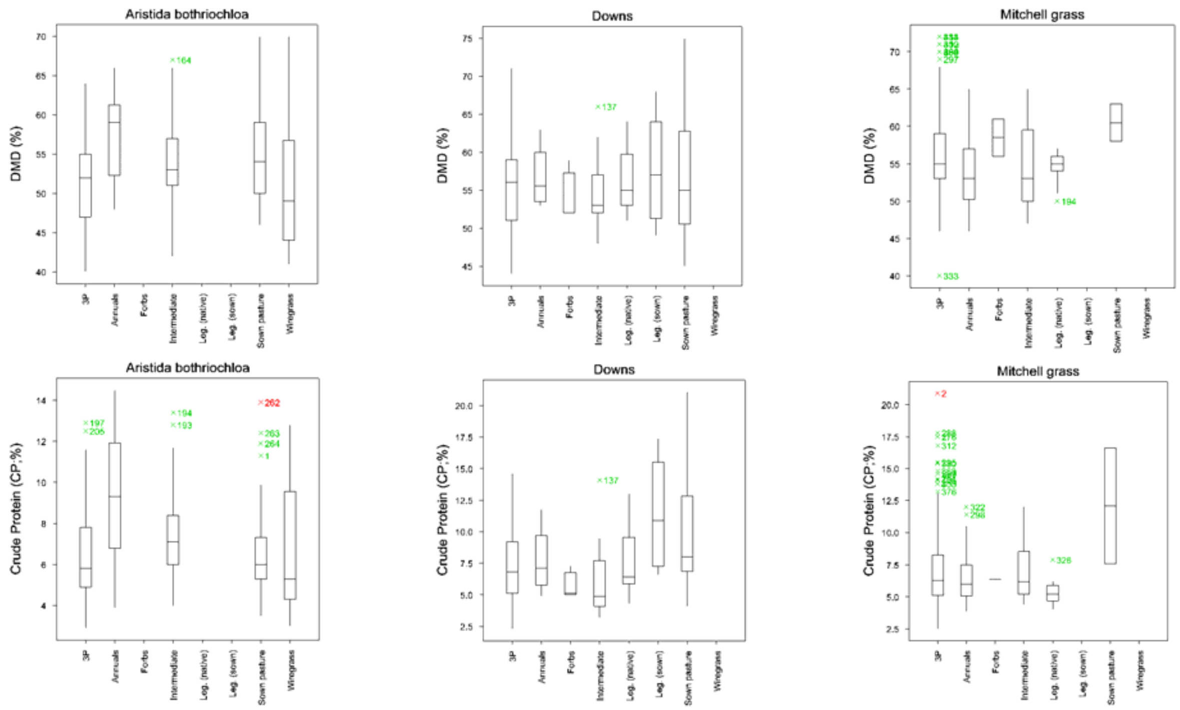


Figure 23. Effect of pasture species grouping on NIRS predictions of DMD% and CP% for the land systems of Aristida/Bothriochloa (left), Bluegrass downs (middle) and Mitchell grass (right)

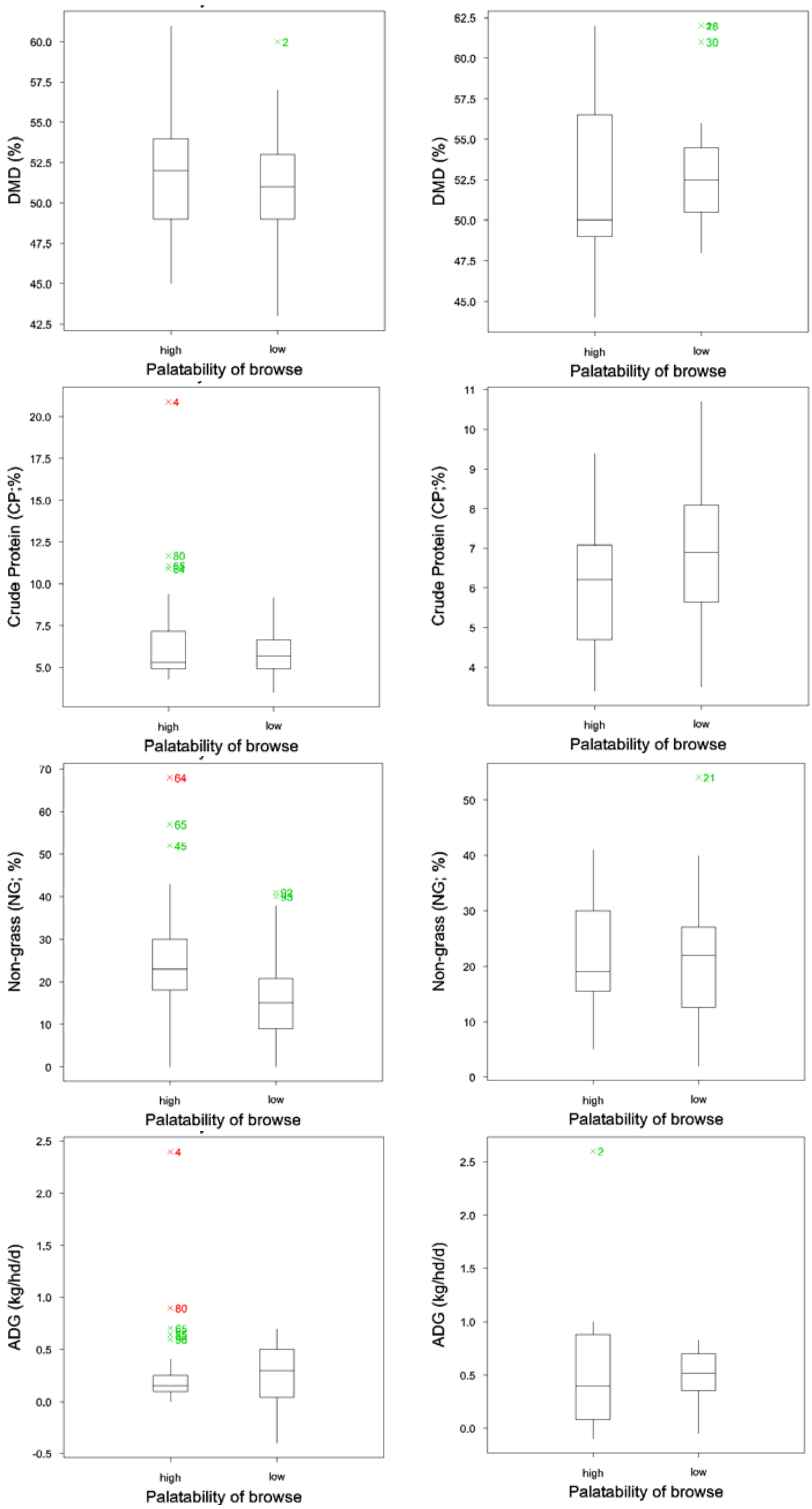


Figure 24. Effect of palatability of browse on the NIRS predictions of DMD%, CP%, non-grass % and average daily gain (kg/ha/d) in the dry season (left) and the wet season (right)

9.6 Appendix F – Fact sheets and communication activities

DPI&F NIRS Fact Sheets

Queensland **the Smart State**

DPI&F note

Faecal Near Infrared Reflectance Spectroscopy (NIRS)—a tool for predicting diet quality in grazing cattle

David Coates, formerly CSIRO, Davies Laboratory, PMB Aitkenvale Q 4814
Désirée Jackson, DPI&F, PO Box 519, Longreach Q 4730

What is NIRS?

NIRS is **Near Infrared Reflectance Spectroscopy**. It is an analytical technique using near infrared radiation that lies between visible light and infrared radiation. When near infrared radiation is beamed onto a substance the energy can be absorbed, transmitted or reflected. The amount reflected depends on both the physical and chemical properties of the material being analysed. Measuring the reflectance at individual wavelengths within the near infrared band produces a "reflectance spectrum" or NIR spectrum. Quantitative estimates or predictions of different attributes of interest (eg. protein) can be derived from NIR spectra using what we call **calibration equations**. Separate calibration equations have to be developed for each attribute.

How are the calibration equations derived?

Calibration equations are developed by relating the attribute values which are determined by a primary analytical technique (for example, determining the protein concentration in pasture samples using a conventional wet chemistry method) to NIR spectra of a large and diverse set of samples known as the **calibration set**. The attribute values determined by the primary method of analysis are called **laboratory reference values**. Complex mathematical procedures are used to develop the calibration equations which can then be applied to estimate the relevant attribute values from NIR spectra of "unknown" samples.

In most NIRS applications, laboratory reference values and the NIR spectra used for developing calibration equations are both derived from the same samples such as forage protein. However, **faecal NIRS** differs from other NIRS applications, at least for some of the attributes of interest. In faecal NIRS the NIR spectra are always obtained by NIRS analysis of faecal samples but, for properties such as diet quality, the laboratory reference values are determined, not on the faeces, but on representative samples of the diet. Nevertheless, the process of developing calibration equations by relating the NIR spectra to laboratory reference values, remains the same.

It is important to appreciate that predictions derived from NIRS calibration equations are not exact quantitative determinations. The accuracy of the prediction varies considerably with the attribute being predicted. In some cases the accuracy of prediction can be very good such as for nitrogen or protein concentration in forage samples. In other cases the accuracy of prediction may be quite poor, for example, forage intake in grazing cattle. In general, predictive accuracy for faecal NIRS determinations of attributes like diet quality (dietary protein and digestibility) will be less than the comparable determinations on forage.

At a glance

NIRS is an analytical tool based on spectral analysis using near infrared radiation.

Calibration equations are mathematically derived relationships between NIR spectra and quantitatively determined properties of a substance.

Faecal NIRS is just one of many applications of NIRS in agriculture and industry.

NIRS is a secondary method of analysis and the predictions or determinations of attributes are not exact. The error of prediction varies considerably between different attributes.

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What attributes can be estimated using faecal NIRS?

Calibration equations have been developed and are currently being used to predict a range of attributes relevant to the nutritional status of grazing cattle.

Dietary nitrogen or crude protein (CP)

Protein contains 16% nitrogen (N) so the terms dietary nitrogen and dietary crude protein mean much the same thing. Most people can relate better to protein levels rather than N concentrations. N concentrations can be converted to crude protein using the following conversion factor:

Crude protein (%) = 6.25 x N%

The amount of protein in the diet has a big influence on animal productivity. Diets high in protein are needed for high performance levels whether it be growth rate, milk production or pregnancy. Published requirements for dietary protein relative to different growth rates in cattle have generally been derived for British or European cattle grazing temperate pastures. There is a lot of evidence indicating that the protein requirements of Brahman cattle and the various Brahman-derived breeds are less than the currently recommended requirements.

Dry matter digestibility (DMD)

Digestibility is defined as the proportion or percentage of ingested food that is broken down and absorbed by the animal. It can be measured either as dry matter digestibility (DMD), organic matter digestibility (OMD) or as digestible organic matter (DOM). Digestibility provides an indication of the energy value of the diet; the higher the digestibility the greater the amount of metabolisable energy (ME) available to the animal.

Faecal nitrogen (N) concentration

Faecal N is the amount of nitrogen in the faecal material. It can also be expressed as faecal crude protein (CP) using the conversion factor of 6.25 mentioned above. Faecal N or faecal CP should not be confused with dietary N or dietary CP. Dietary CP is the amount of protein in the diet (i.e., what goes down the animal's throat); faecal N is the concentration of N in the faeces. Dietary CP is NOT calculated from faecal N. The calibration equations for the two attributes are completely independent. However, there is a correlation between dietary CP and faecal N: when dietary protein levels are low, faecal N concentrations are usually low; and when dietary protein levels are high, faecal N concentrations are usually high.

Dietary non-grass proportions

Grass (e.g. Buffel, Rhodes, speargrass, bluegrass, Mitchell, paspalum, couch, etc.) usually makes up the bulk of diets consumed by grazing cattle. In certain situations non-grass plant material can contribute in a major way to cattle diets. Non-grass plant material includes legumes (native or sown), other forbs and succulents (often called herbage) and browse or top-feed (eg. mulga, prickly acacia, mimosa, wattles, quinine, conkerberry, oak, myrtle, bauhinia, and scores of other shrubs and trees). The prediction of the amount of non-grass in the diet indicates the contribution that different plant groups make to the diet of grazing cattle at different times of the year and in relation to different seasonal conditions.

Growth rate

The reference values used in developing the calibration equation for predicting growth rate were derived predominantly from medium-framed steers (Brahmans, Brahman crosses and Brahman-derived breeds) between 1 and 3 years old. Consequently, the predictions relate best to what we may designate a "standard" animal, which is a 300 kg steer of medium frame size in store condition.

Other attributes

Calibration equations are currently being developed to predict other attributes of nutritional significance and these equations will be used to strengthen faecal NIRS technology sometime in the future.

Further information

For further information, contact the your local beef extension officer or Symbio Alliance. ■

Queensland the Smart State

DPI&F note

Collecting samples for faecal Near Infrared Reflectance Spectroscopy (NIRS)

Désirée Jackson, DPI&F, PO Box 519, Longreach Q 4730
David Coates, formerly CSIRO, Davies Laboratory, PMB Aitkenvale Q 4814

Introduction

The diet quality of a group of the same class of cattle grazing in the same paddock can be determined through the analysis of freshly excreted faecal samples. This provides an indication of whether an animal's diet is adequate, and with ongoing sampling, whether the quality of the diet is improving or declining.

Collecting the sample

With a gloved hand or using a plastic spoon, take approximately one or two tablespoons from 10 to 20 animals or fresh cowpats. Ensure that the quantity of sample taken from each cowpat is the same. Once enough individual samples have been collected, mix thoroughly and with a gloved hand, transfer 0.5 to 1 kg to a suitable plastic jar with a screw top lid, or to a ziplock plastic bag.

If animals can be run up a race, collecting samples from the rectum is the most ideal. Alternatively, collect samples from freshly voided dung in the yards or from the paddock. If any older cowpats are available, remove the top layer and take samples from the "fresh" dung underneath. It is critical that the sample is not contaminated with soil, mucus or dung beetles.

Label the sample container with the following information:

Paddock name

Date of sampling

Class of stock

The sample is now ready for drying or posting.

Posting the sample

It is now a requirement by Australia Post that samples that have not been dried must be sent in special shipping containers, which consist of plastic screwtop canisters inserted into a Styrofoam esky. The sample should still be in its plastic ziplock bag or plastic 250-ml screwtop container, which is then inserted into the larger 1-litre plastic screwtop canister. Alternatively, sample kits can be obtained from Symbio Alliance (phone (07) 3340 5700).

Getting your results

Results can be faxed or e-mailed. Included in the analyses are:

1. Dietary nitrogen or crude protein (CP)
2. Dry matter digestibility (DMD)
3. Faecal nitrogen (N) concentration

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4. Dietary non-grass proportions
5. Growth rate
6. Other attributes

A description of each of the above analyses can be found in the DPI&F Note:
"Faecal Near Infrared Reflectance Spectroscopy (NIRS)—a tool for predicting diet quality in grazing cattle".

At a glance

- Samples must be taken from fresh cowpats only – no more than two hours old.
- Ensure samples are not contaminated with soil or plant material, or taken from cowpats where there have been dung beetles.
- Take a bulk sample from 10 to 20 animals of the same class running in the same paddock.
- Keep the sample cool or freeze it.
- Keep the faecal samples as cool as possible until you reach home. The sample must be either be frozen or dried prior to sending.
- Samples should be collected every 4-6 weeks, to determine whether diet quality is increasing or decreasing, to allow appropriate nutritional management.

For further information, contact your local beef extension officer or Symbio-Alliance.

Queensland the Smart State

DPI&F note

Sun-drying faecal samples for Near Infrared Reflectance Spectroscopy (NIRS) analysis

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David Coates, formerly CSIRO, Davies Laboratory, PMB Aitkenvale Q 4814

Preparing faecal samples for NIRS analysis

Faecal samples can be sent for analysis either fresh or frozen, or dried. The advantage of drying a sample is that it reduces the processing time at the lab for NIRS analysis, so the sample can be analysed more quickly and you will receive your results sooner. The cost of sending frozen/fresh faecal samples is much higher than for dried samples, and there are special packaging requirements for mailing frozen/fresh samples.

Drying methods

There are two methods of drying faecal samples: oven drying and sun drying. Both methods of drying are acceptable, however, if samples are oven-dried, the oven temperature should be no higher than 65˚C. Most conventional ovens are incapable of drying at this low temperature, so this method of drying is usually reserved for laboratories. Faecal samples that are dried at high oven temperatures cannot be analysed.

In terms of the effect of the two drying methods on the NIRS results, there is an effect on the digestibility prediction when a sample is sun-dried. Digestibility predictions on average, are about 1.5% lower for sun-dried faecal samples than for oven-dried faecal samples. It is important to indicate whether the sample is sun-dried or oven-dried when it is sent away for analysis.

Instructions for sun-drying samples

Faecal samples can be sun-dried easily at home. It takes approximately a day to dry the sample and then once the sample is put into a plastic bag and sealed off, it can be posted as per normal mail.

1. Place the bulk sample can be placed on an aluminium cooking tray or some aluminium foil or some other non-absorbent sheet such as galvanized iron.
2. Spread the sample out to a thickness of 1 cm, ensuring that the sample stays in one piece. This makes it much easier to turn the sample over to dry the other side.
3. Label the sample, particularly if there is more than one sample, to avoid losing the correct identity of the sample(s).
4. Place the sample up high, in a sunny position, such as a rain water tank, where it is free from wind, dogs and dung beetles. A cover of mesh or gauze can also be placed over the sample to prevent the wind from blowing it over.
5. The sample can be turned over after approximately twelve hours to dry the bottom side.
6. Once the sample is dry, it is important that it is allowed to cool thoroughly before it is ready for posting.
7. Samples can be sent to Symbio Alliance for analysis. Contact Symbio Alliance (phone (07) 3340 5700 or visit www.symbioalliance.com.au) for further information on analysis costs and posting samples.

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Important

- Ensure that your sample is thoroughly dried and cooled down prior to posting for analysis. Samples that aren't prepared properly will develop mould and cannot be analysed.
- If you oven-dry your sample, ensure that it is dried at a temperature of no higher than 65° C or the sample cannot be analysed.

For further information contact your local beef extension officer or Symbio Alliance.

9.7 Appendix G – Producer notes explaining NIRS and interpretation of results

1. Introduction to NIRS

Sent with the first sample results

Reliability of predictions. Being your first samples I must start off by saying that I cannot guarantee the accuracy of the predictions. Even when the calibration (prediction) equations are improved there will always be some error involved. In most cases however, the predictions will provide a useful guide and certainly better than any alternative method. As an example, true or actual dietary crude protein (CP) will usually be within 1% of predicted dietary CP for most samples.

Effect of supplement on predictions. Where cattle are being fed supplement it should be understood that predictions relate only to the forage component of the diet; they take no account of the supplement being eaten. A reasonable estimate of the crude protein content of the total diet (forage plus supplement) can be calculated if the daily intake and composition of supplement is known. In this calculation an assumption has to be made regarding the forage intake (e.g. 1.6-1.8% of liveweight for dry stock on dry feed).

Growth rate estimates. The growth rate predictions (Liveweight Gain) that are now included in the results provide another indication of the nutritive quality of the diet, but the estimates should be viewed with caution according to the following qualifiers:

The calibration equations used to make the predictions cannot be considered to be reliable at the current stage of development and therefore estimates are mainly for interest at this stage.
The estimates refer to medium frame, young steers (200–400 kg liveweight). If, for example, the sample comes from breeders, then the growth rate prediction relates to what we would expect if steers were running in the paddock.

The estimates are for steers without HGP and without any supplement. With HGP or protein supplement, the actual growth rates should be higher than the predicted growth rates.
Where compensatory growth is significant (e.g. early in the wet season, especially following a severe dry season) then actual growth rates will probably be higher than predicted growth rate.
If some other factor besides dietary protein and energy is limiting growth rate (e.g. mineral deficiency, parasites, disease, small amount of feed on offer) then current NIRS predictions will probably overestimate growth rate.

Estimates relate to growth rate at the time samples are collected. Therefore, they cannot be compared with calculated growth rate where cattle are weighed periodically, but at extended intervals.

Queries contact: Your local NIRS coordinator

2. Measuring the diet quality of your cattle by analysing dung

A new technique to measure the quality of the diet cattle select from grazing pastures is under development and evaluation by DPI, CSIRO and MLA. It is using NIRS (near-infra red reflectance spectroscopy) as an analytical tool, based on the spectral analysis of near infrared radiation reflected from a dried ground dung sample, and comparing results with the reflectance from numerous samples of known feed quality. Faecal NIRS is one of many applications of NIRS in agriculture, for example protein in wheat can be determined using this technique.

Understanding the diet quality selected and the condition of your pastures will help planning marketing and supplementation decisions, aimed at improving your profitability.

The feed quality attributes that are estimated using faecal NIRS include:

a. Dietary nitrogen or crude protein (CP)

This measure indicates the level of protein the animal selects from the pasture. Protein contains 16% nitrogen (N) so the terms dietary nitrogen and dietary crude protein are related. The amount of protein in the diet has a major influence on animal productivity. Diets high in protein are needed for high performance levels, including growth rates, milk production or fertility.

b. Dry matter digestibility (DMD)

Digestibility is the proportion of ingested food that is broken down and absorbed by the animal. It provides an indication of the energy value of the diet. The higher the digestibility level, the greater the amount of metabolisable energy (ME) available to the animal for maintenance, reproduction and growth.

c. Faecal nitrogen (N) concentration

Faecal N is the amount of nitrogen in the dung. Dietary CP is not calculated from faecal N. The calibration equations for the two attributes are independent. However, there is a correlation between dietary CP and faecal N: when dietary protein levels are low, faecal N concentrations are usually low; and vice versa.

d. Dietary non-grass proportions

Grass (e.g. buffel, bluegrass, Mitchell, windmill, wiregrass etc) usually makes up the bulk of diets consumed by grazing cattle. At times of the year there can be high proportions of non-grass plant material eaten. This includes legumes, other forbs and succulents (herbage), as well as browse or top-feed trees and shrubs (e.g. mulga, wattles, myall). Poor seasonal conditions and different soil types can contribute to the amount of non-grass grazed by cattle.

e. Liveweight growth rate

The calibration equations for predicting growth rate (in kg/day) were derived predominantly from medium framed Brahman crosses steers, about 300 kg in store condition, between 1 and 3 years old.

There is a current project where producers can submit sun-dried dung samples and have the results interpreted, showing the quality of the diet their cattle are selecting from grazed pastures.

For further information, contact your NIRS co-ordinator.

3. NIRS - Sun Drying samples

The preferred alternative to posting fresh/frozen dung samples

Sun drying of samples is the preferred alternative to sending fresh/frozen dung.

Tests to date comparing the NIRS predictions on oven dried versus sun dried samples, show the predictions aren't affected by the drying method, except for a small decrease in digestibility with sun drying. The digestibility predictions on sun-dried faeces average about 1.5% lower than those on oven-dried faeces. This difference is corrected in the results.

Sun drying should be done according to the following protocol:

The faecal sample to be dried (about 10 spoon fills) should be placed in a sunny location on a piece of clean, flat galvanized iron or other non-absorbent sheet, such as a metal tray (kitchen dish), laminex or alfoil (not wood or fibro).

The sample should be spread out, like a pancake to a thickness of about 10 mm or less.

After about 4 hours in hot sun, the sample should be turned over using a suitable "egg slice", such as a suitable sized piece of tin or galvanised iron. Try to keep the sample in one piece at this stage if it is likely to blow away.

After another 4 hours the sample should be dry provided the weather remains hot and sunny.
Once the sample has been turned over there is the risk of wind blowing it off the drying tray. Simply put a piece of chicken mesh over the sample to prevent it being shifted by wind.

Sun dried samples can then be broken-up and placed in labelled zip-lock plastic bags for posting to CSIRO, Davies Laboratory, PMB, Aitkenvale Q 4814.

Send the completed Field Data Collection Sheet to Davies Lab. and a copy to your NIRS coordinator (e-mail is preferred, alternatively fax or post).

You may have to make provision to stop dung beetles and blow flies messing up the samples, or interference by dogs or chooks! Use a high location, e.g. tank stand, and flyscreen gauze or netting cover as appropriate.

If you are drying more than one sample, care must be taken to avoid losing the correct identity of the samples. The field sheet and sample must be identified the same.

Once dried, the samples do not need to be kept refrigerated, but they should be stored in a cool, dry place and posted as soon as convenient. You can post the dried samples in any strong envelope or padded bag, and you don't need to wrap them in newspaper, so postage is simpler and cheaper than sending fresh or frozen dung sealed or in an esky.

4. NIRS predictions - Break of season effects on Live Weight Gain

Predicted LWG values indicate the potential for growth in relation to the quality of the diet and assume that there is no limitation in the amount of feed on offer and that the cattle are adapted to the diet. Both these assumptions are not likely to be met immediately after the break of the season when the green pick is short and when cattle are still adjusting to the change in diet, from low quality dry grass to high quality green feed.

There can be a number of different scenarios depending on the amount and distribution of dry stand-over feed.

Where there is a lot of standing dry feed the new green shoot will not likely be readily accessible and though the cattle would try to select for the green component they would be unable to avoid eating dry feed with the green shoot. In this case the diet would be a mixture of high quality green leaf and poor quality dry feed.

Where there is little stand-over dry feed the green pick will be accessible so the grazing cattle may be able to select a diet that is almost entirely high quality green material. However, until some bulk develops, intake will be limited by the amount on offer and the difficulty of harvesting the short, green pick. In this case growth rate would be limited by low intake rather than quality. Moreover, the change in diet from old, dry feed to very high quality green feed is likely to be abrupt and the cattle take a week or two to adjust to the new diet in the context of rumen microbial composition, activity and efficiency. So whereas the new diet has the potential, based on quality, for high growth rate, actual weight changes may be quite different in the short term. There can be considerable gut loss as the diet changes to lush green feed from the dry winter feed, so there is an actual live weight loss, while the quality of the diet suggests potential for a rapid liveweight gain. This loss period usually only lasts several weeks, providing there is sufficient new green feed available to satisfy intake requirements.

5. Diets high in native browse trees and shrubs

When the protein content of the grass declines to low levels during the dry season, cattle in woodlands, forest or scrub country, often start browsing on shrubs and trees. The protein level in browse leaves is much higher than in dry grass, so the protein content of the diet is elevated when cattle start browsing. However, the leaves of many browse species contain condensed tannins. Once the leaves are chewed these tannins are released and “bind” on to the protein, so that a proportion of the protein becomes unavailable to the rumen microbial population. Some of the bound protein may become available for digestion in the small intestine, but the net effect of the condensed tannins is to reduce the overall availability of plant protein for digestion and absorption by the animal.

Importantly, the unavailability of bound protein in the rumen may lead to a deficiency of rumen degradable nitrogen and depressed microbial activity. So while diets high in browse may be reasonably high in protein at face value, such diets may in fact be protein deficient due to the effect of the condensed tannins. Browse species, especially the various Acacia species such wattles, Brigalow, Myall, Mulga and so forth are also high in fibre and have low digestibility. So the faecal NIRS predictions for diets high in browse are often characterized by relatively high dietary crude protein, but low digestibility. This contrasts with diets high in forbs, especially legumes, where both crude protein and digestibility predictions are usually high.

6. Digestibility / Protein ratio (DMD/CP) of the diet of grazing cattle

Most of the digestion of forage in cattle takes place in the rumen by the rumen microbial population. Like other animals these microbes need both energy (which they obtain by breaking down the plant fibre) and protein (most of which they obtain by breaking down the protein in the forage). The fraction of the protein in the forage which the microbes can access and utilize is called rumen degradable protein (RDP). If there is insufficient rumen degradable protein for the available energy, then the forage digestion is reduced, intake of pasture is reduced and animal productivity decreases. Importantly, the amount of energy and rumen degradable protein must be balanced - the greater the amount of energy available from forage the greater is the requirement for rumen degradable protein.

Thus with low digestibility forages, the energy availability is low and the requirement for rumen degradable protein is low, but the reverse applies with high digestibility forages. As summer grasses mature and dry off, protein generally declines more rapidly than available energy so that it is the rumen degradable protein which is often in short supply with dry season pastures. This is why supplementing with protein meal or urea in loose mix or licks can increase animal production. (Strictly, urea is not protein, but it can be used by the rumen microbes in the same way as the protein in protein meals or forage to synthesize microbial protein).

It follows that cattle responses to supplementary rumen degradable protein (or the equivalent as urea supplement) depends on both the protein and energy contents of the diet. We can use the faecal NIRS measurements of diet protein concentration as a measure of the availability of rumen degradable protein, and diet digestibility as a measure of energy availability. Thus the ratio of digestibility to crude protein (DMD/CP) as measured with faecal NIRS is a useful index to indicate whether cattle are likely to respond to urea supplements.

The DMD/CP threshold value above which cattle are likely to respond to urea supplement may differ with the pasture system and the breed of cattle. However, when the DMD/CP ratio is 10 or greater, a response to urea supplement is highly likely. A response may occur when the DMD/CP ratio is in the range between 8 and 10, particularly for more coastal areas such as speargrass pastures. The value of 10 indicating nitrogen deficiency, is a best-bet estimate based on current knowledge, and is likely to be refined as we accumulate more information and experience.

Note to assist managers to interpret NIRS results and understand the meaning of the DMD/CP ratio as an index of when cattle are likely to respond to urea-based supplements. The autumn – winter period is when the ratio is likely to approach the critical 10 level and the NIRS results can be used to decide when to commence feeding urea-based supplements.

7. Green-dry forage mixtures

Predictions of diet quality are generally under-estimated when there is dry stand-over feed with a green shoot. The diet on this feed consists of a mixture of green and dry feed. The green portion is high in leaf and of very high quality and it is highly digestible. The dry part is of very low quality and of very poor digestibility. This means that the dung is dominated by the undigested residues of the dry feed, and this leads to under-estimation of the quality of the overall diet by faecal NIRS. The effect is probably even more pronounced with respect to predicted digestibility than with respect to predicted dietary Crude Protein, though both attributes tend to be under-estimated.

8. Effects on faecal NIRS predictions when molasses is fed with grass hays

When molasses (plus 50 g urea) was fed at the rate of 0.6% liveweight to steers given grass hay in pens, faecal NIRS predictions were affected. The grass hays fed were blue couch, Indian couch, perennial Urochloa (Sabi grass) and forage sorghum.

Predicted dietary CP increased by an average of 1.15%
Predicted digestibility increased by an average of approx 1.5%
Predicted LWG decreased by just under 0.1 kg/day

	Predicted dietary CP%		Predicted digestibility		Predicted LWG kg/d	
	Hay only	Plus Molasses	Hay only	Plus Molasses	Hay only	Plus Molasses
Blue couch	8.1	8.9	52.5	54	0.29	0.25
Indian couch	8.4	9.2	51	52.5	0.37	0.33
Forage sorghum	6.2	8.1	51.5	53	0.50	0.40
Urochloa	7.6	8.7	54.5	56	0.59	0.43
Mean	7.6	8.7	52.4	53.9	0.44	0.35

The experiments had 2 steers per diet for the Blue couch and Indian couch diets and 4 steers per diet for forage sorghum and perennial Urochloa.

9. The ratio of faecal P to dietary N as an indicator of dietary phosphorus status

Background

Cattle requirements for dietary phosphorus (P) vary with productivity. In relative terms, requirements are high when productivity is high (e.g. high growth rates or high milk production) and low when productivity is low or negative (weight loss). In fact when cattle lose weight there is usually a reduction in skeletal mineralisation such that there may be no dietary requirement. Thus, dietary P requirements will largely depend on overall diet quality and its productive potential. It we assume that the animal's productivity is not limited by disease or specific mineral deficiencies (other than P), then the P requirements will depend on the protein and energy status of the diet as the main drivers of productivity.

Basis of the P/N ratio as an index of dietary P status

Faecal P concentration is a reasonable indicator of the concentration of P in the diet such that faecal P is about twice the dietary P concentration. The relationship is far from perfect but a low faecal P concentration (e.g. 0.2% or less) certainly indicates a low intake of P while high faecal P concentration (e.g. 0.4% or more) indicates an adequate intake of P for beef cattle grazing pastures in northern Australia. Faecal P concentration is determined by chemical analysis. The laboratory technique is fairly simple and quite robust.

Dietary N (not including supplementary N) concentration is usually a good indicator, not only of the protein status of the diet (dietary CP = 6.25 time dietary N), but also the energy status of the diet. This is because there is a close correlation between protein and energy levels within pasture species. When protein level is high the energy status is high; when the protein level is low the energy status is low. This relationship varies between different plant types and, in particular, it differs between grasses and legumes due to the high protein levels in legumes. Thus, with certain qualification, dietary N concentration can be used as an index of overall diet quality with respect to the protein and energy status and therefore the productive potential of the diet. Dietary N can now be estimated from faecal NIRS analysis. The technique is simple, quick and inexpensive.

Based on the 2 premises stated above, the ratio of faecal P concentration to dietary N concentration (P/N ratio) provides a measure of the amount of P in the diet relative to the productive potential of the diet, or in other words, an index of diet P relative to requirements.

P/N ratios

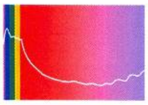
The use of P/N ratios as an indicator of dietary P deficiency or sufficiency is in its early stages of development. At this stage I have set some arbitrary values based on fairly rough calculations to designate dietary P status into certain broad categories as follows:

P/N ratio	Dietary P status
0.21 or higher	adequate
0.16 – 0.20	marginal or suspect
0.11 – 0.15	deficient
0.10 or less	very deficient

The values above will have to be refined with time and different thresholds will probably be required for different pasture types (e.g. grass pastures vs grass/stylo pastures or other legume based pastures) and perhaps for different regions or land types. Nevertheless, P/N ratios offer a simple means of providing a reasonable guide to the dietary P status of cattle.

9.8 Appendix H – NIRS Producer Co-operator Reports

NIRS Task 3 Project Producer cooperator newsletters



NIRS CO-OPERATOR REPORT
No. 1

September 2003

This report is produced by the QDPI Faecal NIRS Task 3 Project team

Welcome to our first edition

Greetings to all producers who have joined us as co-operators in the Faecal NIRS Task 3 project. This quarterly report has been specifically designed for you. I would especially like to recognise those producers involved in Task 3. The purpose of this report is to give you an update of what is happening in the three task areas of the NIRS project and to provide technical tips relating to NIRS and to nutrition in general.

We will endeavour to keep the report as interesting and varied as possible. If there are issues you would like raised, please forward these to either one of your Task 3 NIRS coordinators, or to me.

This report is also your medium for communication with other producers in the project. If you have an interesting story about some of the results you are receiving, we'd love to hear about it.

Best wishes and enjoy the report.

Désirée Jackson
NIRS Task 3 Project Leader

Producers involved in Task 3

The Task 3 component of NIRS basically covers the northern, central and south-west and central-west areas Queensland, with some sites to be set up in the Maranoa area.

At this stage there are approximately 70 producer co-operators with one or more sampling sites on their properties. The areas covered in the north include Mingela, Ravenswood, Prairie, Pentland, Torrens Creek, Hughenden, Richmond, Cloncurry, Einasleigh, Georgetown, Malanda, Woodstock, Charters Towers, and Ravenshoe in the north. In the central west the areas covered are Longreach, Winton, Barcaldine, Aramac, Stonehenge, Yaraka, Corfield, Muttaburra, Jericho and Blackall. In the south-west, we have co-operators in Morven, Augathella, Charleville and Bollon.

Producers are encouraged to collect samples every four to six weeks, so that trends in the changes in diet quality can be more accurately defined.

NIRS Task 3 co-operators from the Desert Uplands area, Ashley House "Fortuna" Aramac and Frank and Stan Lawrence "Cherhill" Aramac, going through the faecal sampling procedure.

NIRS Task 1 project update

The aim of the Task 1 project area is to improve the reliability of the predictions made from the NIRS analysis of dung samples. In other words, better and more robust calibration equations have to be developed and this means expanding the earlier calibration sets.

Calibration equations for predicting the protein and digestibility levels of the diet.

Queensland Government Department of Primary Industries

CSIRO

MEAT & LIVESTOCK AUSTRALIA

To develop these equations we need to measure the actual protein and digestibility levels of forage eaten by cattle so that these values can be related to the NIR spectra derived from the matching dung samples. First we have to be confident that the sample of forage on which we make the measurements is truly representative of the diet eaten by the cattle from which we get the dung.

Next we need to be confident that the cattle have been eating that particular diet for long enough to ensure that the dung used for NIRS analysis really does match up with the diet that we measure. Feeding cattle in pens for no less than 5 days on a constant forage diet is the safest way to make sure we satisfy these requirements and that has been one of the major activities in Task 1.

The calibration equations developed in the earlier work (1995-98) were derived from about 160 different forage diets but most of these diets were from 4 locations in north-east Queensland: Lansdown Pasture Research Station, and research sites at Hillgrove north of Charters Towers, Cardigan south of Charters Towers, and Springmount west of Mareeba.

In the current project we have deliberately cast the net a lot wider to include a much bigger geographic spread and to expand the diversity of forage types. Trials comprising a total of 146 different diets have been conducted at the locations listed below and we have almost completed this part of the project work.

- Katherine Research Station
- Brunchilly Station on the Barkly
- Lansdown south of Townsville
- Swans Lagoon near Millaroo
- Janibee near Capella
- Penrose near Comet
- Brian Pastures near Gayndah
- Mt Cotton near Brisbane
- Croxdale near Charleville

Samples from 75 of the 146 diets have been included in an updated calibration equation. Predictions from this equation should be more reliable than those from the previous equations used to predict dietary protein and digestibility. Samples from the remaining diets will be added to the calibration set before the end of the year and the new, expanded calibration equation will then be our primary tool for predicting dietary crude protein and digestibility for grazing cattle in northern Australia.

See the next co-operator report for updates regarding the prediction of faecal nitrogen (N), dietary non-grass proportions and growth rate.

David Coates
NIRS Task 1 Project Leader

Keep your sample clean!

It sounds a bit paradoxical to ask you to keep a dung sample clean, however soil contamination of faecal samples can cause unusually high crude protein (relative to faecal N) and digestibility results. Soil contamination occurs either through cattle grazing too closely to the ground to chase feed (and thereby ingesting soil) or through picking up soil when collecting a faecal sample. It is difficult to keep the soil out when it is ingested by the animal, but please ensure you take fresh dung samples without the soil as this will result in poor accuracy of your analyses.

Making the job easier for you

One of the objectives of the Task 3 project is to field test the NIRS technology. It is critical that the field data collection sheets are completed with a reasonable degree of accuracy but we don't expect you to make painstakingly slow measurements. The purpose of the NIRS kit is to provide you with tools for completing the various sections.

Your feedback from the survey we sent out in July has been taken on board and we have since modified the field data collection sheet to make it more user friendly. Some of our team also have had the opportunity to use the collection sheets ourselves so

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we can appreciate the difficulty in completing some sections of the form.

We hope you find the latest version easier to use and we are currently developing an electronic version of our latest draft of the form. This will be available within the next week.

Your continual feedback is valued and noted so keep your comments coming.

Désirée Jackson, DPI Longreach

NIRS is . . .

One tool for making decisions about nutritional management of your herd. Other factors need to be considered such as primary limiting nutrients in the diet, stocking rate, pasture yield, sward structure, availability of green leaf, proportion of leaf in the pasture, the likely response from supplementation and the economic return. Relying too heavily on one decision-making tool is risky.

Database well underway

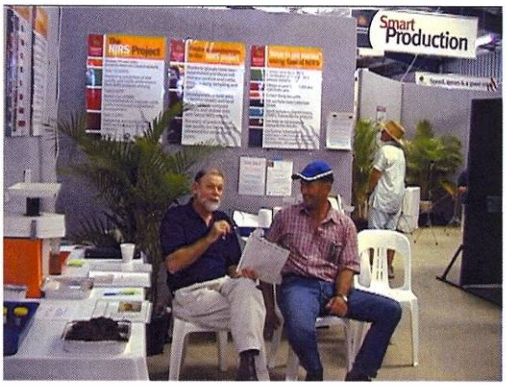
Recently Dave Smith and myself (Bernadette Lyttle), from the Task 3 team travelled to Emerald to meet with David Reid, a biometrician from the DPI at Rockhampton. The purpose of the meeting was to discuss the development of a database for the NIRS Task 3 data. Throughout the two-day meeting, we bombarded David Reid with a long list of issues that resulted from feedback from co-operators, returned surveys, and our NIRS Task 3 team meeting.

David Reid has agreed to become involved and assist in setting up the database in Microsoft Access. He has had a lot of experience in development of similar databases. Initially, he will put together a prototype that we will trial. Once all the major problems are ironed out we then can start entering the data.

The database can be designed to do many things, but realistically as we are setting it up well into the project, the main use will be a data storage facility. Once we have collated the data from the designated land systems in this project we can conduct some data analysis. We can then look at trends and patterns and establish relationships between diet quality and other factors.

We will keep you posted on the progress of the database.

Bernadette Lyttle, DPI Barcaldine
Dave Smith, DPI Charters Towers



Rob Dixon, NIRS Task 2 project leader, discusses the NIRS technology with a producer at Beef 2003.

NIRS in the Pilbara, W.A.

A jointly funded project by Meat Livestock Australia and the Dept of Agriculture Western Australia aimed at documenting changes in diet quality and cattle condition commenced in the Pilbara region of WA in November 2002. There has been little work done on the diet quality of grazing cattle in this low rainfall, 240 mm average, part of Western Australia.

A total of 12 collection sites on 7 properties have been established at stock waters on several of the major land systems of the Pilbara. The major pasture species being grazed at the various sites range from several species of spinifex to buffel and at two sites some Mitchell grass. With the exception of one property all sites recorded good rains early in the year but useful follow up falls have been very patchy.

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Dry breeders have continued to improve in condition at most sites following the rains in January and are presently averaging around condition 7 (1–9 scale). Lactating breeders have generally held condition with breeders with weaners on them now in condition 4–5 (1-9 scale) on most properties.

Pasture monitoring photo sites have been established at each site. Photo sites are located approximately 1.5 and 3 km from each collection site. Pasture condition and yield will be assessed at these sites at regular intervals throughout the duration of the project.

It is hoped that this 2-year project will provide information on how diet quality and subsequent cattle condition changes in relation to rainfall and land system in this area. It may be that the pastures in this low rainfall area will 'hay off' well – similar to the drier downs country in western Queensland and animals will perform better than might be expected from the total rain received.

As a matter of interest and in the interests of other Australia Post users all samples are dried before sending to David Coates in Townsville for analysis – WA leading the way!!

For further information contact Peter Smith (ex QDPI, Charters Towers on phone (08) 9144 2065 or e-mail pcsmith@agric.wa.gov.au.

Peter Smith
WA Dept. of Agric., Karratha

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Remember to . . .

Send a hard copy of your field data collection sheet with the sample to David Coates and either e-mail (or fax if you haven't got access to e-mail) a copy of your field data collection sheet to both David Coates AND your NIRS coordinator.

September 2003

NIRS CO-OPERATOR REPORT
No. 2

January 2004

This report is produced by the QDPI Faecal NIRS Task 3 Project team

Update on NIRS Task 3

I hope everyone has received some useful rainfall in the past few weeks. There are still a couple of months of wet season left, so at least there is hope for more rain.

Some of you have started receiving graphs from your NIRS Co-ordinator, which outline the changes in predicted crude protein, digestibility and non-grass% in the diet for the paddocks that you are monitoring. If there are other trends you would like to see graphed, please contact your NIRS Co-ordinator and it can be arranged.

If you want meaningful graphs, it is important that samples are collected every four to six weeks to maintain a continuum. Also, if you do have a significant rainfall event, make sure that you collect a sample within a couple of weeks so that the change in diet quality can be captured.

We have a new, updated field data collection sheet and we have also made an electronic version of this collection sheet, thanks to the efforts of Liz Gulbrandsen of Charters Towers DPI who worked very hard to make the changes so that the form would be easier to complete.

We thank you for your commitment to this project. The transfer of NIRS technology to producers would not happen without your help so your time and efforts are greatly appreciated.

All the best to you and your families for 2004 and we look forward to working with you this new year.

Désirée Jackson
NIRS Task 3 Project Leader

Stephen Eussen, Primac Elders Merchandise Manager, Longreach, presenting 250 rain gauges to NIRS Task 3 project leader Désirée Jackson, DPI Longreach.

Primac Elders provides additional sponsorship to Task 3 project

The NIRS Task 3 team would like to thank Primac Elders for their generous donation of 250 Nylex® cylindrical rain gauges to the project. These rain gauges would have a retail value of approximately $7,000.

Producers committed to the Task 3 project through ongoing monitoring have received a rain gauge for each paddock they are monitoring to ensure the accurate recording of rainfall data.

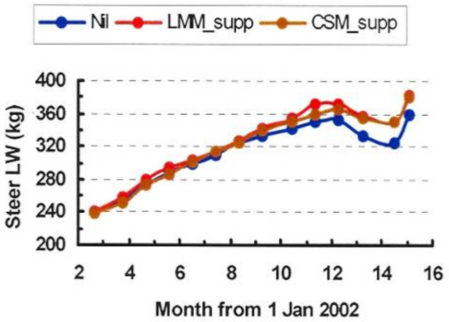
The sponsorship by Primac Elders has also enabled us to give thanks to the producer Co-operators who are committed to this project. We are grateful for their support.

Queensland Government Department of Primary Industries · CSIRO · Meat & Livestock Australia · Elders

NIRS Task 2 project update

The objectives of Task 2 are: (i) to measure liveweight responses to protein supplements by grazing cattle in the northern Mitchell grass downs; and (ii) to use faecal NIRS to estimate the quality of the diet selected by the cattle and to relate these estimates of diet quality to liveweight change and the responses to the supplements. Part of the research work for Task 2 of the NIRS project has been a large supplementation trial at Toorak Research Station, Julia Creek.

For the experiment paddock groups of steers graze pasture without any supplementation, or through the dry season are fed a high-urea loose mix or the equivalent of 400g per head per day of cottonseed meal fed twice weekly. The experiment started in August 2001 with draft 1 of steers.



In late 2001, liveweight loss was reduced by 20kg with a urea dry lick and 40kg with cottonseed meal supplementation. The smaller effect of the urea supplement was probably because the steers did not eat enough of this supplement.

For draft 2 of steers in the second year there was no effect of the protein supplements from March 2002 until September 2002, even though the feed was dry since April. However, from October 2002 through to March 2003, the supplemented steers 20-25kg heavier by March. The steers in all the treatments groups continued to grow through the dry season. The unsupplemented steers gained 113kg from March 2002 to December 2002, but then lost 27kg through to early March 2003.

In 2002-03, the paddocks were lightly stocked due to lack of rain, then de-stocked completely in June 2003. Some of the steers have grazed another paddock on Toorak through the 2003 dry season and gained 153kg from March 2003 until October 2003.

The faecal NIRS predictions of the diet selected by the steers agreed with the measured effects of the supplements on liveweight change of the steers. Diet crude protein and digestibility held up well during the 2002 and 2003 dry seasons, because the steers were consuming a high proportion of forbs. Late in 2001, the dietary crude protein was very low, therefore the large effect of the protein supplements on liveweight change was expected.

We plan to continue the trial through the 2004 dry season with a new draft of steers introduced into the trial in March 2004.

Rob Dixon
NIRS Task 2 Project Leader

How long does it take to get results?

If you are sending in a wet faecal sample, please note that it takes 24 hours to dry the sample before it can be analysed. If you send your sample into a DPI officer for drying prior to going to CSIRO, you need to get it into the office in the morning for it to be dried on time for the following day's mail. CSIRO receive dozens of samples every day in addition to their other work, so please be patient. The turnaround time for receiving your results and interpretation is anywhere from five to 10 working days. To expedite the process, ensure you send your samples off early in the week. Also, it is important that a copy of the field data collection sheet is sent to your local NIRS Co-ordinator and to David Coates, and that it is filled out correctly, in order to get an accurate interpretation of your results.

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Faecal samples with high ash content

Biological samples are composed of organic matter and inorganic matter. In the laboratory the ash content is determined by placing the sample in a muffle furnace at 550 deg. C for 4 hours. The ash gives a measure of the mineral content by the material.

Ash content (%) = (Weight of ash/Dry weight of sample) x 100

The ash content of most faecal samples falls in the range of 18 – 22%. Higher faecal ash levels, are usually due to soil contamination arising from:

- poor sampling technique
- dung beetle activity where soil is deposited within the dung pat; and
- cattle ingesting soil either on purpose or while grazing short pasture or herbage.

Soil contamination of faecal samples from ingestion of soil is more frequent during drought because feed is very short and cattle are fed supplements on the ground (eg. seeds, grains). Unfortunately, soil contamination has an effect on the faecal NIRS predictions causing prediction errors that can be quite large.

When faecal samples are contaminated with soil the following prediction errors occur:

- Dietary CP is over-estimated
- Digestibility is over-estimated
- Dietary non-grass tends to be over-estimated

Steers at “Cotswold”, Cloncurry, monitored by Perry and Kristine Hasted, Co-operators in the NIRS Task 3 project.

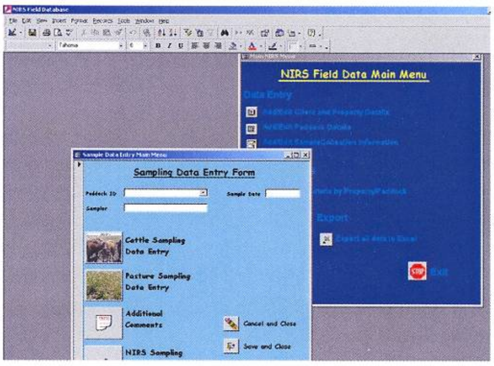
- LWG may be over-estimated even though predicted LWG tends to be low in relation to predicted dietary CP and digestibility

The greater the degree of soil contamination, the bigger the errors.

David Coates
NIRS Task 1 Project Leader

NIRS database update

The database prototype is near completion, and with final checks in progress the workable version will be up and running early in the New Year. Databases are powerful tools, and come into their own for easy repetitive data entry, data storage of large data sets, and generating reports. Initially our database's primary function will be as a data capturing and storage unit. Once in this format, data can be easily transferred to spreadsheet programs like Excel for manipulation, and analysis.



Although you won't see the working database directly, you can be assured it will make our job entering the data you have been collecting monthly much easier.

Dave Smith, DPI Charters Towers
Bernadette Lyttle, DPI Barcaldine

NIRS Co-ordinators now interpreting your analysis results

Please note that whilst CSIRO is still carrying out the NIRS analysis on your faecal samples, your NIRS Co-ordinator has now taken over the role of interpretation of results.

David Coates spent two days with the NIRS Task 3 Co-ordinators in late November 2003, building on our technical knowledge and experience in NIRS, to ensure a smooth transition of the interpretation of results.

If you send your faecal samples directly to David Coates, you will still need to send a copy of your completed field data collection sheet to both David and your NIRS Co-ordinator.

Condition scoring is a must!

Completing the condition score ratings section of your field data collection sheet is necessary if you want a meaningful interpretation of your NIRS results. An easy way to do this is to count the number of animals that fit into each of the condition score ratings when you're looking at a mob in the paddock, then add up the total and work out the percentages when you get home. Remember to look at only those points indicated on the condition score photo standard in your sampling kit.

What does Dietary Crude Protein (CP) mean?

Dietary CP represents the forage component of the diet only. Diets high in protein are needed for rapid growth, milk production or pregnancy.

Remember: NIRS predicts only the quality of the forage consumed and takes no account of the supplement the animals are eating. The NIRS predictions are not affected if cattle are on a urea-based supplement.

The dietary CP prediction should not be confused with the faecal N prediction or faecal crude protein concentration (Faecal CP = Faecal N x 6.25).

Grasses have lower protein than legumes and herbage and cattle on tropical grass pastures will generally have dietary CP values under 10%, particularly once the grasses have moved from growth phase 1 and 2 to growth phase 3 and 4. Grasses in growth phase 4 have a very low CP and the dietary CP values may fall to 3% or less.

Rule of thumb - If dietary CP% falls below 5% dry cattle would definitely be slipping in condition regardless of whether energy is sufficient or not in the diet.

An exception to the rule – When the protein content of the grass declines to low levels during the dry season, the browse content of the diet of cattle in forest country increases. The protein level in browse is much higher than in dry grass so the protein content of the diet increases when cattle start to browse. However, the leaves of many browse species contain condensed tannins, which are released and "bind" to the protein, when the leaves are chewed, greatly reducing the proportion that is available for digestion.

Consequently, while diets high in browse may be reasonably high in protein on analysis, such diets may in fact be protein-deficient because the protein is not available to the animal for digestion. Browse species such as wattle, brigalow, mulga, gidgee, etc. are also high in fibre and low in digestibility.

Bernadette Lyttle
DPI Barcaldine

NIRS features at Hughenden Show

Dave Smith, NIRS Co-ordinator, DPI Charters Towers, discussing the NIRS technology with producers at Hughenden Show.

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January 2004

The Desert Uplands Region – Update on NIRS

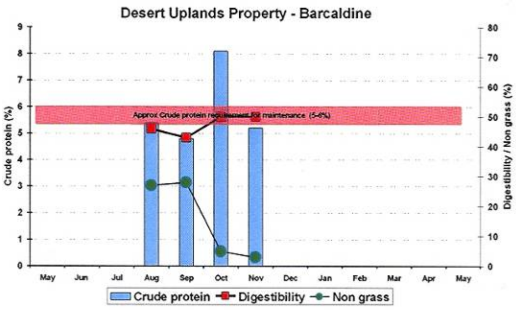
Twelve properties are now involved in the NIRS project and are taking regularly sampling. Producers from this area are finding the NIRS analysis results useful and very interesting, although, some of the predictions are unreliable, in particular, crude protein and average daily gain. This is clearly obvious where properties are droughted yet the NIRS analysis results indicate very high predicted dietary CP levels, and predicted ADG is positive. The high CP levels in paddocks where there is a large browse component in the diet can be attributed to high tannin levels in the leaves.

The predicted non-grass component and the digestibility levels appear to be reasonably reliable for the Desert Uplands.

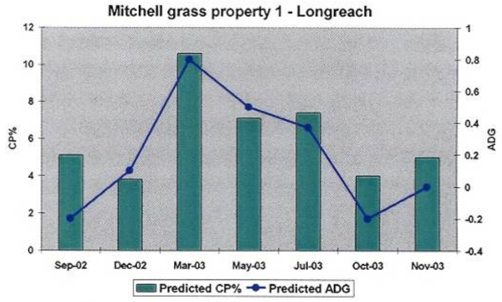
Profile – The Desert Uplands Region

The Desert Uplands region stretches approx 75,000 square km from Barcaldine to Hughenden, across to Charters Towers and back down south of Alpha to just north of Blackall. This bioregion is characterised by hard, red sandy soils with relatively low fertility. Sandstone ridges and sand plains dominate the landscape, supporting predominantly native pastures, including spinifex, wire grasses, and small patches of Mitchell grass. Buffel grass can also be found. The main tree species include Desert oak, Gidyea, Box, Ironbark, Yellow Jacket, and a number of wattles.

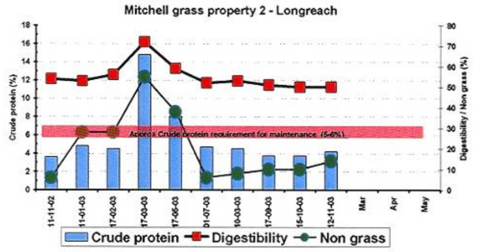
Bernadette Lyttle
DPI Barcaldine



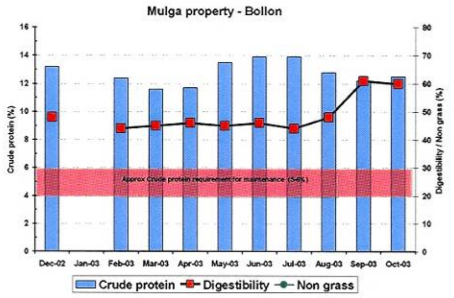
Rain between September and October resulted in an increase in CP% and a sharp shift from a high proportion browse diet to a predominately grass diet.



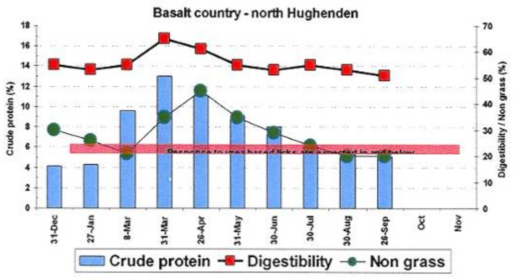
Although initially it looks as if there's a good correlation between Predicted CP% and ADG on Mitchell grass, the correlation is inconsistent, hence the need for frequently sampling.



There is a reasonably good positive correlation between Predicted CP% and Digestibility %. Digestibility and animal condition higher than expected given the seasonal conditions and Predicted CP%.



Again, a property where the diet consists of a large browse component, resulting in high Predicted Dietary CP%. A large proportion of the CP% is unavailable for digestion due to presence of tannins.



There isn't a good correlation between non-grass and dietary CP% and Digestibility% due to the change from high quality herbage to browse as the non-grass component.

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NIRS in the Pilbara

A project similar to the NIRS project currently underway in Queensland has just completed 12 months of sampling and information collection in the Pilbara region of Western Australia. The southern boundary of the Pilbara lies roughly along the Tropic of Capricorn and the northern boundary is a similar latitude to Townsville.

There is little documented information of the performance of grazing cattle in the Pilbara and even less information on the quality of the diet that cattle actually select while grazing different land systems.

This project is aimed at recording at least some of this information by recording cattle body condition at 4 - 6 weekly intervals during 2003 and 2004 and utilising faecal NIRS to monitor diet quality selected by cattle. Other information collected at each observation is similar to that collected in NIRS Task 3.

Fifteen collection 'sites' representing 6 pasture systems have been established since December 2002.

NIRS predictions of diet quality during 2003 appeared to reflect observed changes in body condition of lactating and non-lactating breeders grazing the majority of the Pilbara pasture systems currently included in the project.

The main exception is spinifex-based pastures where NIRS seems to over-predict diet quality and animal performance.

Peter Smith
Dept of Agriculture, Karratha. WA

Provide plenty of shade for cattle whilst in the cattle yards – the Western Australian way.

Updated NIRS Co-ordinators List

Désirée Jackson, Longreach
Telephone: 07 4658 4423
Facsimile: 07 4658 4433
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Ross Dodt, Mackay
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Trevor Hall, Roma
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Facsimile: 07 4622 4824
Email: Trevor.Hall@dpi.qld.gov.au

Bernadette Lyttle, Barcaldine
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Facsimile: 07 4651 1087
Email: Bernadette.Lyttle@dpi.qld.gov.au

Dave Smith, Charters Towers
Telephone: 07 4754 6112
Facsimile: 07 4787 4998
Email: Dave.Smith@dpi.qld.gov.au

Felicity Hill – currently on leave

Identifying when diet quality and liveweight performance changes occur

0.5 Condition score = 10-15kg LW
@ $1.50/kg = $15+/head in a month

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January 2004

NIRS CO-OPERATOR REPORT
No. 3

July 2004

This report is produced by the QDPI Faecal NIRS Task 3 Project team

What's happening in NIRS?

Hello everyone,

Our current NIRS Task 3 group has certainly increased in size, with two major pastoral companies coming into the project. This will add value to the quality of feedback we already receive and hopefully, will help us to understand how well the NIRS technology works for each of the land systems. At present, we have **138 properties** involved in the project, which far exceeds our original target of 60 properties.

Meat Profit Day

Longreach is hosting a **Meat Profit Day** August 18-19, which starts at noon on the first day and finishes at noon on day 2. The Meat Profit Day will cover the areas of profit, people and property. Our NIRS Task 3 team will have a joint trade display with NIRS Tasks 1 (led by David Coates) and 2 (led by Rob Dixon). David Coates will also be making a presentation on NIRS. Be sure to come visit us at this very special event, which is guaranteed to challenge some of the current ways we manage our properties.

New team member

I'd like to welcome **Russ Tyler**, DPI&F Gayndah to our NIRS Task 3 team. Russ brings with him a lot of practical experience and knowledge in nutrition, and he is also our project leader for the Nutrition EDGE package.

Co-operator Report

If you have any suggestions for what you'd like to see in the NIRS Co-operator Report, or if you have photos/information relating to your NIRS monitor sites that you think other might find interesting, please send them to me so I can include them in the next report.

This report is written expressly for the producers involved in this project, so we welcome your input.

I hope most of you are still having a reasonable season, and let's keep our fingers crossed for some early storms.

All the best.

Désirée Jackson
NIRS Task 3 Project Leader

Staff at "South Galway", Windorah, Jered Pearce and Adrian Jessup, looking chuffed with the dung sample they've just collected.

Mark your diary

Come visit our NIRS trade display at the Longreach Meat Profit Day, to be held August 18 and 19. Team members from NIRS Task 1, 2 and 3 project teams will all be there. David Coates, CSIRO, who initiated the NIRS work on beef cattle in northern Australia, will also be giving a talk on the NIRS technology.

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Using faecal NIRS measurements to help decide when to commence urea-based supplements in the autumn-winter

Faecal NIRS is used to better estimate when cattle are likely to respond to protein supplements (eg. a urea-based supplement). The cost and effort of taking dung samples and getting them analysed can be repaid many times over if the NIRS results lead to better decisions on the time to commence feeding supplements.

Nutrition textbooks will usually state that responses to urea supplements can be expected when a forage diet is below 6% protein. This does not allow for differences associated with tropically-adapted cattle or some of the characteristics of the pastures in northern Australia.

Using DMD:CP ratio as a tool

Using the ratio of the dry matter digestibility to the protein concentration in the diet as we can measure it with faecal NIRS (or DMD/CP) is a much better indicator than using the protein content of the diet to predict when grazing cattle are likely to respond to urea-based supplements.

Balancing protein with energy

Most of the forage digestion in cattle takes place in the rumen by the rumen microbes. These microbes need both energy (which they obtain by breaking down the plant fibre) and protein (most of which they obtain by breaking down the plant protein).

The fraction of the protein in the forage that the microbes can access and utilize is called rumen degradable protein (RDP). If there is insufficient RDP for the available energy then the forage digestion is reduced, intake of pasture is reduced and animal productivity decreases.

The greater the amount of energy available from forage the greater is the requirement for RDP. In low digestibility forages the energy availability is low and the RDP requirement is low. As grasses mature and dry off, protein generally declines more rapidly than available energy so RDP is often in short supply with dry season pastures. This is why supplementing with protein meal or urea can increase animal production.

Using NIRS to determine when to supplement

Cattle responses to supplementary RDP (or urea equivalent) depend on both the protein and energy contents of the diet.

Want to ensure your results don't get held up?

Ensure you write your NIRS Co-ordinator's name on the Field Data Collection sheet before sending a copy to both your co-ordinator and to CSIRO with your sample.

We can use faecal NIRS measurements of dietary crude protein as a measure of the availability of RDP, and diet digestibility as a measure of energy availability. The ratio of digestibility to crude protein (DMD/CP) as measured with faecal NIRS is a useful index to indicate whether cattle are likely to respond to urea supplements.

The DMD/CP threshold value above which cattle are likely to respond to urea supplement may differ with the pasture system and cattle breed however, when the DMD/CP ratio is 10 or greater a response to urea supplement is highly likely. A response may occur when the ratio is in the range between 8 and 10, particularly for more coastal areas such as spear grass pastures.

There are obviously many considerations in the decision of when to commence dry season supplementation. The DMD/CP ratio may indicate whether an animal response can occur, but other factors may be more important. These include (i) the amount, species and leafiness of available pasture, (ii) the type of cattle, (iii) condition score and liveweight of the cattle and associated targets, and (iv) the production system and cash flow.

Rob Dixon
NIRS Task 2 Project Leader

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July 2004

AA Company joins the NIRS Task 3 project

I had the opportunity to visit some of the AA Company properties in the channel country and Northern Territory at the end of April. The amount of Flinders grass across all of the Mitchell grass region that I flew over was phenomenal, literally stretching from Longreach up to "Brunette Downs".

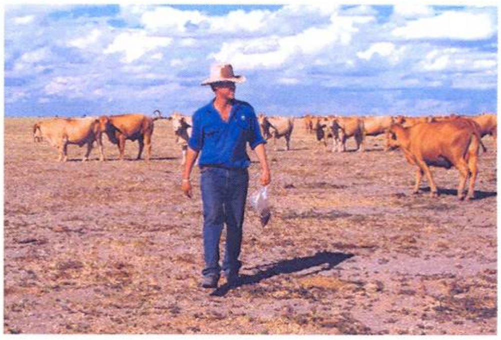
Whilst Flinders is very palatable and nutritious in the early growth phases, once it dries out the quality drops very rapidly, and as Flinders grass doesn't yield high in terms of kg/ha, this means that pasture yields on a lot of downs country will have been quite low due to the preponderance of Flinders.

Paddock names and mob identifiers

We've had a number of samples that have come through with a different name to what is recorded on the Field Data Collection Sheet. Please ensure these are both the same.

We've also been asked on a number of occasions what a mob identifier is (page one of the FDCS) – this is a name you choose to identify a group of cattle that you want to monitor that may get shifted between paddocks.

Steve Hagan, manager of "Headingly", Urandangie, giving staff member Susie Thomson lessons on dung sampling.



Ben Wratten, Assistant Manager, "Brunette Downs", NT, looking over the Composites that have come in for a drink.

The quality of cattle on all of the AA properties I visited was phenomenal, but what struck me in particular was the excellent temperament of the cattle. Given the large numbers of cattle running on these properties, it goes to show how effective selection pressure can be. The cattle are a real credit to the Company and its staff.

Ellena Hannah, Rangelands Officer, "Headingly", and Cameron Rasheed, manager, "Avon Downs", sampling cattle at "Avon".

Many thanks to Ellena Hannah, AA Co. Rangelands Officer based at "Headingly" for organizing the field visits.

Désirée Jackson
DPI&F Longreach

Sun drying your samples?

Make sure you write this on both the label on the sample and also in the Comments section of the Field Data Collection Sheet.

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July 2004

Desert Uplands Region – Update on NIRS

Twelve properties within the Desert Uplands region are now involved in the NIRS project and are regularly sampling.

Producers who are regularly sampling from this area are starting to really see the benefit of using NIRS predictions on diet quality in conjunction with their management options.

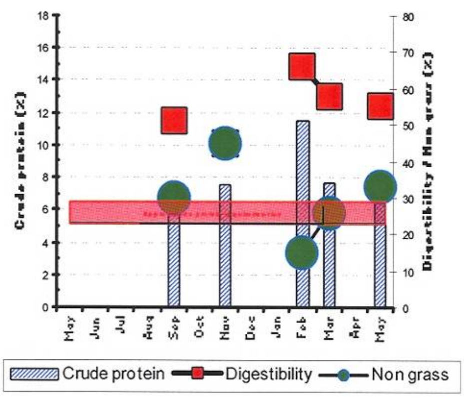
At present, CP% and Digestibility are starting to rapidly decline with levels getting down to that critical 5 to 6% for CP and under 50% Digestibility. At this stage, no results are showing diets with a high proportion non-grass component therefore there is adequate pasture available so cattle have not moved back to the browse.

Recently, I gave a presentation to The Desert Uplands Committee on the NIRS Task 3 Project. The presentation and other related documents have been included on the Desert Uplands web site. Task 3 producer co-operators at this meeting gave the rest of the group an overview of how they are combining their NIRS predictions and other observations into their everyday management of their herd.

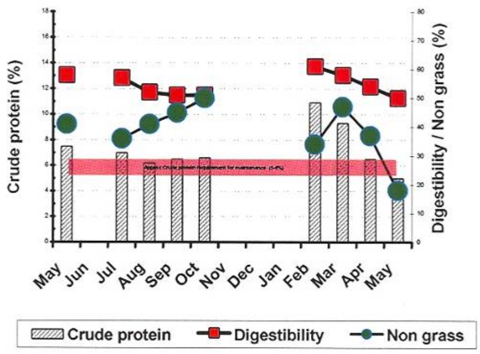
If anyone wants to know more about the project within the Desert Uplands, please contact me.

Bernadette Lyttle
DPI&F Barcaldine

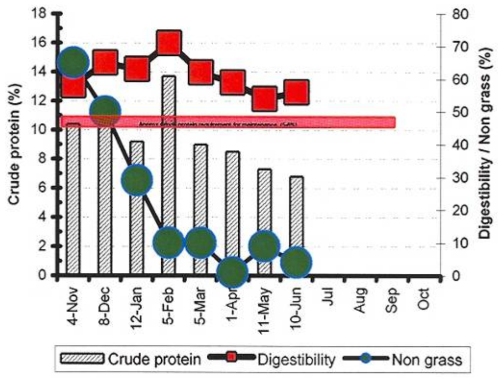
Desert Uplands spinifex - north of Aramac



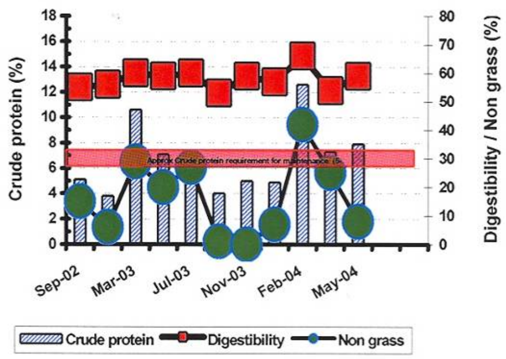
Forest, river country - north of Cloncurry



Buffel pasture on brigalow - north of Surat



Mitchell grass - north of Longreach



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July 2004

NIRS CO-OPERATOR REPORT
No. 4

January 2005

This report is produced by the DPI&F Faecal NIRS Task 3 Project team

Welcome to 2005

I hope everyone managed to have a break during the Christmas holidays and that you all received some relief rain. For those of you who've missed out, I hope the wet season ahead brings more joy.

I'd like to thank all of the co-operators who responded to our survey. We live in a world where everyone is constantly bombarded with surveys. We appreciate the time that you have taken to respond and your honest feedback.

The information from the surveys will be used to plan future work in NIRS as well as provide a useful guide to MLA on commercialising the technology once the research is finished.

Thanks goes to **Alistair Brown**, who contacted over 100 private producers. Alistair, who is the new DPI&F beef extension officer in Roma, is also new to our NIRS project team. The phone survey has well and truly inducted him into our project team. He was last seen throwing his phone into the bin.

I'd like to give special acknowledgement to **Meridy** Kadel of **"Kynuna"** Station, McKinlay, Queensland and **Pam Allsop** of **"Alexandria"** Station, NT, who send us a number of pasture and cattle photos for each paddock they submit dung samples for. The photos make interpreting the NIRS results a breeze. Many thanks, ladies!

This newsletter is larger than usual, but I thought it would be interesting to include graphs and photos from properties all around Queensland and from the NT, for you to see what's happening on other NIRS co-operator properties.

Happy reading!

Désirée Jackson
NIRS Task 3 project leader

NIRS Task 3 Producer Surveys Round Up

In the end it was a total of 117 producers multiplied by three phone calls in two weeks and the NIRS Task 3 producer survey was completed.

My job was to survey all of the privately owned properties in Queensland who had been or still are involved with the NIRS Task 3 project.

The overall results of all of the participants are still being collated however some interesting points have been highlighted in relation to the technology being utilised in different areas.

Go – Go Gadget Phone

I would like to thank all of the participants for their co-operation and honest responses at a very busy time in the year.

I hope I didn't annoy too many with my relentlessness but to get a comprehensive outlook on how the technology is going and where it needs to head it was essential to speak with as many producers as possible. I hope 2005 is a prosperous and productive one.

Alistair Brown
DPI&F Roma

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Diet selection from two pastures in southern Queensland

The NIRS Task 3 project has identified the variation in diet quality and species selected from different pasture types in southern Queensland in 2003-04.

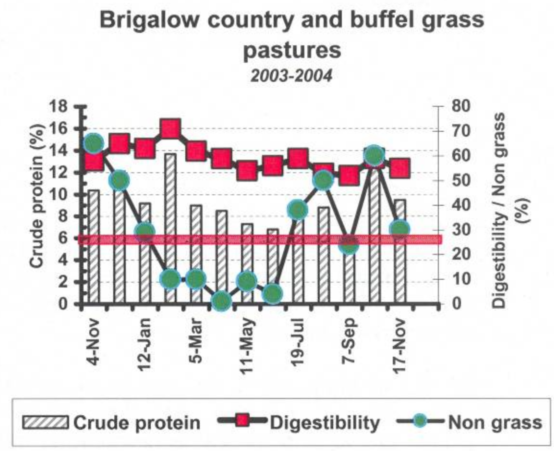
A buffel grass pasture on brigalow country maintained a crude protein level above 6.5% throughout the year and there were rapid responses to rain in autumn and spring. The digestibility was always above 50%, even though there was negligible non-grass selected in late autumn and early winter (see Figure 1). The live weight gain predictions throughout the year ranged from a loss of 0.05 kg/day to a gain of 1.2 kg/day on this pasture.

In a good native pasture in poplar box woodland on clay soil, there was a steady decline in crude protein from January to October, even though the cattle had a high proportion of non-grass in their diet.

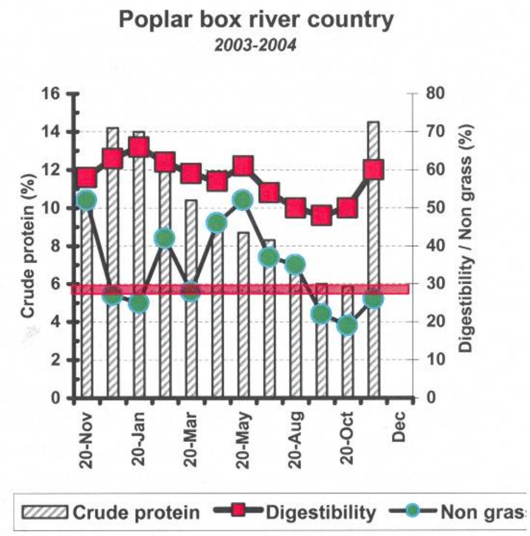
There was up to 50% non-grass selected in late autumn as native legumes, including woolly glycine, dried off and became more palatable. There was a change in digestibility of 10% within a 2-month period as the pasture dried off, and then again in response to rain. Crude protein more than doubled, and digestibility increased from 48% to 60%, following the spring storm season in this pasture. Throughout the year, the non-grass proportion of the diet remained above 20% (see Figure 2). The monthly live weight gain predictions ranged from gaining 0.15 kg/day to 1.5 kg/day on this pasture.

The ratio of digestibility to crude protein remained below 10 throughout the year for both pastures.

The protein levels were higher than the 4.1% recorded by NIRS on frosted Queensland bluegrass pastures on open downs country in winter in the same region.



Diet selected from a buffel grass pasture on cleared brigalow country in southern Queensland.



Diet selected from a native grass pasture in open poplar box woodland in southern Queensland.

Trevor Hall
DPI&F, Roma

The comfort zone is a dangerous place to be.

January 2005

DMD:DP Ratio
(Summary 26-10-04)

Field testing the validity of DMD:CP Ratio in central Queensland.

Urea required per animal per day for yearling steers

DMD:CP Ratio	Grams urea/day
8-9	15-20
9-10	30
10-13	60
>13	90

Sarina 2003-04, 89 maiden heifers, two paddocks:

1. Maudsley: 100 acres, 70% Tea Tree: 30% Blue Gum 23-04-04 Dunder 0.7 litre per day, cattle moved 18-04-04

2. Top Kahns: 365 acres, 60% Blue gum; 35% Messmate: 5% Tea Tree

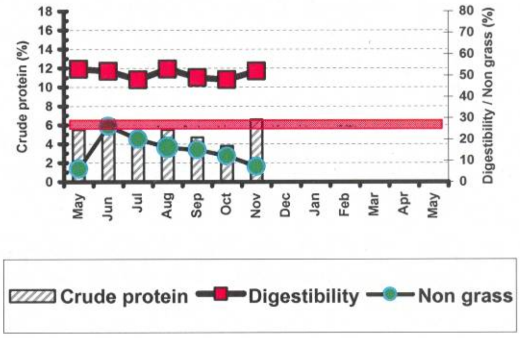
Sample taken	DMD %	CP %	DMD:CP Ratio	Dunder l/day	Urea Req'd
2-10-03	58	9.1	6.37		Nil
4-12-03	56	8.0	7.00		Nil
12-2-04	64	10.6	6.04		Nil
23-4-04	59	8.1	7.20	0.7	Nil
1-10-04	51	6.5	7.85	3.0	Maybe a response

Ross Dodt
DPI&F Mackay

A picture is worth a thousand words

If you have a digital camera at home, the next time you collect samples take a photo of your pasture and cattle. This makes our job of interpreting your results so much easier.

Open forest country at Alpha, using rotational grazing



Know your pasture species?

In some analyses, the results do not reflect the pasture details (green:dry leaf, growth phase and leaf:stem ratio) therefore it is critical that you take the time to record all of the major species eaten by stock. It is often in the species list of the field data collection sheet where we identify the species that is causing high NIRS nutrient predictions.

Cattle on Desert Uplands country, north of Aramac. This country is extremely phosphorus-deficient. Breeders appear to be holding on well given current seasonal conditions.

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January 2005

Results from NIRS survey

Although the results for the NIRS analysis have not yet been finalized, at this stage we have received back 131 surveys from a possible 150 co-operators so these results will be fairly representative of the final outcome.

In the meantime, here is a sample of the responses to some of the survey questions for your interest.

Q5 Do you feel that the NIRS technology is useful for predicting diet quality in your district?

Yes 86% **No** 11%
No Response 3%

Q6 Have you used the results and/or the interpretation of NIRS in your management decisions regarding:

a.)	Selling livestock	14%
b.)	Moving stock between paddocks	3%
c.)	Managing drought strategies	49%
d.)	Commencing supp. feeding	60%
e.)	Selecting appropriate supplements	53%
f.)	Continuing a supplement program	51%
g.)	Breeder management decisions	36%
h.)	Weaner management decisions	34%
i.)	Better understanding of pasture	69%
j.)	All useful	8%

Q7 On a scale of 1-5, how useful do you find the results of the following (1 = not helpful, 5 = very helpful)?

	1	2	3	4	5
CP%	7%	4%	10%	22%	43%
Faecal N%	10%	12%	20%	17%	25%
Digestibility%	6%	3%	14%	17%	45%
Non-grass%	6%	4%	16%	27%	31%
LWG	11%	12%	22%	19%	19%
All Useful	6%	2%	6%	5%	16%

Q8 On a scale of 1-5, how useful do you find the interpretation provided by your NIRS Task 3 co-ordinator (1 = not useful, 5 = very useful)?

1	5%
2	7%
3	13%
4	27%
5	34%
No Response	14%

Q9 Do you feel that NIRS results adequately reflect what is occurring in the paddock where you are sampling?

Yes 73% **No** 13%

Q10 Have you studied or discussed your NIRS results with any of the following?

	Yes	No
Stock feed merchant	31%	54%
Consultant	15%	70%
Beef Advisor	46%	39%
Neighbours	63%	21%

Q11 Would the results be of more value with further training regarding data interpretation?

Yes 66% **No** 21%

Q12 Are you still submitting samples for NIRS task 3 results?

Yes 53% **No** 41%

Q13 What were your reasons for leaving the project?

Cost of analysis	3%
Destocked and sold of your cattle	4%
Collecting samples too time consuming	5%
Obtaining results was too slow	3%
The NIRS results weren't useful	3%
Submitting samples was too difficult	7%
Used other methods information	2%

Other reasons not mentioned included:
Too busy (15 producers), drought, shifted cattle, supplementing, cattle moved out of paddock where sampling, inconvenient, moved property, paddocks are all open, not feeding out lick for breeders

Q14 After the NIRS Task 3 project has been completed, will you continue to use the service?

Yes 85% **No** 11%

Q15 If so, do you anticipate using the NIRS technology for the following future management practices?

	Yes	No	Uncertain
Selling livestock	29%	40%	17%
Moving stock between paddocks	48%	24%	15%
Managing drought	66%	11%	11%
Commence supp. feeding	77%	3%	11%

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	Yes	No	Uncertain
Select appropriate supps	67%	10%	13%
Modify a supp. Program	66%	9%	11%
Breeder management	48%	27%	13%
Weaner management	50%	27%	11%
Better understand pasture	78%	2%	7%
At the end of each wet	41%	19%	2%
Purchase new property	24%	47%	17%
Stock performance aide	66%	5%	15%

Q 16 How often would you submit samples?

Monthly	37%
Every 2nd month	21%
Quarterly	13%
Specific time	10%

The response rate from the survey at this stage is over 87% which is a tremendous result. More importantly, this means that the results are a true reflection of your feedback on the NIRS technology. Thanks again for your input.

Désirée Jackson
DPI&F Longreach

NIRS in a dry winter in the southern Mitchell grass downs

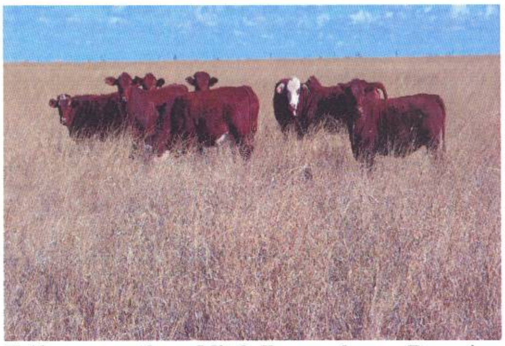
Heifers on the southern Mitchell grass downs near Roma have been monitored as part of NIRS Task 3. This has been a long, dry and cold winter, with the grass-dominant pastures drying off early in mid-autumn. There were no rainfall events exceeding 22 mm of rain between March and December.

With the exception of access to a legume crop for 2 weeks in mid-May, the cattle were on Mitchell grass downs country, which had a higher yield of Queensland bluegrass than the original Curly Mitchell grass, since recovering from the drought of the early 1990's.

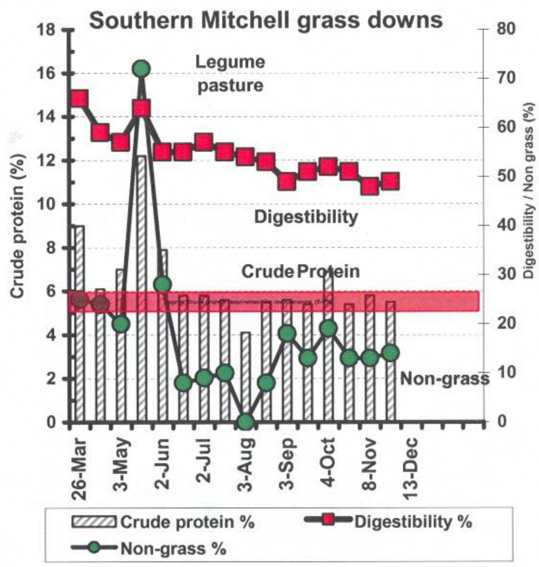
The CP% of the diet was only at maintenance in April, before the legume crop boosted feed quality during May. CP% in the diet remained near maintenance from June to November, with the exception of a small increase to 7% CP following a 22 mm rainfall event in September. The grass response was short-lived.

Digestibility has steadily declined throughout the year. The non-grass diet component was 70% while stock grazed the legumes and declined to nil in August, after multiple consecutive frosts.

The live weight gain predictions ranged from 1kg/day on the legumes to zero gain in mid-winter. The actual live weight change between March and November was 0.32 kg/day.



Heifers on southern Mitchell grass downs, Roma in June 2004.



Trevor Hall
DPI&F Roma

What's the difference?

A producer on the Atherton Tablelands took a faecal sample and a forage sample from the same paddock and had each of these samples analysed using NIRS.

The results below show what a significant difference there is in nutritional quality, and highlights why analysing diet quality rather than the quality of a sample of pasture gives us a much better indication of what is actually going down a beast's neck.

Sample	CP* %	Digestibility %	Non-Grass	LWG
Faeces	10.1	57	11	0.6
Forage	3.2	53		

*** CP% in the case of the faeces is dietary CP and in the case of forage it is the CP% of the plant sample.**

If the producer had used the forage results as a tool for deciding whether to supplement, a lot of money could have been wasted buying lick.

The comparison also demonstrates that cattle have a very good ability to select nutritious plants and plant parts (eg. leaf).

Dave Smith
DPI&F Charters Towers

Barkly Tablelands, NT co-operator

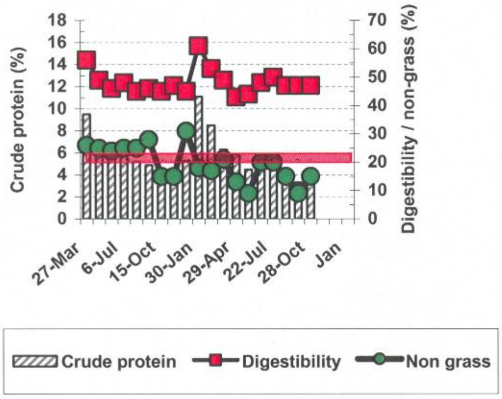
Photo courtesy Pam Allsop

Mitchell grass pasture, Barkly Tablelands, NT, having a below average rainfall season.

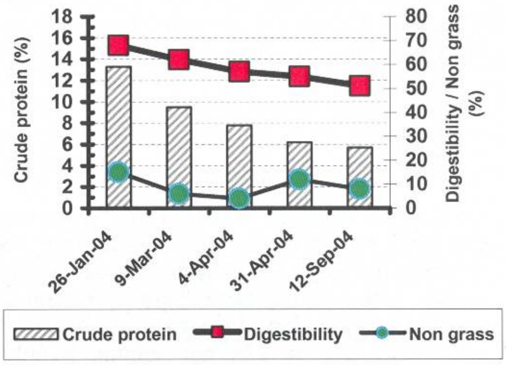
Photo courtesy Pam Allsop

Some of the cows and calves running in the paddock in the photo above and still holding up well in December.

Charters Towers Goldfields country



Silver leaf ironbark country at Mundubbera in the central Burnett area



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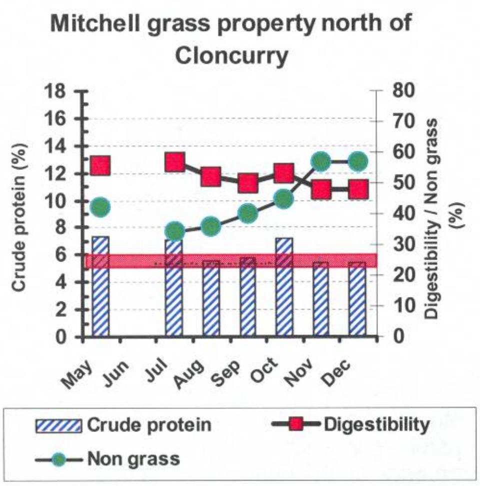
Cloncurry NIRS co-operator

Steers monitored for NIRS on a Mitchell grass property north of Cloncurry. Photo was taken in August.

Pasture that the steers in the above photo are running in. Photo was taken in August.



Kynuna NIRS Co-operator

Photo courtesy Meridy Kadel

Mitchell grass property at Kynuna experiencing a dry season back in August.

Photo courtesy Meridy Kadel

Breeders running in the paddock in the photo above, in very good condition, given the poor diet quality due to poor seasonal conditions.

Man who shoots at nothing is sure to hit it.

Confucious

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Don't let the wet season stop you

The number of samples sent in for analysis usually decreases when there is green feed around. Sometimes, it is impractical to collect samples when there's a lot of green feed, or the cowpats are just plain hard to find.

However, there is value in getting NIRS analyses done when stock are grazing green feed. It provides an indication of how quickly diet quality increases in response to rain and the sort of production you can expect from your cattle.

More importantly, getting NIRS analyses done allows you to follow the trend of how quickly diet quality declines once feed begins to mature and dry off so that timely management decisions on paddock/property movements, stock sales and supplementary feeding can be made.

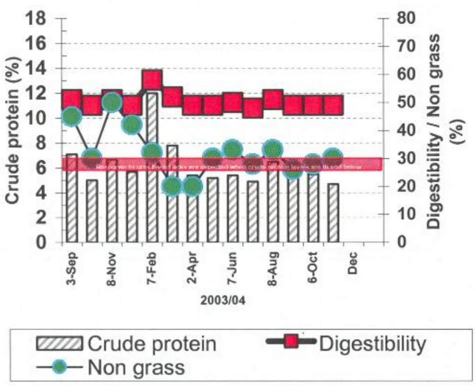
We encourage you to keep sampling every four to six weeks for the duration of this project.

For more information, contact your NIRS co-ordinator.

Désirée Jackson
DPI&F Longreach

Hughenden basalt co-operator properties

Basalt country - property no. 1



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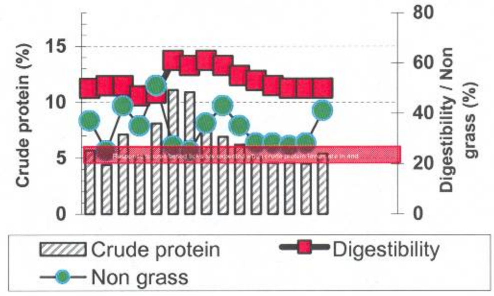
Basalt country - property no. 2



Property No. 1 missed out on the follow-up storm rain that Property No. 2 received, resulting in a rapid drop in diet quality. The property on the right shows an interesting rise in non-grass around November each year.

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9.9 Appendix I – List of Extension Activities

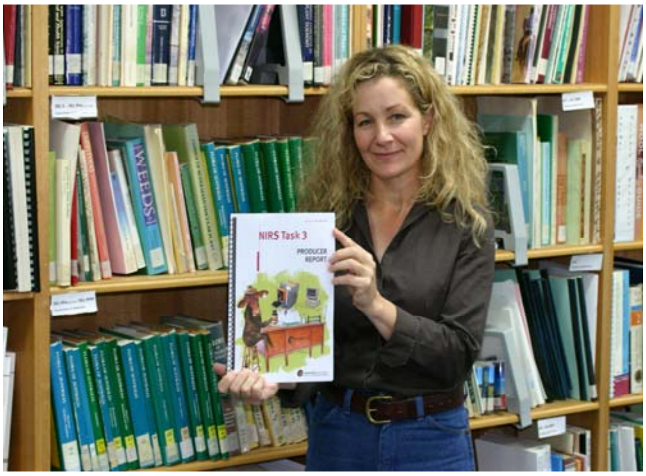
NIRS Task 3 Meetings, workshops and displays

Producer activities conducted

- Presentation of NIRS technology and Task 3 project – MLA Nutrition EDGE workshop at Longreach July 2002
- Meeting with Mitchell grass producer group – Longreach – October 2002
- Meeting with Bollon Best Prac group November 2002 with a number of producers becoming involved in monitoring
- Presentation of NIRS technology and Task 3 project – MLA Nutrition EDGE follow-up at Winton November 2002 – a number of producers became co-operators as a result of this
- Update of NIRS Task 3 technology to Channel Country Grazing project producer advisory committee meeting 2003
- Teleconference – Georgetown group – April 2003
- NIRS Task 3 Display – Beef 2003
- NIRS Task 3 Display – Longreach Show May 2003
- NIRS Task 3 Display – Hughenden Show May 2003
- Update of NIRS Task 3 project and tools to WQRBRC June 2003
- Presentation to NQRBRC June 2003
- Meeting with group of producers at “Fortuna”, Aramac August 2003
- Meeting with producers at “Stratford”, Barcaldine August 2003
- Meeting with producers at Barcaldine DPI August 2003
- Meeting with producers at “Winhaven” Aramac August 2003
- Presentation of NIRS technology and Task 3 project – MLA Nutrition EDGE workshop at Augathella August 2003 – 2 producers became co-operators in NIRS Task 3
- Presentation to Agforce in Hughenden September 2003
- Presentations at the Desert Uplands Field days at Pentland, Aramac and Jericho September 2003, with a number of producers becoming Task 3 co-operators
- Meeting with producers at Jericho Hall October 2003
- Presentation of NIRS technology and Task 3 project – MLA Nutrition EDGE workshop at Jundah November 2003 – all of the workshop participants became co-operators in NIRS Task 3
- Meeting with Box Creek Landcare Group, north of Mitchell December 2003, with three new producers becoming involved in monitoring
- Proposed presentation to the Malanda BeefPlan Group in January 2004
- Numerous e-mail discussions with producers on NIRS results and supplementation requirements
- Telephone hook-up with producers discussing the kit and completing the field data collection sheet
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Longreach, June 2005
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Hughenden, August 2005
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Miles, September 2005
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Charters Towers, September 2005
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Gayndah, September 2005
- Virginia Park (Charters Towers) field day, October 2005

- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Longreach, October 2005
- Hughenden NIRS Task 3 group meeting November 2005
- Pentland Landcare meeting, November 2005
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Townsville, December 2005
- Producer group meeting with Injune Box Creek NIRS Task 3 producers and other local producers plus local feed company staff and Maranoa Landcare staff, Injune, December 2005
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Stanthorpe, February 2006
- Virginia Park (Charters Towers) field day No. 2, March 2006
- Balfes Creek Landcare meeting, April 2006
- NIRS Fact Sheets were converted to DPI Notes, which are now web-based, and easily accessible by the general public, May 2006
- NIRS trade display at Beef 2006, Rockhampton, May 2006 – promotion of NIRS technology, benefits of NIRS technology in management, as well as redirecting interested people to the Symbio Alliance trade display to obtain sampling kits
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Roma, May 2006
- NIRS display at DPI trade display, Longreach Show May 2006
- NIRS display at North Queensland Field Days, Townsville, May 2006
- Presentation on the use of NIRS technology for monitoring diet quality – MLA Nutrition EDGE workshop at Alpha, June 2006
- Set up three monitoring sites at channel country property, to determine whether NIRS can be used as a management tool for detection of when stock are consuming Georgina gidgee, so that cattle can be removed from the paddock before deaths occur; monitoring will continue beyond the scope of the NIRS Task 3 project end date
- NIRS identified as a diet quality monitoring technique in a Q & A article in DPI&F ***Beeftalk*** magazine, April 2006
- Two Gayndah producer group discussions were held
- Each NIRS co-ordinator has received numerous enquiries on NIRS monitoring, as well as general nutritional enquiries which led to the recommendation that producers take up NIRS monitoring to determine when to begin supplementing animals and when to upgrade their licks to include energy supplements; in addition, we have redirected numerous producers to Symbio Alliance to obtain NIRS sampling kits
- 820 samples were received through the NIRS Task 3 project, between July 2004 and May 2005, for which 540 reports were written, averaging 1.5 samples per submission; a total of 1500 samples were received from producers over the duration of the project
- Second, major survey conducted of co-operators (Appendix J, Appendix K)
- major NIRS trade display at the Longreach Meat Profit Day, August 2004, co-ordinated by Task 3 team, which catered for all learning styles
- Presentation and a display at the Y-Not BeefPlan group field day at Jericho, February 2005, which attracted over 100 producers. A number of producers have since contacted the team to begin NIRS monitoring on their property
- presentation at the Western Queensland Regional Beef Research Committee (WQRBRC) meeting, November 2004
- Agforce meeting, Gayndah, June 2005
- NIRS display at Longreach Show, May 2005
- NIRS display at Roma Show, May 2005
- Roma Research Station Open Day, Sept 2004,
- NIRS and Cattle Nutrition workshop, Injune, July 2004

- Presentation on the project's progress at the WQRBRC meeting, April 2005, at which Geoff Niethe and John Cox (NABRC) were also present
- Project team continues to receiving ongoing requests by producers outside the project for sampling kits and advice on submitting samples for NIRS analysis
- Northern muster article (Oct 2004)
- Presentation at RMP Managers Conf, Brisbane (February 2005)
- Publication of the Producer NIRS Booklet, which was distributed to all producer co-operators in December 2007.



Specialist training activities

- A planning and training meeting for the NIRS Task 3 team was held in Townsville for 12 DPI&F staff, in June 2002. Staff were provided with technical training on the development of NIRS technology, how it has been adapted to tropical pastures, and current progress on the development of calibration equations for various tropical pasture land systems.
- The team was also provided with an update on current NIRS Task 1 and Task 2 work, by David Coates, CSIRO and Rob Dixon, QDPI, respectively.
- In June 2003, a team meeting was held in Longreach and the team received further technical updates on NIRS from David Coates, as well as the latest findings and progress in Task 1 and Task 2 from David Coates and Rob Dixon.
- Project team members received training in November 2003 to take on the role of interpretation of NIRS results. NIRS Task 3 co-ordinators began in the role of interpretation of results in December 2003.
- Six members of the team have taken on the role of interpretation and reporting on NIRS results for all samples sent to CSIRO both from project co-operators and producers outside the project, June 2005, until the NIRS technology is commercialized.
- Project team members received training in November 2003 to take on the role of interpretation of NIRS results.
- NIRS Task 3 co-ordinators began in the role of interpretation of results in December 2003.
- Additional sponsorship received from a major rural supplies company to purchase rain gauges for all producer co-operators.
- Initiated the mulga feeding trial carried out to refine the calibration sets for mulga land systems.

9.10 Appendix J – Producer co-operator survey questionnaire

NIRS Task 3 Producer Survey

Q1: In what shire or shires have you faecal sampled for the NIRS Task 3 project?

____

Q2: How many years have you been submitting dung samples for NIRS analysis?

<1 year 1-2 years 2-3 years >3 years

Q3: Have you attended a DPI&F organised NIRS presentation in your local area?

YES / NO

Q4: Have you attended an NIRS Task 3 producer group meeting in your local area?

Yes / NO

Q5: Do you feel that the NIRS technology is useful for predicting **diet quality** in your district?

YES / NO

Q6: Have you used the results and/or the interpretation of NIRS in your management decisions regarding:

Selling livestock	YES / NO
Moving stock between paddocks	YES / NO
Managing drought strategies	YES / NO
Commencing supplementary feeding	YES / NO
Selecting appropriate supplements	YES / NO
Continuing a supplement program	YES / NO
Breeder management decisions	YES / NO
Weaner management decisions	YES / NO
Better understanding of pasture	YES / NO
All useful	YES / NO

Q7: On a sale of 1-5, how useful do you find the following results: (1 = not helpful, 5 = very helpful)?

Crude protein	1	2	3	4	5
Faecal nitrogen	1	2	3	4	5
Digestibility	1	2	3	4	5
Non-grass	1	2	3	4	5
Live Weight Gain	1	2	3	4	5
All Useful	1	2	3	4	5

Q8: On a scale of 1-5, how useful do you find the interpretation provided by your NIRS Task 3 co-ordinator (1= not useful, 5 = very useful)?

1	2	3	4	5

Q9: Do you feel that the NIRS results adequately reflect what is occurring in the paddock where you are sampling?

YES / NO

Q10: Have you studied or discussed your NIRS results with any of the following?

Stock Feed Merchant	YES / NO
Consultant	YES / NO
Beef Advisor	YES / NO
Neighbours	YES / NO
Other	List ………………………

Q11: Would the results be of more value with further training regarding data interpretation?

YES / NO

Q12: Are you still submitting samples for the NIRS Task 3 project?

YES / NO

(If NO, go to next question, if YES proceed to Q 14)

Q13: What were your reasons for leaving the project?

Cost of analysis	YES / NO
De-stocked and sold all of your cattle	YES / NO
Collecting of samples was too time consuming	YES / NO
Obtaining results were too slow	YES / NO
The NIRS results weren't useful	YES / NO
Submitting samples was too difficult	YES / NO
Used other methods to derive the same information	YES / NO
Other reasons not mentioned …………………………………………………………………………………………	

Q14: After the NIRS Task 3 Project has been completed, will you continue to use the service?

YES / NO

(If NO, proceed to Q17)

Q15: If so, do you anticipate using the NIRS technology for the following future management practices?

Selling livestock	YES / NO	Uncertain
Moving stock between paddocks	YES / NO	Uncertain
Managing drought strategies	YES / NO	Uncertain
Commencing supplementary feeding	YES / NO	Uncertain
Selecting appropriate supplements	YES / NO	Uncertain
Modify a supplement program	YES / NO	Uncertain
Breeder management decisions	YES / NO	Uncertain
Weaner management decisions	YES / NO	Uncertain

Better understanding of pasture	YES / NO	Uncertain
At the end of each wet season	YES / NO	Uncertain
Purchase of a new property	YES / NO	Uncertain
Stock performance aide	YES / NO	Uncertain
Other	List………………………………………	

Q16. How often would you submit samples?

Monthly	Every 2nd month	Quarterly	Specific Time. ………………

Q17. When the technology becomes commercialised, how much would you be willing to pay for the NIRS analysis and interpretation?

$ _______________

Q18. How will commercialisation of NIRS affect your confidence in the technology?

More confident in the analysis and interpretation	YES / NO
No change in confidence regarding the analysis and interpretation	YES / NO
Less confident in the analysis and interpretation	YES / NO

9.11 Appendix K – Producer co-operator survey results

There were a total of 135 survey respondents (properties) with 117 (87%) identified as *private* enterprises and the remaining 18 as *company* enterprises.

A distinction has been made between company and private properties because all of the owners/managers of the private properties volunteered to be involved in the NIRS Task 3 programs, whereas the company management made the decision to get their properties involved in the project, rather than the property managers.

Individual Questions

Q1. In what shire or shires have you faecal sampled for the NIRS Task 3 project?

There were 43 shires across Queensland and the Northern Territory, represented by the co-operating properties in the project.

Q2. How many years have you been submitting dung samples for NIRS analysis?

Overall, 16 respondents had not yet submitted dung samples with all of these from private enterprises. Of the 119 who had submitted samples, just over half (52%) had been submitting for less than 1 year with a greater (P<0.05) proportion of company enterprises (78%) submitting for less than 1 year compared with private enterprises (47%).

Table 1. Proportion of those submitting samples by length of time submitting.

Time	Private		Company		Total	
	No.	%	No.	%	No.	%
<1 year	48	47	14	78	62	52
1-2 years	33	33	2	11	35	29
2-3 years	12	12	1	6	13	11
>3 years	8	8	1	6	9	8
Total	101		18		119	

Q3. Have you attended a DPI&F organised NIRS presentation in your local area?

Overall, only 38% of respondents had attended a DPI&F organised NIRS presentation. Only 2 company enterprises had attended a presentation while almost half (42%) of the private enterprises had.

Q4. Have you attended an NIRS Task 3 producer group meeting in your local area?

Overall, only 18% of respondents had attended an NIRS Task 3 producer group meeting and all these were from private enterprises.

Whilst there was a low number of company properties that attended a DPI&F-organised NIRS presentation and/or NIRS Task 3 producer group meeting, NIRS co-ordinators went to most of the company properties to explain the technology to the managers and to set up monitoring sites.

Q5. Do you feel that the NIRS technology is useful for predicting **diet quality** in your district?

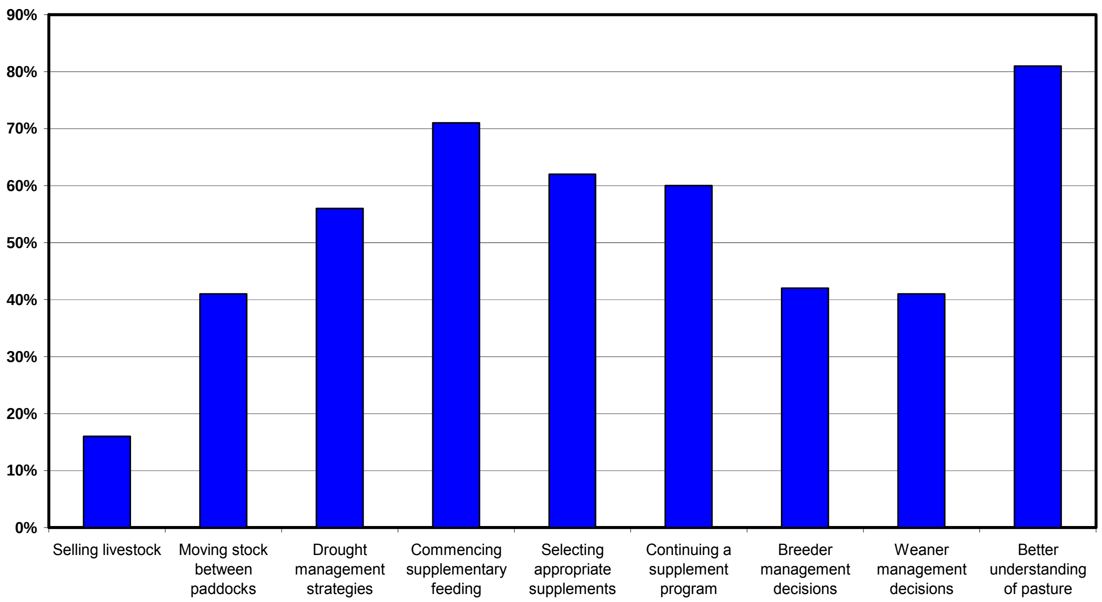
Of the 131 that responded, 88% (n=100) of private enterprises and almost all company enterprises (94%; n=16) believed the NIRS technology was useful for predicting **diet quality** in their district.

Q6. Have you used the results and/or the interpretation of NIRS in your management decisions?

Of the 117 people responding to this question, the majority had used the NIRS results/interpretation for a better understanding of pastures (81%), commencing supplementary feeding (71%), selecting supplements (62%), continuing a supplementation program (60%) and drought management strategies (56%) (Table 2). It was seen as least useful as an indicator for selling livestock (16%).

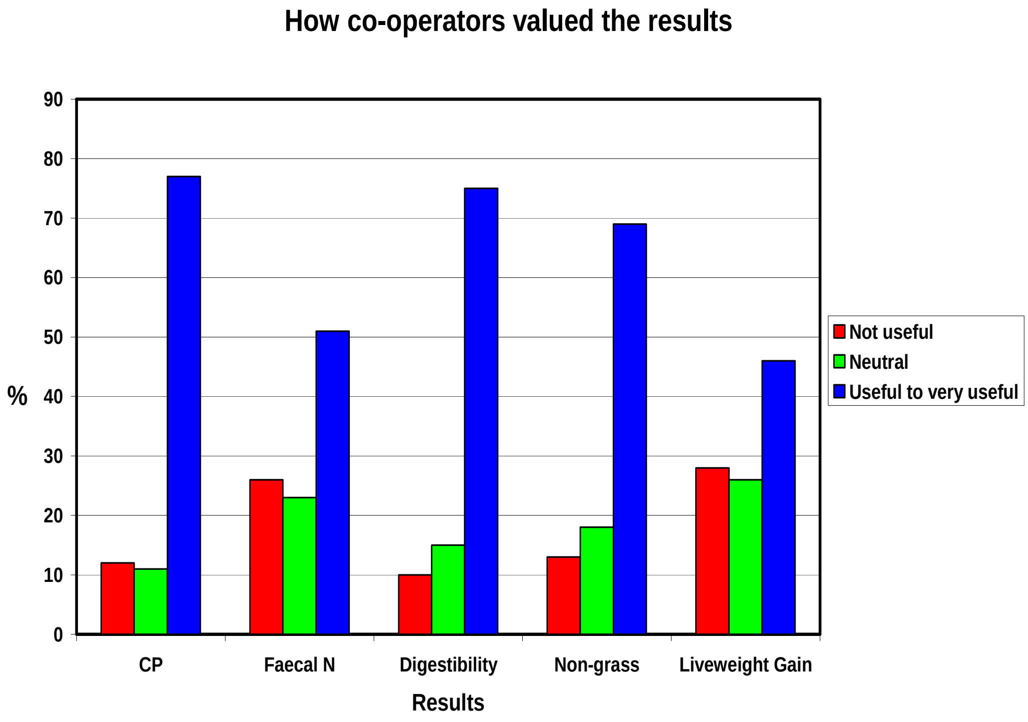
Only 29 people responded to the option of 'all useful' of which 15 suggested they had found NIRS useful for all the management decisions.

How NIRS results are used as a management tool



Q7. On a scale of 1-5, how useful do you find the following results: (1 = not helpful, 5 = very helpful)?

A total of 117 people responded to this question with about three-quarters finding estimates of crude protein (77%) and digestibility (74%) quite helpful (rating of 4 or 5; Table 3). In fact, more than half found these very helpful (rating of 5). Liveweight gain was considered the least helpful estimate (only 47% as 4 or 5). Respondents from private and company enterprises were similar in their ratings although digestibility was slightly (P<0.10) more useful for company enterprises than private enterprises (93% vs 71% as 4 or 5).



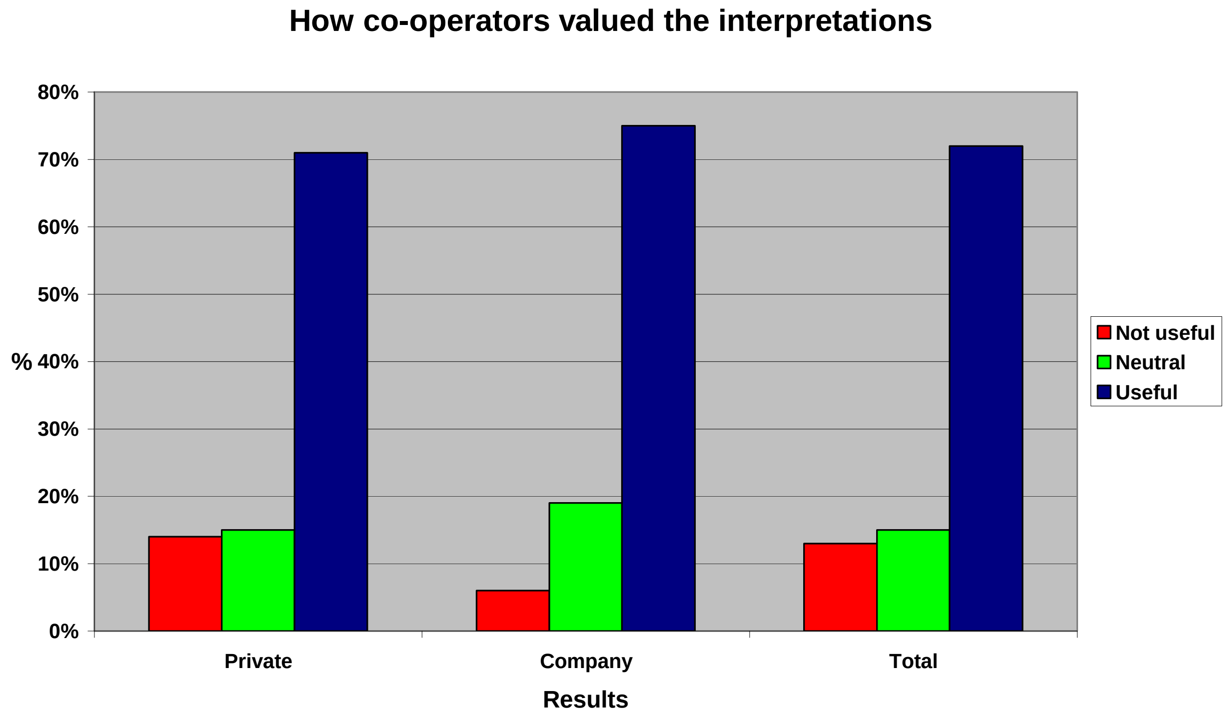
Only 48 people responded to the 'all useful' option with 58% (n=28) of these indicating that all parameters were useful.

Q8. On a scale of 1-5, how useful do you find the interpretation provided by your NIRS Task 3 co-ordinator (1= not useful, 5 = very useful)?

There were 117 responses of which almost three-quarters (72%) found the interpretation useful to very useful (rating of 4 or 5) with little difference between private and company enterprises.

Q9. Do you feel that the NIRS results adequately reflect what is occurring in the paddock where you are sampling?

There were 117 responses of which 85% felt that the NIRS results adequately reflected what was occurring in the paddock. Responses from private and company enterprises were similar.



Q10. Have you studied or discussed your NIRS results with any of the following?

A total of 117 people responded to this question, however only 109 (95 private and 14 company) of these had discussed their results with others. Of those who responded and had discussed their results, most discussed their results with neighbours (78%; Table 4). Further, 24 respondents indicated they had discussed their results with 'others', primarily business managers or staff; family or friends; and groups such as Beefplan groups.

Private enterprise respondents were more likely ($P<0.01$) to discuss their results with beef advisors (61% vs 14%) and neighbours (82% vs 50%) than company respondents.

Table 4. Proportion of respondents who had discussed their results with each of the following:

Stock feed merchant	40%
Consultant	18%
Beef advisor	55%
Neighbours	78%

Q11. Would the results be of more value with further training regarding data interpretation?

Of the 117 respondents, about three-quarters (78%) believed the results would be of greater value with further training regarding data interpretation, irrespective of enterprise.

Q12. Are you still submitting samples for the NIRS Task 3 project?

Just over half (55%) of the 131 people (113 private; 18 company) who responded were still submitting samples. This was more prevalent ($P<0.05$) for respondents from company enterprises, for which 83% were still submitting, compared with 50% of private enterprises.

Q13. What were your reasons for leaving the project?

From Q12, 59 people indicated they were no longer participating in the project. For those no longer participating, the main reasons from those listed in the survey were the difficulty in submitting samples (n=9); the time necessary to collect samples (n=7); and have de-stocked (n=6). Most (n=45) provided specific reasons, with too busy and/or too slack the main response (n=20). Other common reasons included too dry and/or supplementing (n=5); felt there was no point and/or results were inaccurate (4); have moved cattle; and health reasons.

Table 5. Number of private and company respondents indicating the various reasons why they left the project.

Reason	No. respondents		Total
	Private	Company	
Cost of analysis	4	0	4
Destocked and sold all cattle	6	0	6
Collecting samples too time consuming	5	2	7
Obtaining results too slow	4	0	4
NIRS results weren't useful	4	1	5
Submitting samples was too difficult	8	1	9
Used other methods to get information	3	0	3

Q14. After the NIRS Task 3 Project has been completed, will you continue to use the service?

Of the 132 respondents providing a definitive answer, 88% (n=116) suggested they would continue using the service, with all but one of the 17 company respondents suggesting they would continue.

Q15. If so, do you anticipate using the NIRS technology for the following future management practices?

The results from this question were restricted to the 116 people who suggested they would continue to use the service at the end of the project (Q14). A considerable number of respondents were unsure if they would use NIRS for the listed management practices with generally between 10 and 20% of respondents. Of those that were definite in their response, the main practices for which NIRS would be used in management are 'better understanding of pastures'; for 'commencing supplementary feeding'; as a 'stock performance aide'; modifying and selecting supplements; and 'managing drought strategies'. These were all independent of the type of enterprise. The practices for which NIRS is least likely to be used are for 'purchasing a new property' and 'selling livestock'. Again, these were relatively independent of the type of enterprise.

Table 6. The number of respondents within private or company enterprises and the proportion of respondents within these groups identifying they would or would not use the technology for the management practice or that they were unsure.

Q16. How often would you submit samples?

	n	yes	no	unc	yes	no	unc	yes	no	unc
Selling livestock	115	36 36%	44 44%	20 20%	3 20%	11 73%	1 7%	39 34%	55 48%	21 18%
Moving stock between paddocks	115	55 55%	28 28%	17 17%	11 73	3 20%	1 7%	66 57%	31 27%	18 16%
Drought management strategies	116	75 75%	13 13%	12 12%	15 94%	1 6%	0	90 78%	14 12%	12 10%
Commencing supplementary feeding	116	89 89%	4 4%	7 7%	16 100%	0	0	105 91%	4 3%	7 6%
Selecting appropriate supplements	116	77 77%	12 12%	11 11%	14 88%	1 6%	1 6%	91 79%	13 11%	12 10%
Modifying a supplement program	116	76 76%	11 11%	13 13%	14 88%	1 6%	1 6%	90 78%	12 10%	14 12%
Breeder management decisions	116	57 57%	30 30%	13 13%	8 50%	8 50%	0	65 56%	38 33%	13 11%
Weaner management decision	116	57 57%	31 31%	12 12%	10 63%	6 37%	0	67 58%	37 32%	12 10%
Better understanding of pasture	116	92 92%	3 3%	5 5%	14 88%	0	2 12%	106 91%	3 3%	7 6%
At the end of each wet season	115	47 47%	24 24%	29 29%	10 67%	2 13%	3 20%	57 50%	26 23%	32 28%
Purchase of a new property	116	27 27%	53 53%	20 20%	5 31%	10 63%	1 6%	32 28%	63 54%	21 18%
Stock performance aide	113	77 78%	7 7%	15 15%	11 79%	0	3 21%	88 78%	7 6%	18 16%

Of those that indicated they would continue to use the service (Q14) there were 116 respondents providing information on frequency of sample submission, of which 41% would submit monthly, 24% every second month and 23% quarterly. The remaining 13 respondents indicated they would submit at specific times including frequently (three weeks, six weeks); 2-3 times a year; last six months before wet; end of summer/winter; early dry; change of season; when cattle start to look rough; when feed is turning; when feed is drying off; and even weekly if testing new grazing strategies.

Frequency of submission would appear to be independent of whether they are private or company enterprises with 64% and 75%, respectively, submitting at least every second month.

Q17. When the technology becomes commercialised, how much would you be willing to pay for the NIRS analysis and interpretation?

Of the 107 respondents who indicated they would continue using the service and who provided a dollar value, 83% suggested they were willing to pay up to $30 for NIRS analysis and interpretation while 10% (all private) were willing to pay between $40 and

$50 (Table 7). Company enterprises tended to be willing to pay more than private enterprises (86% vs 33% for $21-$30) but this was based on only 7 company enterprise responses. A further company response indicated a willingness to pay 'as much as it takes' while another indicated 'as cheap as possible'.

Table 7. Proportion of the 107 respondents who indicated a dollar value and were intending to continue using the service by various cost categories.

Cost	Proportion
$0 - $10	7%
$11 - $20	40%
$21 - $30	36%
$31 - $40	3%
$41 - $50	10%
$51 - $60	0%
$61 - $70	0%
$71 - $80	0%
$81 - $90	0%
$91 - $100	4%

Q18. How will commercialisation of NIRS affect your confidence in the technology?

Of the 130 respondents, 71% indicated there would be no change in confidence in NIRS analysis after commercialisation, 18% indicated more confidence and 11% less confidence. Company respondents were less concerned with commercialisation, with no respondents being less confident in the analysis/interpretation.

Relationships

Due to limited cell numbers in these relationships, the time submitting samples was reduced to 3 categories (<1 year, 1-2 years and > 2 years (includes 2-3 years and > 3 years)), while the rating scale was also reduced to 3 categories (not useful (score 1 or 2), indifferent (score 3), useful (score 4 or 5)).

- *Relationships with Q2*

  (i) Q2 vs Q5

  The belief that NIRS is useful for predicting diet quality is independent (P>0.10) of the length of time submitting samples with 89%, 89% and 82% agreeing that it is useful given they had been submitting for <1 year, 1-2 years and >2 years, respectively.

  (ii) Q2 vs Q7

  The proportion of respondents indicating that the NIRS crude protein, digestibility, non-grass and liveweight gain results were useful was independent (P>0.10) of the length of time they had been submitting samples with 75%, 83% and 73% for crude protein; 69%, 80% and 77% for digestibility; 73%, 71% and 55% for non-grass; and 46%, 46% and 50% for liveweight gain indicating they were useful given they had been submitting for <1 year, 1-2 years and >2 years, respectively.

In contrast, the proportion of respondents indicating that the NIRS faecal nitrogen results were useful was related (P=0.052) to the length of time they had been submitting samples with those submitting for more than 2 years more likely to be indifferent (45% vs 18%). The proportion that found it useful was 54%, 53% and 36% for those submitting <1 year, 1-2 years and >2 years, respectively.

(iii) Q2 vs Q9
The proportion of respondents indicating that NIRS results were adequately reflecting what was happening in the paddock was independent (P>0.10) of the length of time they had been submitting samples with 83%, 89% and 77% indicating it was given that they had been submitting for <1 year, 1-2 years and >2 years, respectively.

(iv) Q2 vs Q12
The proportion of respondents indicating that they were still submitting samples was independent (P>0.10) of the length of time they had been submitting with 61%, 63% and 55% indicating they were still submitting given they had been submitting for <1 year, 1-2 years and >2 years, respectively.

- *Relationships with Q3*
  The proportion of respondents who felt the NIRS technology was useful for predicting diet quality, who were still submitting samples and who would continue to use the service once the project was complete was independent (P>0.10) of whether or not they had attended a DPI&F organised NIRS presentation . Further, the usefulness of the co-ordinator's interpretation was also independent (P>0.10) of whether or not they had attended a DPI&F organised NIRS presentation with 12%, 18% and 70% of those attending a presentation rating it as 'not useful' (1 or 2), 'indifferent' (3) or 'useful' (4 or 5), respectively.

- *Relationships with Q4*
  The proportion of respondents who were still submitting samples and who would continue to use the service once the project was complete was independent (P>0.10) of whether or not they had attended an NIRS Task 3 producer group meeting. Further, the usefulness of the co-ordinator's interpretation was also independent (P>0.10) of whether or not the respondents had attended an NIRS Task 3 producer group meeting with 14%, 9% and 77% of those attending a meeting rating it as 'not useful' (1 or 2), 'indifferent' (3) or 'useful' (4 or 5), respectively.

- *Relationships with Q11*
  (i) Q11 vs Q7
  There was no evidence (P>0.10) of a relationship between people's response to the value of further training in interpretation and their rating of usefulness of the faecal nitrogen, digestibility, non-grass and liveweight gain results. However, there was evidence (P<0.05) of a relationship between their response to training and the usefulness of the crude protein results with a greater proportion of those not indicating any value in training also indicating a lack of usefulness in the crude protein results (8% vs 27% finding the crude protein results not useful and 81% vs 62% finding crude protein useful for those indicating training would be useful versus those that didn't, respectively).

  (ii) Q11 vs Q8
  The usefulness of the co-ordinator's interpretation was independent (P>0.10) of whether or not they regarded more training on interpretation as valuable, with 11% vs 19% rating it not useful given they did or did not see value in training, respectively.

9.12 Appendix L – Economic model of commercial adoption of NIRS

An economic analysis of using F.NIRS technology in a northern beef cattle herd to improve supplementation management was conducted with the following assumptions:

Model assumptions:

- Costs incurred by adopters are estimated as $500 per annum for a typical cattle property ($45/test, with four tests needed per season per major land type on the property)
- In the absence of F.NIRS, cattle managers would continue to use traditional subjective assessment of the nutritional value of pastures
- The size of the average adopting property is 3,000 AE's, and the type of property is an integrated beef property that breeds and fattens beef cattle
- The breeder herd would normally be fed supplements six years out of ten without the F.NIRS technology. With the technology, supplement costs are reduced by 75% in one of those six years. This equals a cost saving of 12.5% per annum on average in breeder supplements.
- Replacement livestock and other livestock are normally fed supplements in four years out of ten without the application of F.NIRS technology. With the application of the technology, supplement costs are reduced by 75% in one of those four years. This equals a cost saving of 18.75% per annum on average in replacement and other livestock supplements.

Results

A $3.90 GM/AE/annum benefit by adopting F.NIRS technology.

(F Chudleigh, DPI&F Toowoomba)

9.13 Appendix M – Example of results reports to producer co-operators

Example of analysis results

CSIRO Davies Laboratory

University Rd, Townsville, Queensland, Australia.
Postal Address: Private Mail Bag, PO Aitkenvale Qld 4814

Telephone : (07) 4753 8500 *Fax (07) 4753 8600*
Direct Telephone No. (07) 4753 8545 *email: David.Coates@csiro.au*

To: **property NW of Longreach** ***Fax:***
Email:
From: David Coates ***Wednesday 12th May 2004***
Faecal NIRS predictions on samples from: **Property:** M

Sample No	*Date Collected*	*Paddock Name*	*Dietary CP%*	*Faecal N %*	*Digestibility %*	*Non-Grass (%)*	*LWG kg/day*	*Ash %*
E23096	18/03/04	Corella	6.8	1.21	58	29	0.6	25

Fresh faecal samples, no digestibility adjustment

CORELLA PADDOCK 18 Mar. '04

1545 hectares, continuous grazing, Mitchell, Flinders, feathertop, whitewood, mimosa, average rainfall last season, 144 Brahman breeders, mixed ages, plus 5 bulls, bulls in 21 Feb. '04, not removed yet, gaining weight, dry stock CS 6 – 50%, CS 7 – 50%, wet stock CS 5 – 25%, CS 6 – 75%, 60% pregnant, bore water, cattle mustered and weaned 10 Jan. '04, grass in growth phase 2, 75% green:dry leaf, 50% leaf:stem, non-grass 100% green:dry leaf, 2001-3000 kg/ha, 86 mm rain, 1 x <10 mm, 5 x 10-20 mm, legumes and forbs, nil supp.

Reasonably good dietary crude protein level (adequate for dry stock) and good digestibility so feed intake should be good. The live weight gains are based on a 300-kg medium frame steer. Breeders should have a lower weight gain.

There is a reasonably high non-grass content in the diet, most probably coming from herbage. Once your herbage dries out and becomes more sparse, then the diet quality will decrease slightly, however, without adverse weather conditions or spoiling rain, the diet quality should remain reasonably stable.

Regards

Désirée Jackson

9.14 Appendix N – Graphical presentation of results to producer co-operators

A graphical presentation of monthly F.NIRS results was sent to producers showing the crude protein, digestibility and non-grass proportion of the diet at each sampling, along with a table of all results.

The graphs in Figures 1 – 9 show horizontal bar at 5-6% crude protein indicates the maintenance protein requirement for growing, dry cattle.

From these graphs, producers could easily see the seasonal trends in diet quality and follow protein, digestibility and proportion on non-grass being grazed each month. They could subsequently plan their supplement programs in advance and be ready to feed when the diet quality declined to level below requirements for the particular class of stock monitored.

These graphs also show the rate of change in diet quality to allow producers to plan their feeding and grazing regimes. They also show the wide variation in diet quality from a range of pastures on different landtypes in northern Australia. Some of the low fertility sandy soil pastures had consistently low diet quality with a short–lived increase over summer, while some high fertility soils and the fertilised sown tropical pastures maintained significantly higher diet quality throughout the year. The mulga pastures had a consistently high prediction of crude protein and a consistently low digestibility, except for a short time while cattle had access to green summer pasture.

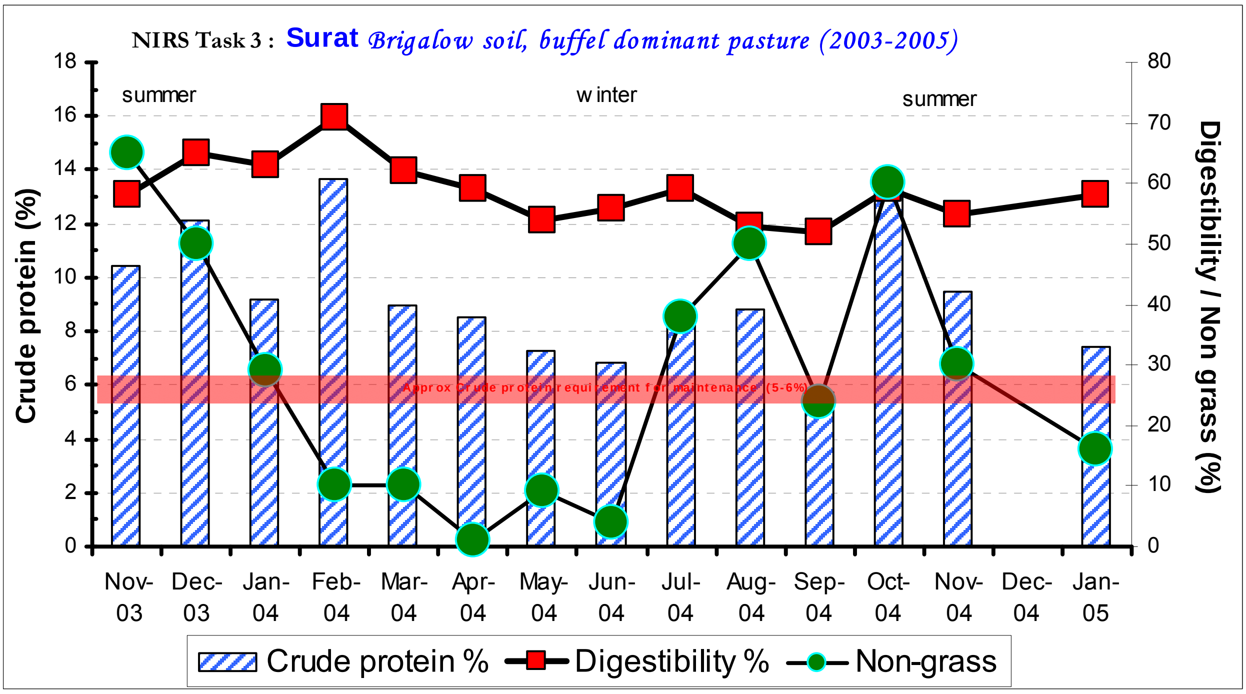


Figure 1 - Monthly F.NIRS results from buffel and forb pastures on heavy clay soil of brigalow country

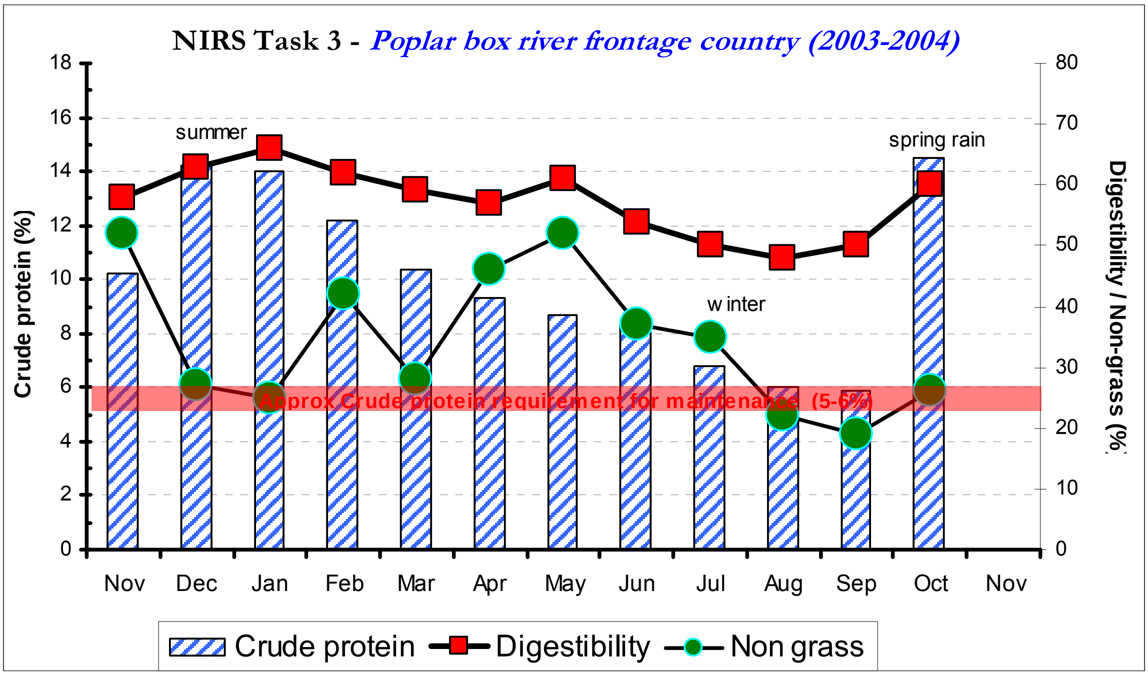


Figure 2 - Monthly F.NIRS results from bluegrass-dominant native pastures on duplex soil of poplar box country

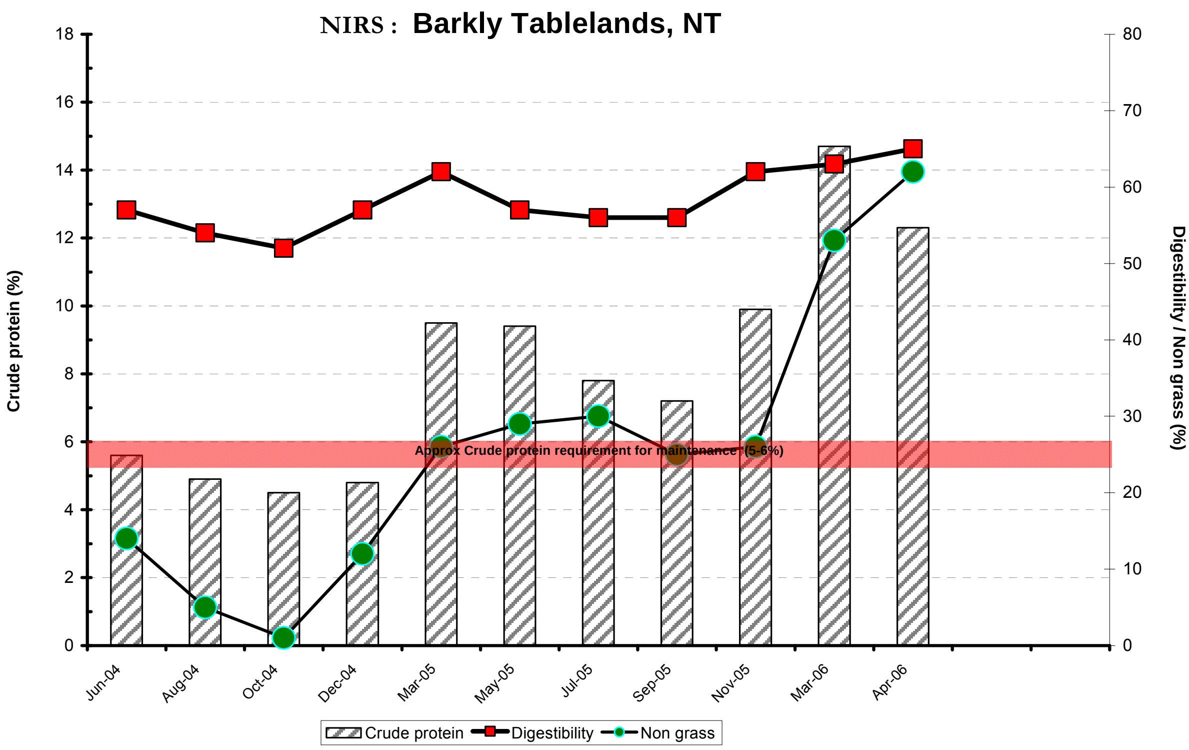


Figure 3 - Monthly faecal NIRS predictions from Barkly Tablelands pastures

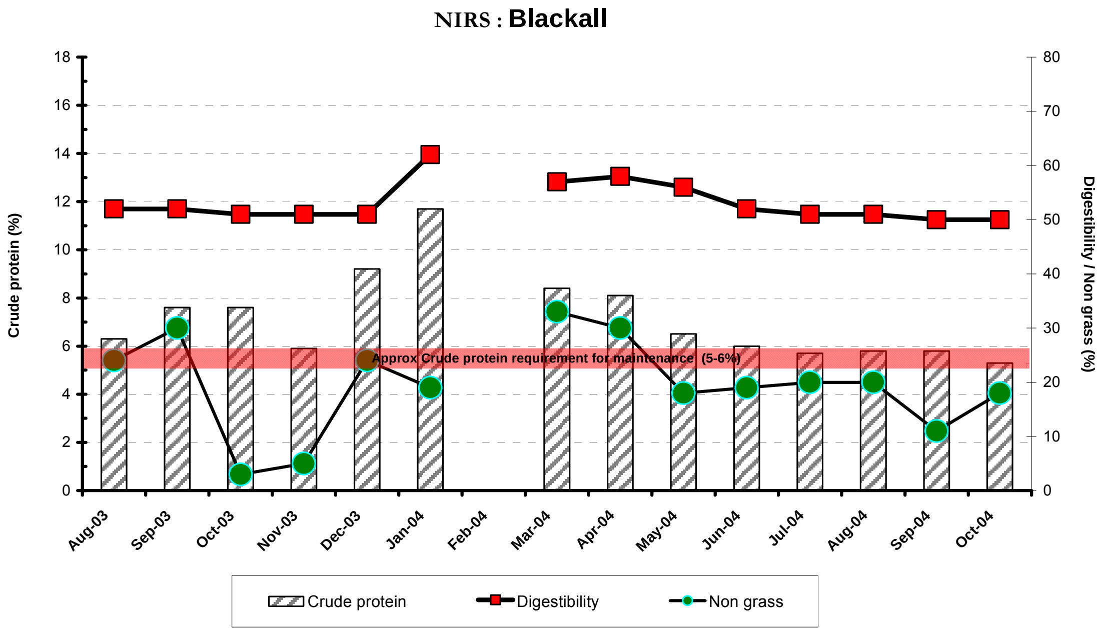


Figure 4 - NIRS predictions for pastures in the Desert Uplands in Blackall region

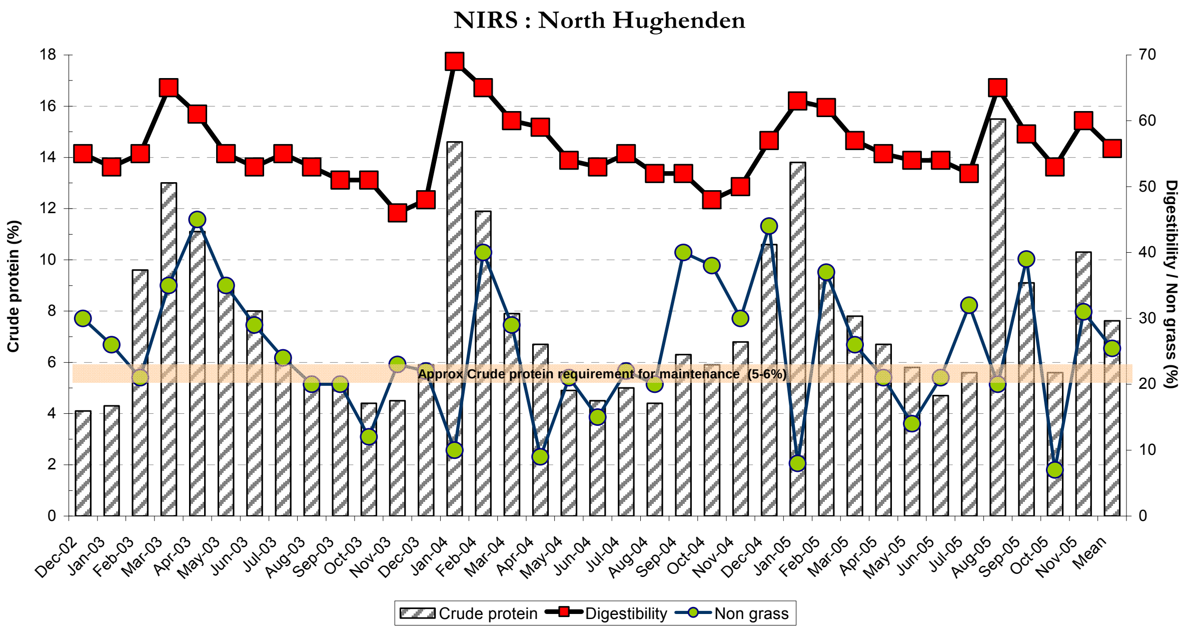


Figure 5 - Seasonal changes in NIRS predictions for downs and forest pastures north of Hughenden

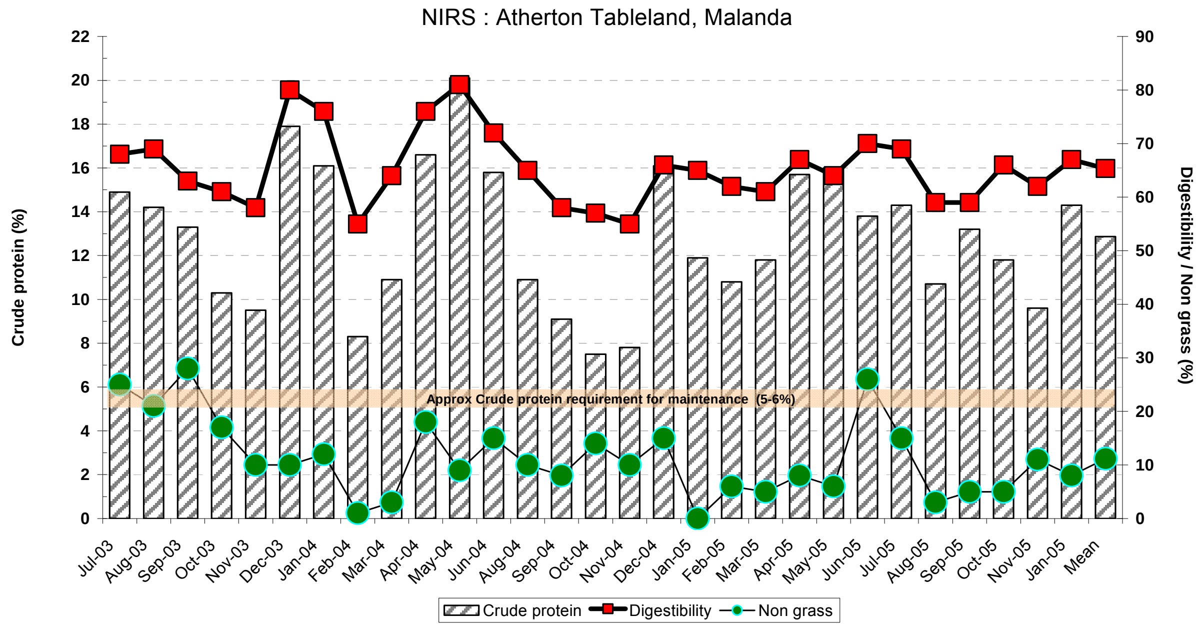


Figure 6 - NIRS predictions for sown tropical pastures on the Atherton Tablelands. These pastures produced consistently high quality diets

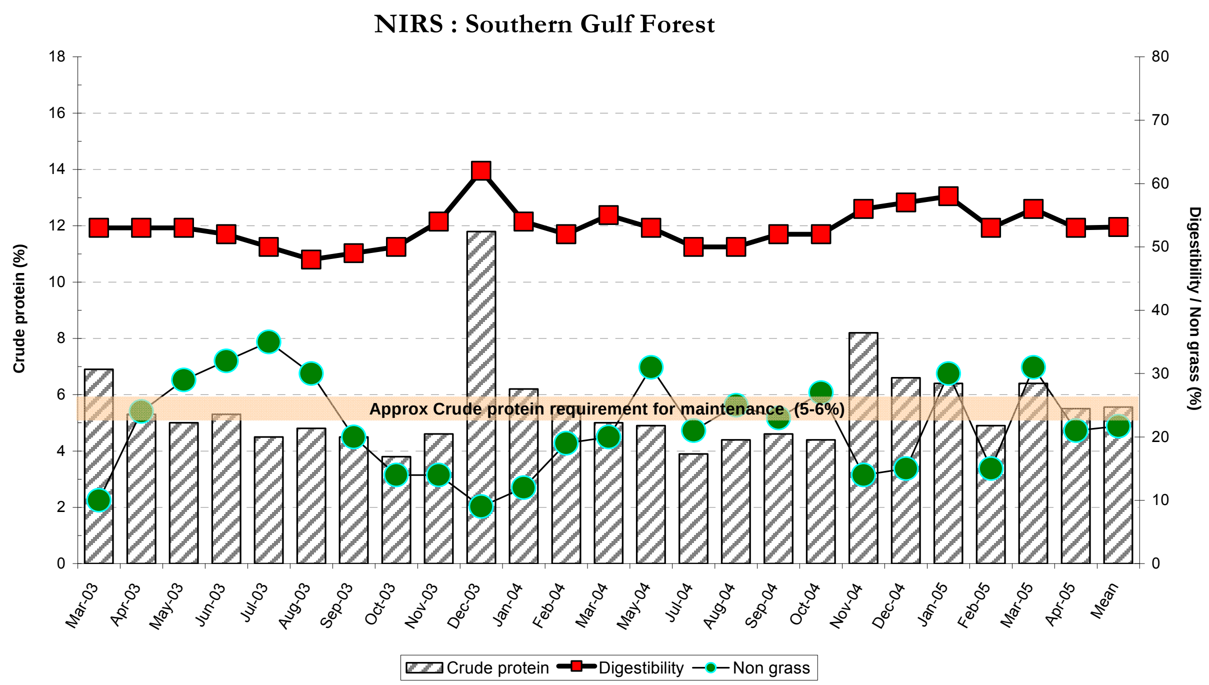


Figure 7 - NIRS predictions for sandy soil pastures in the Southern Gulf forest country

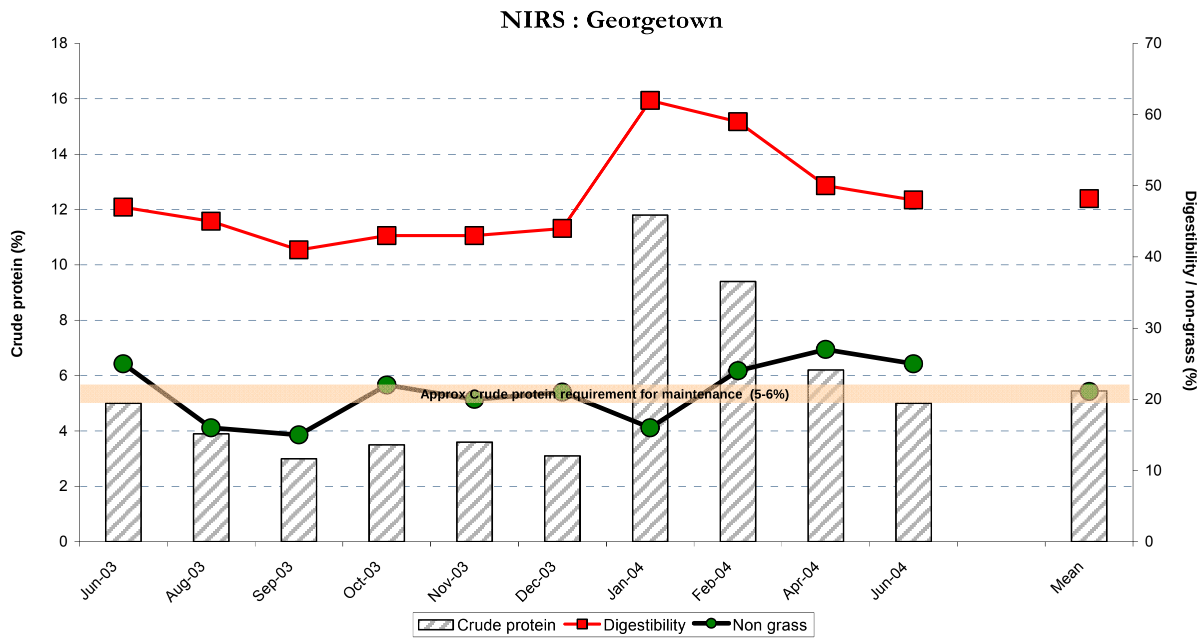


Figure 8 - NIRS predictions for forest country pastures in the Georgetown region

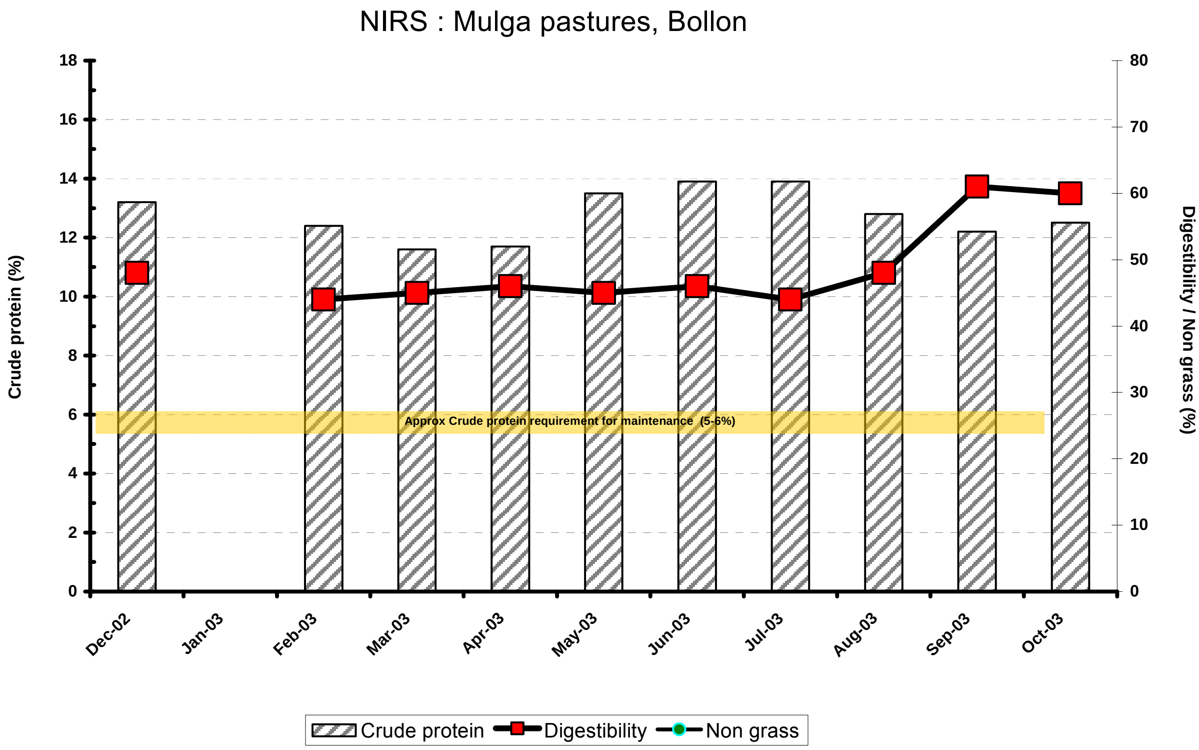


Figure 9 - NIRS predictions of crude protein and digestibility in the diet of cattle on mulga pastures in the Bollon district

9.15 Appendix O – List of acronyms

Table 1 - List of acronyms used in faecal near infrared reflectance spectroscopy and in this report

ADG	Average daily gain in kg/hd/day - calculated by NIRS; gives an indication of the liveweight performance of a 300 kg, medium frame steer on the base pasture diet, excluding any effect of feed supplementation that may be supplied with the pasture.
CP	Crude Protein (%) - calculated by NIRS prediction equation; equivalent to protein calculation from wet chemistry method, Nitrogen % * 6.25.
DMD	Dry Matter Digestibility (%) - calculated by NIRS.
DMD:CP	Dry Matter Digestibility to Crude Protein ratio – both calculated by NIRS; used as indication of the balance between protein and energy. Values of 8 and above indicate likelihood of an animal response to supplemented nitrogen e.g. urea; below 8 indicates sufficient dietary protein.
FN	Faecal Nitrogen (%) - calculated by NIRS; used as a check on the Crude Protein analysis. These results are correlated.
F.NIRS	Faecal near infrared reflectance spectroscopy. Analysis of dried, ground, fresh faecal samples for prediction of crude protein, digestibility, non-grass, faecal nitrogen, liveweight gain and ash content. Reflectance spectra is analysed and compared with the spectra from known diets to produce correlation equations.
LWG	Live Weight Gain – equivalent to ADG, daily liveweight gain in kg/hd/day - calculated by NIRS.
NG	Non-grass (%) - calculated by NIRS; the proportion of the predicted diet that is from feeds other than C4 grasses. It will include forbs, legumes, any C3 grasses and any tree or shrub browse.
NIRS	Near infrared reflectance spectroscopy (used as an abbreviation of F.NIRS); The analysis of reflectance spectra from ground dried faecal samples in a NIRS machine.
CP:FN	Crude Protein to Faecal Nitrogen ratio – both calculated by NIRS
Ash	Remaining material after incineration, indicating if sample was contaminated with soil; Measured as a % of the original dry weight.
N	Nitrogen concentration (%).
P	Phosphorus concentration (%).
P:N	Phosphorus to Nitrogen ratio.

9.16 Appendix P – Photo gallery from project

South Queensland

Figure 1 - TL. Poplar box woodland; TR. Brigalow; CL. heifers on Mitchell grass (June) and BL. weaners on mature buffel pastures (October), with associated faeces, in southern Queensland

Western Queensland

Figure 2 - TL Collecting samples at South Galway, Windorah; TR Collecting samples at Avon Downs, NT; CL Weaners near Tambo; CR Breeding herd on mulga country, Bollon; BL Spinifex country in the Desert Uplands, north-east of Aramac; BR Thomson River channel 80 km south of Longreach.

North Queensland

Figure 3 - TL Southern Gulf pastures; TR Basalt country; CL Atherton Tablelands; CR Gulf forest cattle in dry season; BL Eucalypt forest north Clermont; BR Weaners on supplement north of Cloncurry