NORTHERN TERRITORY GOVERNMENT

DEPARTMENT OF PRIMARY INDUSTRY AND FISHERIES

PRIMARY INDUSTRIES

ANNUAL RESEARCH ACHIEVEMENTS REPORT 2014-15

December 2015

Bibliography:

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Contents

About this report

The 2014-15 Annual Research Achievements Report (ARAR) provides a summary of research and development (R&D) activities in primary industries in the Northern Territory (NT) by the Department of Primary Industry and Fisheries (DPIF) excluding fisheries for which there is a separate annual report series now titled *The Status of Key Northern Territory Fish Stocks Report*. This report covers current and recently completed research in the pastoral and plant industries sectors. It highlights the effort of DPIF researchers through which services are provided to primary producers to improve their productivity and profitability.

Biosecurity and Animal Welfare Services of DPIF focus on preventing, excluding, effectively managing and, where possible, eradicating risks to the economy, animal and plant industries, the environment and human health posed by pests, diseases and chemical residues, and ensuring continued access for Territory primary produce to domestic and international markets.

Due to an outbreak of the cucumber green mottle mosaic virus disease in the NT in 2013-14, which required the full attention of plant industries staff, it was not possible to include plant industries R&D reports in that financial year's ARAR. Plant industries researchers are back on board now and their contribution is published in this report.

DPIF's Industry Development Plan 2013-17 focuses on profitable and productive primary industries, highlighting the following emerging challenges for R&D among others: provide certainty and security to encourage investment, facilitate continuous improvement in production quantity and quality, expand market options for Territory products, develop and promote a more efficient and environmentally sound production system, promote biosecurity and encourage Indigenous participation. Research project reports in this ARAR addresses many of these challenges.

The NT's primary industries sector is involved in pastoral, crop and horticultural production. The main products include beef cattle raised mostly on native pastures, buffalo, crocodiles, field crops, improved pasture, hay, seeds, forestry products, mangoes, melons, vegetables and flowers.

The primary industries sector in the NT has significant links with other sectors of the local economy and contributes to manufacturing, transport, storage and retail, thereby enhancing employment.

Comments and suggestions for improvements of future editions of this report, including content, layout and structure, are most welcome. Please send your comments and suggestions to technical.publications@nt.gov.au.

Images/photos: Unless otherwise stated, all images and photos are sourced from the lead researcher.

Cover Images	Left: Potted flowering curcuma nutrition trial (Source: Doris Marcsik) Right: Examples of two 2014-branded steers in the Quality Graze Producer Steer Challenge (Source: Chris Materne)
Report compilation:	Hassan Bajhau, Jason De Araujo, Tim Schatz, Cameron McConchie and Christine Long

Glossary of abbreviations

ACIAR	Australian Centre for International Agricultural Research
AGBU	Animal Genetics and Breeding Unit
AI	Artificial insemination
a.i.	Active ingredient
ASPIAC	Alice Springs Pastoral Industry Advisory Committee
AZRI	Arid Zone Research Institute
BF	Berrimah Farm
BHF	Beatrice Hill Farm
BRAC	Barkly Research Advisory Committee
BVL	Berrimah Veterinary Laboratories
CDU	Charles Darwin University
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific Industrial Research Organisation
DDRF	Douglas Daly Research Farm
DPIF	Department of Primary Industry and Fisheries (NT)
EBVs	Estimated breeding values
F1	First filial generation (the generation of hybrids arising from a first cross (animal genetics))
KPIAC	Katherine Pastoral Industry Advisory Committee
KRS	Katherine Research Station
MLA	Meat and Livestock Australia
MSA	Meat Standards Australia
NT	Northern Territory
NTCA	NT Cattlemen's Association
OMPRS	Old Man Plains Research Station
PDS	Producer demonstration site
PD	Pregnancy diagnosis
PPMS	Precision pastoral management system
PPMT	Precision pastoral management tools
QAAFI	Queensland Alliance for Agriculture and Food Innovation
RCD	Resin canal discolouration
RLMS	Remote livestock management system
SOC	Soil organic carbon
SRM	Society for Rangeland Management
UNE	University of New England
VRD	Victoria River District
VRRS	Victoria River Research Station

1 Pastoral Production

1.1 An Investigation of Finishing and Pre-trucking Strategies to Maximise Meat Standards Australia (MSA) Compliance for Steer Turn-off to Abattoirs

Contact: Jocelyn Coventry - Pastoral Production Officer

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Commenced.

A pre-trucking trial using anecdotal industry information about 'best management practice' was initiated using turn-off steers from Old Man Plains Research Station (OMPRS) destined to abattoirs. It is investigating strategies to improve MSA compliance in Australia. It involves:

- Pre-trucking management and feeding to improve compliance for MSA grading, including the study of individual steer growth rates, rangeland pasture and management within a six-week period prior to the trucking of steers to abattoirs.
- The measurement of muscle glycogen in steer carcasses at abattoirs. It is recognised that muscle glycogen is optimised by pre-trucking factors, such as improvements in pre-slaughter nutrition and a decrease in incidents leading to stress or muscle contraction. Meat and Livestock Australia has provided carcass criteria for MSA grading and general pre-trucking guidelines that help to maximise them.

Leading steers to the Mulga Dam trucking yard for training

Steers drinking water supplemented with a commercial electrolyte at the recommended rate

Results

Daily weights were recorded for 97 30-month-old steers for six weeks prior to trucking to abattoirs.

Records were kept of yard training, consumption of water, mineral supplement, electrolytes and hay.

1.2 The Use of Alternative Tropical Breeds Part D: Senepol Crossbreeding Trial

Contact: Tim Schatz – Principal Pastoral Production Research Officer
Collaborating staff: Kieren McCosker and Whitney Dollemore

Reference to the DPIF Industry Development Plan 2013-2017:

1.2 Facilitate continuous improvement in production quantity and quality.

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.3 Expand market options for Territory products.

1.3.2 Work collaboratively with industry to identify and respond to potential and actual market disruptions.

Project Status: Continuing.

The project evaluated a Senepol crossbreeding program in the north of the Northern Territory (NT) to compare the performance of F1 Senepol x Brahman cattle with that of Brahmans. Brahmans have a reputation in Australian domestic markets for having poor meat tenderness and as a result high grade Brahman cattle are not highly sought after in southern Australian domestic markets. The South-East Asian export market is the reverse, with Brahman normally considered the breed of choice with perceived discrimination against *Bos taurus* infusion. The performance and marketability of Senepol cross progeny were tested in both the Australian domestic market (south-east Queensland) and in the South-East Asian export market (Indonesia). In terms of growth rate and performance in both markets, Senepol cross steers outperformed pure Brahman, thus demonstrating that this strategy would increase the marketing options for NT cattle producers currently with Brahman herds as they could produce cattle that would be suitable for both the live export and Australian domestic markets.

F1 Senepol x Brahman steers at Lampung (Indonesia)

Brahman and F1 Senepol first-lactation heifers at the Kumbidgee leased paddock

Results

Table 1. Growth rates in four groups of Brahman and Senepol steers

Year (period of time)	Brahman growth (kg)	F1 Senepol growth (kg)	Difference : F1 Senepol – Brahman (kg)
2010-11 (287 days)	118.4	129.2	10.8
2011-12 (254 days)	94.8	107.8	13.0
2012-13 (245 days)	90.9	100.6	9.7
2013-14 (210 days)	82.6	98.1	15.5

The average post-weaning growth from June to March in four groups of steers grazing improved pasture at Douglas Daly Research Farm was 12.3 kg higher in F1 Senepol than in Brahman steers.

A comparison between Brahman and F1 Senepol steers in an Indonesian feedlot in 2014-15 using 54 F1 Senepol and 32 Brahman steers at the Elders feedlot near Lampung, Sumatra for 121 days showed that the average daily gain over the period was 0.17 kg higher (P<0.001) in F1 Senepols (1.71 vs 1.54 kg/day). F1 Senepols were 21.6 kg heavier (P=0.002) by the end of the trial period. There was no significant difference between the groups in average fat depth at the P8 site at the end of the feeding period (F1 Senepol = 10.5 mm, Brahman = 10.6 mm) despite F1 Senepols being heavier. The results should encourage live-export cattle buyers to purchase such animals (Brahman x tropically adapted *Bos taurus*) with confidence.

The performance of F1 Senepol and Brahman heifers is being compared on native pasture in the Katherine area. Pregnancy rates in maiden (two-year-old) heifers are 18% higher in F1 Senepol heifers than in Brahman heifers.

Table 2. Pregnancy rates in four groups of Brahman and F1 Senepol maiden heifers

	#10 (%)	#11 (%)	#12 (%)	#13 (%)	Average for all years (%)
Brahman	83.7	75.2	58.9	61.2	70
F1 Senepol	94.4	86.8	84.1	85.4	88
Difference	10.7	11.7	25.2	24.2	18

Table 3. Pregnancy rates in three groups of Brahman and F1 Senepol first lactation heifers

	#10 (%)	#11 (%)	#12 (%)
Brahman	26.7	7.0	1.5
F1 Senepol	46.4	6.0	5.6
difference	19.8	-1.0	4.1

F1 Senepol calves were heavier at weaning by about 20 kg due to hybrid vigour.

F1 Senepol steers are usually about 20 kg heavier than Brahman steers after weaning and then grow about 12 kg more over the post-weaning year becoming about 30 kg heavier at turn-off around 18 months of age.

Most F1 Senepol calves are polled or scurred with very few (less than 5%) having horns.

It has been reported that many Indonesian cattle importers have a strong preference for high-grade Brahman cattle over crossbred cattle. The feedlot trial was conducted to also investigate whether this perception was true or it was just an assumption based on previous performance of crosses with British breeds. The results of the feedlot trial show that Brahman crosses with a tropical *Bos taurus* breed will perform as well as or better than Brahmans under Indonesian conditions. This should mitigate concerns that importers may have about buying such crossbred cattle from the NT.

The results also showed that F1 Senepol calves were heavier by about 20 kg at weaning than Brahman calves due mainly to hybrid vigour and that they weighed about 10 kg more over the post-weaning year, thereby weighing about 30 kg more at turn-off at around 18 months of age; also F1 Senepol heifers appeared to grow faster than Brahman heifers following weaning and, combined with their heavier weaning weights, they were heavier at joining by about 30 kg and that pregnancy rates in maiden F1 Senepol heifers were about 10% higher.

1.3 Cell Grazing of Improved Pastures for Increased Beef Production and Soil Carbon Sequestration

Contact: Tim Schatz – Principal Pastoral Production Research Officer

Reference to the DPIF Industry Development Plan 2013-2017:

1.2 Facilitate continuous improvement in production quantity and quality.

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.3 Expand market options for Territory products.

1.3.3 Identify opportunities for primary producers to participate in the climate change and carbon economies.

2.1 Develop and promote more efficient and environmentally sound production systems.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

This project is comparing the effects of set-stocking and cell-grazing regimes on animal and pasture production, pasture composition and (see a separate report by David Ffoulkes) on sequestration of soil organic carbon at the Douglas Daly Research Farm (DDRF).

The groups being compared are (a) Cell grazing (CELL), (b) Set stocking constantly at the long-term safe carrying capacity (SSc) and (c) Set stocking at a variable stocking rate that is set to be the same as the effective stocking rate in the cell-grazing group (SSv).

Young animals join the trial shortly after weaning and remain for about one year to be replaced by next year's group of weaners. The large CELL group animals rotate around 26 paddocks, each 6 hectares, while the set-stocked group animals always remain in the same 6-hectare paddock.

Results

Individual animal performance was highest in the set-stocking group with the lowest stocking rate. Production per hectare has been highest in the set-stocking group with the highest stocking rate. The same trend has been seen in the 6-hectare groups, although in 2012-13, the average growth was slightly lower in the SS group with the lowest stocking rate due to one of the paddocks having much lower growth rate than the other two paddocks (121 kg/animal in paddock 25 vs 142 kg/animal in the other two paddocks).

Cell grazing trial animals during the wet season

Cell grazing trial animals during the dry season

Table 1. Average growth during the post-weaning year in the different groups

Year	Treatment	Average growth / animal (kg)	Average growth / ha (kg)
2009-10	SSc 1.5 head/ha	132.7	199.0
	SSv 1.33 head/ha	137.3	183.0
	Cell 1.33 head/ha	114.6	152.9
2010-11	SSc 1.5 head/ha	186.0	279.0
	SSv 1.67 head/ha	174.0	289.9
	Cell 1.67 head/ha	161.2	268.6
2011-12	SSc 1.5 head/ha	167.7	251.6
	SSv 1.83 head/ha	151.9	278.5
	Cell 1.83 head/ha	119.9	219.9
2012-13	SSc 1.5 head/ha	135.6*	203.4*
	SSv 1.83 head/ha	138.0	253.0
	Cell 1.83 head/ha	122.1	223.8
2013-14	SSc 1.5 head/ha	141.2	211.8
	SSv 1.5 head/ha	139.4**	209.0**
	Cell 1.5 head/ha	127.3	191.0
2014-15	SSc 1.5 head/ha	148.8	223.2
	SSv 1.33 head/ha	150.6	200.7
	Cell 1.33 head/ha	134.6	179.4

Note: Weights were recorded after a 12-hour fast without feed or water. SSc = Set stocked at a constant rate (1.5 animals/ha), SSv = Set stocked at a variable rate (equivalent to the stocking rate in the cells) and Cell = Cell grazing.
*Average growth was reduced probably due to wallaby competition for pasture.
**Data from one paddock was excluded due to buffel grass die back, which resulted in its destocking for three months.

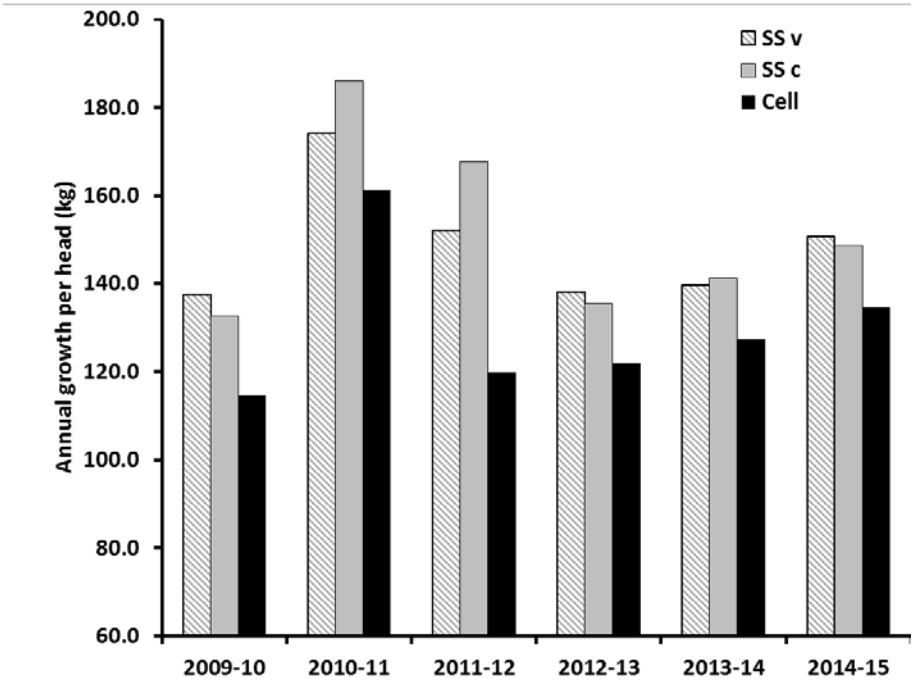

Figure 1. Annual growth per animal in the different groups

1.4 Cell Grazing for Better Productivity and Carbon Sequestration

Contact: David Ffoulkes – Pastoral Officer
Collaborating staff: Peter Shotton

Reference to the DPIF Industry Development Plan 2013-2017:

1.3 Expand market options for Territory products.

1.3.3 Identify opportunities for primary producers to participate in the climate change and carbon economies.

Project Status: Under review.

Time-controlled or cell grazing (CG) management systems for beef production are claimed to improve animal and pasture production as well as increase soil carbon (C) sequestration compared with continuous grazing (CC) systems. The aim of this project was to verify these claims. If true, this would lead to increased profitability and provide a potential source of extra income for producers in the form of C credits. This is a part of the cell grazing trial reported earlier in this Annual Research Achievements Report.

The project area was divided into a lattice of 32 x 6 hectare uniform buffel pasture paddocks on sandy Blain soils. Twenty six paddocks were used for CG and the rest were used for CC at two stocking rates (SR) with three replicate paddocks for each SR (see Figure 1).

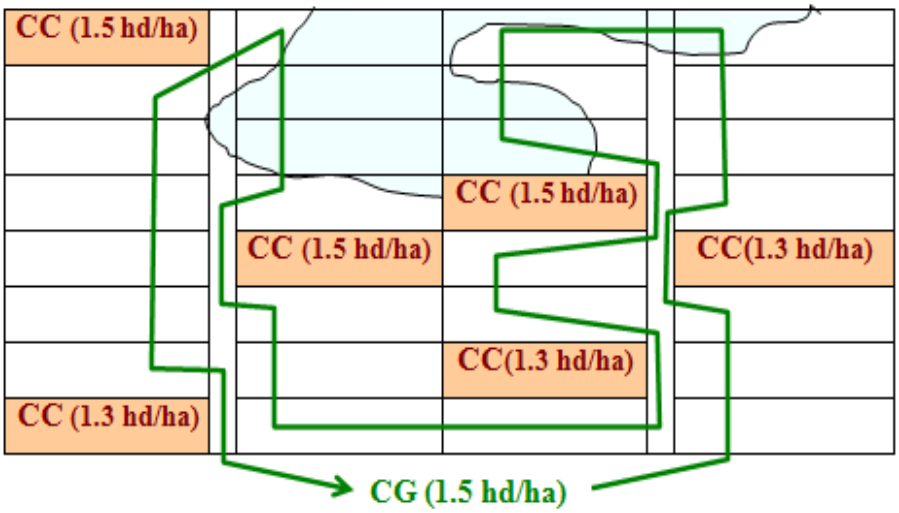

Figure 1. Paddock plan of the cell grazing (CG) trial showing continuous grazing (CC) paddocks (shaded brown) and approximate path (green arrow) of CG while a small area of the project (shaded green) was not used for soil sampling

Soil samples were collected annually towards the end of the dry (October) and wet (May) seasons for five years using a systematic random sampling methodology (Allen et al. 2010). Ten soil core samples were randomly taken from 15 GPS points of a 3 x 5 grid of approximately 50-m spacing transecting the sampling paddock. The 10 samples from each site were bulked for each depth (0-10 cm, 10-20 cm and 20-30 cm), air-dried and sieved to 1 mm for total C analysis at CSIRO. Soil pH was recorded on random samples and three bulk density measurements were taken at each depth using volume-calibrated tanner rings and oven-dried soil contents.

Results

The overall means of C stocks in the top soils of each grazing area for the trial period are presented in Table 1. There were clear differences in soil C content between depths (p=0) with 45% of top soil C in the first 10 cm and 55% in the 10 to 30 cm profile; but there was no evidence of a treatment effect. The variance of data-sets for dry season measurements was much less than for wet season data-sets, which is reflected in the p-values for each season in Table 1.

Table 1. Overall means and totals of C stocks (t/ha) at each depth in top soil (0-30 cm) for the dry and wet seasons for each grazing area

October	Cell grazing	Cont. grazing (variable SR)	Cont. grazing (constant SR)	Mean C (t/ha) p=0
0-10 cm	7.63	6.92	7.45	7.33
10-20 cm	5.18	5.04	5.18	5.13
20-30 cm	4.11	4.05	4.18	4.11
Total C (t/ha) p=0.5	16.92	16.01	16.81	
May				
0-10 cm	7.86	7.37	7.85	7.69
10-20 cm	5.31	5.24	5.03	5.19
20-30 cm	4.18	3.77	3.99	3.98
Total C (t/ha) p=0.86	17.35	16.38	16.87	

The linear regression analysis of soil C stocks (t/ha) in paddocks under each different grazing management over five to six years is shown in Table 2. The results show that towards the end of the dry season (October), there was no additive sequestration of C in the CG group, while there were significant increases in C stocks in the CC groups. The wet season data (May) did not show any significant C stock increases over time; however, the regression lines suggest a similar pattern to the dry season results.

Table 2. Probability (p) of correlation (r) between increases in soil C (t/ha) at 0-30 cm depth over time for each grazing system (individual system models)

Grazing management	Oct (2009-14)		May (2009-14)	
	r	p	r	p
Cell grazing (CG)	0.07 (df 34)	0.70 ns	0.18 (df 22)	0.41 ns*
Continuous (variable SR)	0.59 (df 16)	0.01 **	0.36 (df 10)	0.25 ns
Continuous (constant SR)	0.54 (df 16)	0.02 *	0.34 (df 10)	0.29 ns

Not significant (ns), p<0.01 (**), p<0.05 (*); df = degrees of freedom

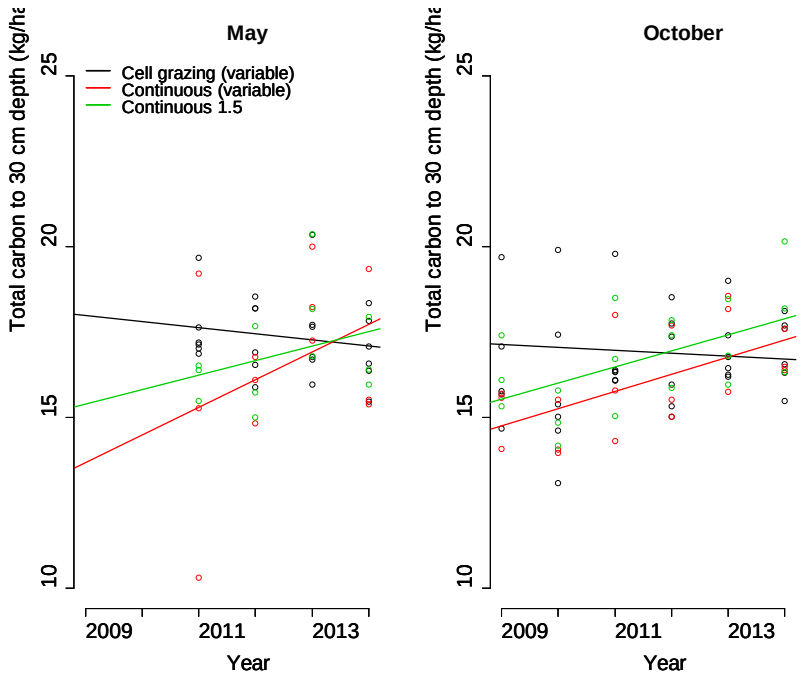

Figure 2. ANCOVA linear modelling of total C stocks (y) over years (x) for continuous grazing groups relative to cell grazing based on wet season (May) or dry season (October) measurements

Table 3 presents estimated rates of C sequestration for the CC groups relative to CG, for which there was no increase in C stocks over five years. Based on dry season (October) measurements, the CC treatments both sequestered 0.6 tonne (t) C per annum and strongly tended towards being significantly different from CG ($p<0.06/0.08$). Based on wet season (May) measurements, only the CC (variable SR) treatment showed a strong tendency to increasing C storage (0.89 t C/year) relative to CG ($p<0.07$).

Table 3. Significance of C sequestration rates in continuous grazing groups relative to cell grazing

Grazing management	Oct (2009-14)		May (2009-14)	
Sequestration rate	t ha/year	p	t ha/year	p
Cell grazing	-0.085	0.1	-0.177	0.1
Continuous (variable SR)	0.585	0.06*	0.984	0.07*
Continuous (constant SR)	0.555	0.08*	0.600	0.26 ns

Not significant (ns), $p<0.10$ (*)

The mean top soil C stocks (t/ha) at 0 to 30 cm presented in Table 1 are less by 10% than average values of soils taken from the surrounding natural landscape during the trial (16.7 vs 18.5). Most of this difference appears to be due to a 20% higher soil C level in the top 10 cm layer of the adjacent savannah woodlands (9.6 vs 7.5), which could be due to the additional tree litter and accumulated C ash from bushfires.

Independent modelling of the CG treatment indicates that there was no increase in C stocks in the top soil (0-30 cm) of the paddocks over the five-year measuring period. This result is contrary to the belief that CG systems increase C sequestration as well as pasture and cattle productivity (McCosker 2011). Alternatively, it could be argued that C sequestration pathways are impacted by very heavy grazing (±40 animals/ha) as the herd rotates from paddock to paddock in short time cycles (one to three days) leaving much less plant litter available on the soil surface for decomposition. When the herd returns to the paddock at the next rotation cycle, the uniform regrowth across the paddock is consumed again before the grass has time to age and contribute to soil C.

The increase in top soil C stocks in CC treatments (based on dry season measurements) is likely the result of more plant litter available for decomposition, particularly from less palatable forage components and species that are avoided by set-stocked cattle. This increase in soil C, however, was not apparent when based on wet season measurements, possibly because of fewer measurements (four vs five years) and the variability of soil C values in the wet season compared with dry season values.

The multiple regression modelling found that set stock CC systems were likely to be different from CG management in terms of C sequestration based on dry season measurements. This was also the case based on wet season measurements for the CC treatment (variable SR) that was aligned with the CG SR, whereas the CC (constant SR) treatment was not different from CG, most likely due to fewer data-sets and wet season variability in soil C. This variability is due to significant CO_2 emissions from top soils after rainfall events in the wet season.

Based on dry season measurements, CC treatments sequestered an average of 0.6 t C/ha per annum which, after five years, amounts to 3 t C or 11 t CO_2 abatement per hectare. Under the Australian Government's Emissions Reduction Fund ($13.95/t abatement), the CC area of 36 hectares used in this project is worth $5540 of C credits, with the potential to increase this over another five to six years. This would be of interest to cattle producers who are planning to intensify operations by developing improved pastures together with a grazing management strategy to optimise soil C sequestration and storage.

Conclusions

The project demonstrated that CG did not result in any additive storage of soil C in buffel grass pastures over a five-year period. Both low and high SR under CC management systems on buffel grass sequestered and stored about 0.6 t C/ha annually over a five-year period with potential for further C storage under this grazing system. Set stocked CC management of improved tropical pastures has the potential to provide significant extra income in the form of C credits.

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Cell grazing paddocks

Soil sampling

1.5 The Effect of Phosphorus Supplementation on Female Cattle Growth and Fertility

Contact: Tim Schatz – Principal Pastoral Production Research Officer
Collaborating staff: Kieren McCosker and Whitney Dollemore

Reference to the DPIF Industry Development Plan 2013-2017:

1.2 Facilitate continuous improvement in production quantity and quality.

1.2.1 Targeted research, development and extension to address agreed industry priorities.

2.1 Develop and promote more efficient and environmentally sound production systems.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

Despite a common belief that phosphorus (P) supplementation of cows in deficient country is beneficial, the benefits in northern Australia remain largely unproven by scientific studies and P supplementation is lower than expected.

This project is observing the effects of P supplementation on growth and reproductive performance in female cattle grazing native pasture. The supplemented group is supplied a P supplement throughout their lives while the unsupplemented group receives no supplement. Both groups graze in adjacent paddocks, which are P deficient. The groups alternate paddocks each year.

Weaner heifers in the unsupplemented group in August 2014

Eighteen-month-old heifers in the unsupplemented group in May 2015

Results

Preliminary results show benefits from P supplementation. Average post-weaning growth was 31.9 kg higher in the supplemented group (90.5 kg vs 58.6 kg). Blood P levels were higher in the supplemented group (1.98 mmol/L vs 1.37 mmol/L).

1.6 A Comparison between the Use of Bopriva and Spaying

Contact: Tim Schatz – Principal Pastoral Production Research Officer

Reference to the DPIF Industry Development Plan 2013-2017:

1.2 Facilitate continuous improvement in production quantity and quality.

1.2.1 Targeted research, development and extension to address agreed industry priorities.

2.1 Develop and promote more efficient and environmentally sound production systems.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

This study is evaluating the effectiveness of a new drug (Bopriva®) in preventing pregnancy in cattle and comparing it with spaying.

One group of 45 cows was spayed and another group of 45 cows was treated with Bopriva. The trial started on 31/8/2014 when all cows were weighed and the Bopriva group received their first injection. The second Bopriva injection was given on 21/11/2014 i.e. 82 days or almost 12 weeks later and all cows were weighed on that date. The final recording of weights and pregnancy was on 25/3/2015 i.e. 125 days or 4.5 months after the second injection.

Cows at Victoria River Research Station

Cows at Brunchilly Station

Results

One Bopriva-treated cow became pregnant. There was no difference in weight changes between the groups.

Bopriva use was more profitable than spaying by $12.80 per animal. However, the cost-effectiveness of Bopriva to prevent pregnancy depends largely on the mortality rate due to spaying, which is in the range of 2% to 10% and the break-even point is 2.1%, above which Bopriva use becomes more profitable.

1.7 The Repronomics Project – the Animal Genetics and Breeding Unit (AGBU) Collaborative Genetics Project

Contact: Tim Schatz – Principal Pastoral Production Research Officer
Collaborating staff: Whitney Dollemore

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.

Project Status: Continuing.

This project is in collaboration with AGBU and QDAF/QAAFI to study the genetic effects on age at puberty of heifers and post-partum anoestrus interval after first calving to increase the accuracy of fertility estimated breeding values (EBVs) to improve the rate of progress through selection. It may also develop new fertility EBVs and find genomic markers for the traits.

Ultrasound scanning ovaries to detect a *corpus luteum*

Selected Brahman heifers at Douglas Daly Research Farm

Results

The growth rate and consequently joining weights of 2013-weaned heifers were lower than normal, resulting in a lower pregnancy rate. Only 15% of group 13 heifers were pregnant following yearling mating and 68% had reached puberty by eight months of age. The average weight at puberty was 297 kg and all heifers had conceived for the first time by the end of two-year-old mating. Growth rates and consequently joining weights in weaned heifers in 2014 were better and 50% of group 14 heifers were pregnant following yearling mating.

Of the 28 heifers from the 2011 drop, which calved for the first time over the 2013-4 wet season, 22 (79%) reconceived by the end of mating (30/3/2014) and four of the six empty heifers had recommenced cycling by 3/7/2014.

Of the 24 heifers from the 2012 drop, which calved for the first time over the 2013-14 wet season, 18 (75%) reconceived by the end of mating. The six empty heifers were then scanned throughout 2014 to determine when they recommenced cycling.

1.8 The Interaction between Weaning Weight and Post-weaning Nutrition on Live-weight Gain and Body Size in Cattle

Contact: Kieren McCosker – Pastoral Production Officer, Beef Cattle
Collaborating staff: Tim Schatz

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.

Project Status: Continuing.

This study is investigating several nutritional management strategies for young cattle during their first dry season after weaning.

Two live-weight groups of weaners were fed to achieve five different weight gains over the 2014 dry season. Compensatory growth and the effect on puberty of heifers over the subsequent wet season were measured to develop a relationship between live-weight gain during the dry and wet seasons and their interaction with weaning weight.

Study animals during the dry season

Heavy T5 and heavy T1 animals post feeding during the dry season

Results

Results are presented in Table 1. Although not yet statistically analysed, the data suggests that while there was some compensatory weight gain during the wet season in treatment groups that had lower live-weight gain during the dry season, total annual weight gain was higher in groups that grew more during the dry season, especially in the heavy weaner group.

Table 1. A summary of the results

Treatment group	Light weaner group			Heavy weaner group		
	Dry	Wet	Annual	Dry	Wet	Annual
			Live-weight gain (kg/animal)			
T1	15.5	66.8	82.3	8.2	68.4	76.6
T2	17.8	64.7	82.5	20.5	69.2	89.7
T3	37.4	65.7	103.1	39.2	59.8	99
T4	48.6	57.6	106.2	52.8	50.8	103.6
T5	51.0	52.5	103.5	60.1	49.0	109.1
			Skeletal elongation rate (mm/100 days)			
T1	55.8	32.9		52.7	19.8	
T2	58.8	33.3		59.2	26.9	
T3	72.1	37.8		60.3	21.4	
T4	75.6	35.1		66.4	19.0	
T5	79.1	32.5		68.2	14.5	

1.9 Selected Brahmans - Improvement in the Fertility of the Brahman Breed through the Use of BREEDPLAN EBVs and Selection

Contact: Whitney Dollemore – Pastoral Research Officer
Collaborating staff: Tim Schatz

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.

Project Status: Continuing.

Research to improve fertility in Brahman cattle started in 1986. Selection was based on yearling mating of heifers and a strict culling of females older than two years that did not rear a calf each year. Bulls were selected at 12 and 18 months on testicular size, growth and dam performance. Artificial insemination (AI) was also used to introduce outside genes. AI sires were selected using a selection index that places high importance on low days to calving and high scrotal circumference estimated breeding values (EBVs). The herd joined the Australian Brahman Breeders' Association and became a member of BREEDPLAN in 1994. The current project is a continuation of the previous work.

Breeders and their weaners at Victoria River Research Station

A scurred bull mated to two and three-year-old heifers at Douglas Daly Research Farm in 2014-15

Results

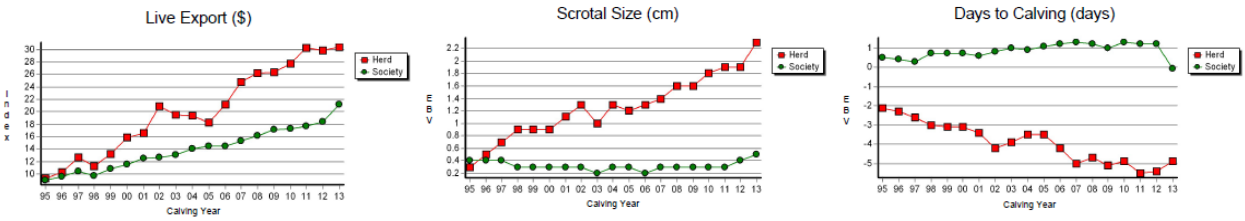


Figure 1. The updated 2014 Group BREEDPLAN figures

In 2014-15 animal numbers reached 183 females at Victoria River Research Station (VRRS) and 218 first and second-calf heifers, 151 bulls (of which 90 will be sold) and 261 yearlings at Douglas Daly Research Farm (DDRF).

Semen was collected in June 2015. Emphasis will be on gaining linked sires with the Beef CRC herd for the collaborative project with AGBU titled 'Intensive Genotyping and Phenotyping for Accelerated Genetic Improvement of Reproduction in Northern Australia'.

The following notable results were observed at Round 1 muster (May 2015):

- 50% of yearling heifers (2014) were detected to be pregnant at DDRF.
- 67% (10/15) lactating first-calf heifers, which had conceived as yearlings in 2013 at DDRF, re-conceived.
- 79% (62/78) 2012 wet heifers re-conceived at DDRF.
- 75% (71/94) was the weaning rate in 2012 heifers at DDRF.
- 72% (107/149) wet cows re-conceived at VRRS.
- 10% (16/165) was the calf loss rate at VRRS.

The pregnancy rate in the breeder herd at VRRS was lower in 2015 than in previous years. The pregnancy rate in yearling-mated heifers at DDRF was considerably higher than in previous years due to an increase in the average joining weight. Calf losses were higher than normal (average 8%), perhaps due to an increased presence of dogs.

1.10 Improving Breeder Herd Efficiency in the Arid Region with Performance Recording and Objective Selection

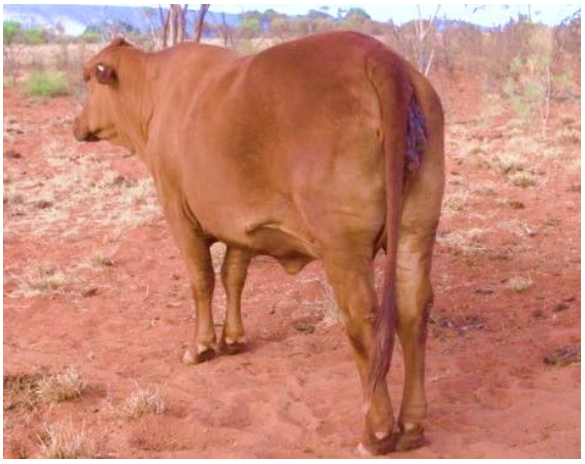
Contact: Jocelyn Coventry – Pastoral Production Officer
Collaborating staff: Chris Materne and Coral Allen

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.

Project Status: Continuing.

This project uses a breeding herd of Droughtmaster-infused cattle at Old Man Plains Research Station (OMPRS) in the arid region to demonstrate benchmarking of herd performance, best-practice management, bull breeding soundness evaluation, genetic improvement through objective selection and BREEDPLAN recording.

A calf tries to lick its dam's ear to persuade her to stand and allow suckling



A cow with a suspected increase in dietary phytoestrogens, which may have caused the external reproductive tract to swell

Results

By July 2015, 753 Droughtmaster cattle were recorded on the Droughtmaster database for BREEDPLAN performance recording. In 2014-15, information on 240 new calves was added to the data base.

The weaning rate in 2014 in pregnant cows in the naturally-mated group at OMPRS was 85%. In mature cows (three to 10 years old) calf losses in the third trimester were 3.0%, perinatal were 8.1% and postnatal were 1.0%. Perinatal and first-calving heifer losses were associated with poor heifer nutrition during early pregnancy and a suspected increase in dietary phytoestrogens.

By the middle of 2015, 88% of mated cows were pregnant. It appears that conception efficiency declined with age, as only 14% of five-year-old cows conceived in the first trimester, whereas 33% of nine to 11 year-old cows conceived in the first trimester.

Culling bulls to meet herd breeding objectives and to improve the efficiency of the breeding herd reached 58%.

1.11 A Comparison between the Productivity of a Multi-breed Composite and a Brahman Breeder Herd

Contact: Barry Lemcke – Principal Livestock Management Officer
Collaborating staff: Grant Hamilton, Robert McDonald, Douglas Dickerson, Jarod Palmer, Spud Thomas and Christine Hazel

Reference to the DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

The limitations of the Brahman breed for the Top End of the Northern Territory are well known and the search for a better alternative has been ongoing. Finding a breed that can also be suitable for a southern market is paramount should the South-East Asian export markets fail, as happened in 2011. This project compares the performance of a multi-breed composite under Top End conditions and assesses its suitability as an alternative to the Brahman breed. A multi-breed composite is able to combine the attributes of a larger number of breeds and capture a larger amount of heterosis than conventional two-breed crossings. The composite is 56.3% Brahman, 12.5% Afrikander, 12.5% Tuli, plus 6.3% each of Shorthorn, Hereford and Charolais. This mix is 81% tropically-adapted and 19% unadapted *Bos taurus*. Some other breeds, such as Senepol, have been introduced to heifers through artificial insemination to see whether they can contribute to overall productivity. The composite is expected to retain 64% of heterosis in the second generation onwards. The two breeds (composites and Brahmans) are run together except during mating between January and March. Their performance is assessed through BREEDEPLAN, which is also used to select bulls for breeding and for sale. Females are culled if they fail to get pregnant at two years of age or at any time as mature cows four years old or older. A yearling heifer that calves as a two-year-old is allowed one missed pregnancy, but thereafter there are no exceptions. Cows are culled if they do not raise a calf to weaning, unless due to a known accidental cause. Herd numbers are now limited to about 80 to 90 animals at mating so a substantial number of pregnant females are available for sale to the industry annually. Now selection for polled animals is emphasised.

Composite bulls at Douglas Daly Research Farm at the 400-day semen test in December, 2014 to select for yearling mating in 2015. Polled calves are increasing in the composite herd, which is an important trait of the selection index

S6 (Suzie), a Senepol-Charbray cross, which was born in 2003 at Douglas Daly Research Farm and has had nine calves all born in October every year since in 2005

Results

Table 1. Herd composition in 2014-15

	Composite breeder herd at BHF	Brahman Breeder herd at BHF	Composite three-year-old heifers at mating at DDRF (wet unless lost a calf)	Composite two-year-old heifers at mating at DDRF	Composite two-year-old heifers at BHF at mating	Brahman two-year-old heifers at mating at BHF	Composite yearling heifers combined at BHF and DDRF at BHF mating	Brahman yearling heifers at BHF
Herd size at start of mating in 2015 (animals)	102	56	87	48	33	28	96	30
Pregnancy rate in 2014 (%)	92.6 (n=95) All non-pregnant culled	77.5 (n=89)	82.6 (n=92)	45.8 (n=48) (Pregnancy rate from yearling mating)	NA (none at BHF)	7.1 (Pregnancy rate from yearling mating)	NA	NA
Number culled at pregnancy test Jun-15 / % of breeders mated	20 / 19.6% 7 not pregnant (NP); 13 dry)	21 / 38.9% (n=54) 4 NP; 17 dry	18 / 21% (n=87)	12 / 25.0% (n=48	1 / 2.9% (Not culled as a two-year-old unless empty and dry	None culled	None culled	None culled
Mean live weight at pregnancy diagnosis (kg)	406	405	372	334	348	391	276	278
Mean birth weight (kg) for calves born in 2014-15	28.7 (n=89)	30.2 (n=51)	26.9 (n=74)	23.9 (n=21)	23.3 (n=24)	23.0	NA	NA
Calf mortality to weaning / % of calves born	2 / 2.2% (n=89)	5 / 9.8% (n=51)	6 / 8.1% (n=74)	1 / 4.8% (n=21)	5 / 20.8% (n=24)	0	NA	NA
Number of calves weaned	87	46	69	19	19	1	NA	NA
Weaning rate (%)	83.7	51.6	75	42.2	52.8	3.6	NA	NA
Mean calf weaning weight (kg)	184.1	178.1	153.7	136.3	152.2	143.0	NA	NA
Adult breeder mortality	0	1 (prolapse)	2 (lightning)	2 (1 lightning, 1 dystocia)		1	1	1
Pregnancy rate in 2015 (%)	93.1 (n=102) All non-pregnant culled	92.6 (n=54)	79.3 (n=87) All non-pregnant culled	78.3 (n=46)	67.6 (n=34)	100 (n=28)	67.7 (n=96)	3.3 (n=30)

BHF = Beatrice Hill Farm. DDRF = Douglas Daly Research Farm.

Table 1 shows that the composites continue to be superior to Brahmans in most traits.

The mature Brahman herd unexpectedly improved its pregnancy rate this year to almost equal that of the composite group. This may indicate that the heavy selection imposed on the group to bring them in line with that used on the composites is starting to have an effect. It may also be, in some part, due to the smaller herd size getting some stocking density relief with more feed being available during the mating period.

However, since the average weight this year was not greater than in the previous year, this is not thought to be a major factor. The earlier maturity of composite heifers is again shown in the yearling mating results when they had a much higher pregnancy rate than the Brahmans (68% vs 3%) despite being similar in weight. Weaning weights are variable and tend to be heavier in calves from older dams. There was little difference in average live weight between breeds except in two-year-old heifers, where Brahman heifers had a 43 kg advantage because they did not have a calf from yearling mating.

As the number of animals rises at BHF due to the relocation of heifers from DDRF, there has been a heavier emphasis on selection for fertility to match carrying capacity, where breeders are kept only if they never miss a calf since the age of three years. Each year, between 60 and 80 are sold to breeders to increase supply to the industry.

1.12 Riverine Buffalo and Crossbreeding Project

Contact: Barry Lemcke – Principal Livestock Management Officer
Collaborating staff: Grant Hamilton, Robert McDonald, Douglas Dickerson, Jarod Palmer and Tim Schatz

Reference to the DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.
1.2.1 Targeted research, development and extension to address agreed industry priorities.

Project Status: Continuing.

Riverine buffalo were imported from the USA between 1994 and 1997. They were the foundation for the Australian buffalo dairy industry. Crossbreeding with the local swamp buffalo allowed an expansion in animal numbers and also improved growth rates by 40% in calves enabling the production of quality meat (TenderBuff®) due to a younger age at slaughter, which improved tenderness and therefore, profitability. It also enabled milk production more rapidly, based on cheaper first and subsequent crosses, whilst backcrossing to riverine. Imported Italian dairy buffalo semen also facilitated the expansion of the herd and prevented inbreeding problems due to the low starting population base. The target is 100 purebred breeders able to turn-off around 40 purebred heifers per year to the industry.

Results

Table 1. Calving and pregnancy rates in 2014-15

Breeder group	Calving rate (%) 2014-15 calves born/cows mated	Pregnancy rate (%) cows preg Aug 2015/cows mated Jan 2015	Pregnancy rate in wet cows (%) (preg wet cows/total wet cows)
3/4 cows	78.4 (n=37)	81.8 (n=33)	76.9 (n=26)
7/8 cows	22.5 (n=40)	61.9 (n=42)	57.1 (n=21)
15/16 cows	87.1.(n=31)	80.4 (n=51)	81.6 (n=38)
Two-year-old cross-bred heifers (continued mating)	100 (n=15)	100 (n=5)	NA
Cross-bred yearling heifers (continued mating)	NA	55.6 (n=9)	NA
Two-year-old pure-bred heifers(continued mating)	84.2 (n=38)	85.7(n=35)	NA
Pure-bred yearling heifers(continued mating)	NA	42.1 (n=19)	NA
Riverine cows by AI	47.1 (n=38)	22/08/14 - 14/50 = 28 30/01/15 - 24/49 = 49 02/04/15 - 10/34 = 29.4 05/06/15 - 23/38 = 60.5	8/33 = 24.2 11/20 = 55 6/16 = 37.5 18/30 = 60
Old pure-bred group			
Old cows	73.3 (n=15)	47.0 (n=17)	2/8 = 25
Young pure-bred	NA	78.6 (n=14)	All weaned (Dry – rejects from AI)
Total	62.5 (n=261)	71.6 (n=225) excluding AI groups	69.9 (n=93) excluding AI groups
Weaning weight (kg) (2014-15)	7/8 calves 213.2 (n=29)	15/16 calves 203.5 (n=20)	Pure-bred from 15/16 cows 210.6 (n=40)

Pregnancy rates this year were higher mainly due to the improvement in the 7/8 group, but were still 20% below expectation. The wet cow pregnancy rate in the same group was below expectation for the second year in a row. The wet cow pregnancy rate improved compared with last year.

The success of artificial insemination (AI) was average. Conception rates were similar between wet and dry cows. Cows that failed to become pregnant with AI were naturally mated.

With over 100 riverine heifers now available for sale, the 10 buffalo dairies in Australia will have a chance to expand their enterprises.

The Vietnamese market demand for buffalo is strong. Also a South Australian farmer wishes to source more buffalo in the future to increase production.

Yearling riverine bulls at Beatrice Hill Farm

Two-year-old Italian cross bulls grazing on a floodplain at Beatrice Hill Farm in the dry season

1.13 Stocking Rate and Pasture Spelling Demonstration – Alexandria Station

Contact: Helen McMillian – Pastoral Production Technical Officer
Collaborating staff: Jane Douglas, Jodie Ward and Casey Collier

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.
2.1.3 Continue work to optimise sustainable and productive use of NT rangelands.

Project Status: Continuing.

The aim of this long-term project is to demonstrate the benefits of wet season spelling and sustainable stocking rates for maintaining good land condition at new bores and improving land condition at old bores. The demonstration commenced during the now completed Northern Grazing Systems project, which aimed to develop practical, region-specific management options for managing issues which impact on the profitability and sustainability of the northern beef industry.

Results

The results show that average annual utilisation rates in the demonstration paddock were within recommended levels for Mitchell grass pastures in the Barkly (<20-25%).

Sunrise through one of the gates heading out to Alexandria Station

Alexandria composite cattle

1.14 Pasture Sustainability - Kidman Springs

Contact: Dionne Walsh – Rangeland Program Manager
Collaborating staff: Robyn Cowley, Caroline Pettit, Helen McMillan and Jenna Keech

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.
2.1.3 Continue work to optimise sustainable and productive use of NT rangelands.

Project Status: Continuing.

The aims of this long-term research project are to monitor the pastures and land condition at Victoria River Research Station, verify whether the recommended stocking rates derived by Cowley and Bryce (2004) are sustainable and refine objective carrying capacity methods to improve the quality of advice to the industry.

Results

A preliminary report on pasture and land condition performance was produced in 2014, which showed that a revision of the carrying capacity estimates for all paddocks was warranted. This will be done in late 2015.

Pasture assessments showed that between 2003 and 2014 land condition improved in three paddocks, remained stable in five paddocks and declined in five paddocks.

The long-term land condition trends indicate that the carrying capacity estimates derived in 2004 were probably overestimated for three paddocks and underestimated for one paddock.

As a result of the land condition findings, cattle numbers for each paddock have been revised to ensure they are in line with their recommended carrying capacity and are appropriate for the current seasonal conditions.

Training observers to estimate grass yield at Kidman Springs

A great day at the office

1.15 Northern Grazing Carbon Farming - Integrating Production and Greenhouse Gas Outcomes (Climate Clever Beef 2)

Contact: Dionne Walsh – Rangeland Program Manager
Collaborating staff: Robyn Cowley, David Ffoulkes and Peter Shotton

Reference to the DPIF Industry Development Plan 2013-2017:
1.3 Expand market options for Territory products.
1.3.3 Identify opportunities for primary producers to participate in the climate change and carbon economies.

Project Status: Completed.

The aim of this project was to identify practices that improve both animal productivity and emissions performance, trial and demonstrate practices than can reduce emissions from cattle and/or increase carbon (C) sequestration in soils and vegetation, and assess the economic benefits of the practices and determine whether there is a business case for northern beef producers to participate in "C farming" projects.

Cattle at Douglas Daly Research Farm

Open Mitchell grass plains on the Barkly Tableland

Results

The project used case studies, on-farm demonstrations, business analysis and bio-economic modelling to evaluate the business case for integrating C farming practices into northern beef enterprises. The results were delivered across six regions in the NT and Queensland on more than 147 million hectares of land with more than 8.6 million cattle.

The project officers directly engaged with more than 2600 people and 1100 businesses through 67 field days and industry events and 90 publications. Seventy eight producers from 35 businesses implemented changes to their practices during the project's duration.

Conclusions

A reduction in livestock emissions intensity of 10% to 30% can be achieved by improving production efficiency, such as improving weaning rates and live-weight gain. Transaction costs of a C project would negate revenue for the majority of northern beef producers unless multiple projects could be aggregated within or between enterprises.

A number of complementary practices are required to achieve substantial improvements in productivity, profitability and emissions performance. The economic viability of C projects related to reducing livestock emissions is highly sensitive to herd size, project costs and C price.

Woody regrowth retention in Queensland has the potential to sequester significant amounts of C, but needs to be considered against the negative impact on long- term livestock carrying capacity.

The impact of grazing management practices on soil C was found to be negligible or inconsistent for the wide range of soil types, regions and production systems sampled, which presents a significant risk for participation in the C economy. Despite the low potential for soil C income, grazing management to optimise land condition has other desirable productivity, profitability and land management benefits.

Recommendations

Livestock methane emissions intensity can be minimised in the northern beef industry by improving agricultural production systems. However, the scale of most businesses is small to offset current C project management costs and C price risk. Due to high risk, producers should be cautious about conducting soil C projects for the sole purpose of generating revenue from the C economy. Most northern beef businesses should focus on cost-effective changes to improve production efficiency and the associated improvement in livestock revenue. Potential C income should be considered a bonus and not the basis for management change.

1.16 Shruburn (Victoria River Research Station Long-term Fire Experiment)

Contact: Robyn Cowley – Senior Rangeland Scientist
Collaborating staff: Caroline Pettit, Helen McMillan, Dale Jenner, Jenna Keech and Dionne Walsh

Reference to the DPIF Industry Development Plan 2013-2017:

1.2 Facilitate continuous improvement in production quantity and quality.

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.2.4 Support industry to understand, and adapt to, changes in climate.

1.2.5 Deliver improved information on the relative benefits and costs of implementing research outcomes to enable producers to make informed decisions.

2.1 Develop and promote more efficient and environmentally sound production systems.

2.1.3 Continue work to optimise sustainable and productive use of NT rangelands.

Project Status: Continuing.

The long-term Kidman Springs fire experiment, which was established in 1993, assesses the impact of fire management on woody vegetation cover and pasture condition. The experiment is replicated on red and black soil sites, with grazed experimental plots burnt early or later in the dry season, every two, four and six years, to compare with unburnt control plots.

Lighting fires in Rosewood West Paddock, Kidman Springs

Monitoring pastures in Rosewood West Paddock, Kidman Springs

Results

Early dry season fire was not effective to manage woody cover and leads to poorer pasture composition. Late dry season fires were the most effective in managing woody cover. If early fire is used, post-fire spelling is recommended until after the following wet season to protect pastures from grazing.

1.17 Making Production and Conservation Gains through Adaptive Grazing: Beetaloo Pilot Project

Contact: Jane Douglas – Pastoral Technical Officer
Collaborating staff: Dionne Walsh, Helen McMillan, Jenna Keech and Caroline Pettit

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.
2.1.3 Continue work to optimise sustainable and productive use of NT rangelands.

Project Status: Continuing.

The aim of this project is to evaluate and promote grazing land management practices, infrastructure development and animal productivity improvements that will increase business resilience in the Barkly pastoral region.

Rotation paddocks at Mungabroom Station

Bulls at Mungabroom Station

Results

Pasture data from 2012 to 2015 is now ready for statistical analysis.

1.18 Delamere Burning and Wet Season Spelling Demonstration

Contact: Jodie Ward – Pastoral Production Officer

Reference to the DPIF Industry Development Plan 2013-2017:

2.1 Develop and promote more efficient and environmentally sound production systems.

2.1.3 Continue work to optimise sustainable and productive use of NT rangelands.

Project Status: Continuing.

This demonstration project aims to provide recommendations on the use of wet season spelling (with and without early wet season burning) to improve pasture quality and condition on black soils in the Victoria River District. Two observers completed the pasture monitoring from 22 to 25 June.

A healthy sward of desirable native perennial pasture species at the Delamere Spell Burn Demonstration Site

Burning of treatment plots occurs after the first rains of the wet season every third or fourth year

Results

The key extension message this year from the trial was that not all forbs are created equal. Unpalatable forbs were found in significant amounts at all distances from water. Land managers must be familiar with local pasture species and their palatability and to what extent they contribute in the diet of cattle.

1.19 Central Australian Quality Graze Trial and Producer Steer Challenge

Contact: Chris Materne – Pastoral Production Officer
Collaborating staff: Coral Allan and Jane Tincknell

Reference to the DPIF Industry Development Plan 2013-2017:
2.1 Develop and promote more efficient and environmentally sound production systems.

Project Status: Continuing.

The aim of the project is to demonstrate and test the impact of various grazing strategies on land condition and the production of quality beef in Central Australia. The Stuart north paddock was stocked in May 2015 in a continuous set-stocking system according to grazing land management recommendations plus 5% to complete planned investigations. The 2013-branded steers were trucked to abattoirs in March-April, 2015 and their meat was graded according to Meat Standards Australia (MSA) specifications.

Examples of two 2014-branded steers in the Quality Graze Producer Steer Challenge

Steers from the Central Australian Quality Graze trial, which were branded in 2013 , ready for trucking to a premium quality beef market

Results

The majority of 2013-branded steers reached the target average growth rate of 0.5 kg/day (94%), p8 fat depth of over 5 mm (93%), ossification score of less than 175 (89%), fat colour of less than 4 (75%) and meat pH of less than 5.71 (90%). However, only 34% met the meat colour target of less than 4. Therefore, only 33% of the 2013-branded steers met MSA specifications.

Project results for 2014-15 were presented at the Southern Beef Producers' Field Day (Tieyon Station) and at several Northern Territory pastoral field days. The www.qualitygraze.nt.gov.au web site was launched. Between 18 March and 17 June, 2015, 268 site hits were recorded.

1.20 Precision Pastoral Management Tools Project

Contact: Sally Leigo – Principal Research Leader

Reference to the DPIF Industry Development Plan 2013-2017:

1.2 Facilitate continuous improvement in production quantity and quality.

1.2.1 Targeted research, development and extension to address agreed industry priorities.

2.1 Develop and promote more efficient and environmentally sound production systems.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

This is one of 12 projects of the CRC for Remote Economic Participation in cooperation with the Department of Primary Industry and Fisheries. It aims to develop a commercial precision pastoral management system (PPMS) based on integrated modules that are compatible with existing software and hardware. PPMS will integrate precision data on cattle and pasture performance using minimal labour and will determine its accuracy and benefit for beef producers.

Results

While the project's research activities during 2014-15 were focused on data collection at five research sites across the Northern Territory, Queensland and WA, it was noted that the station manager at Glenflorrie Station (WA) used PPMS to make decisions on stocking rates.

The location of the five cattle stations participating in the Precision Pastoral Management Tools Project (Glenflorrie, WA; Newcastle Waters and Undoolya, NT; Dalgonally and Tarrina, Queensland)

Assessing the pasture at Newcastle Waters Station

2 Plant Industries

2.1 Identifying Factors that Contribute to Mango Resin Canal Discolouration

Contact: Cameron McConchie – Research Leader

Reference to DPIF Industry Development Plan 2013-2017:

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.2.2 Develop effective research partnerships that support innovation and efficient delivery of extension information to clients.

2.1.1 Improve production and environmental management through innovation.

Project Status: Completed.

A one-year project investigated possible reasons for resin canal discolouration (RCD) in Kensington Pride (KP) mangoes in cooperation with the Queensland Department of Agriculture and Forestry. RCD is a quality defect that reduces the market value of ripe mangoes. The incidence of RCD has increased during the past two mango seasons, particularly in early-season KP mangoes produced near Darwin. KP mangoes were monitored in orchards and in the market.

Kensington pride mangoes showing symptoms of resin canal discolouration after ripening

Results

RCD was also occasionally found on green fruit on the tree or at grading when the fruit or stems had physical injury or were infected by pathogens. RCD occurrence varied considerably between different orchards and on different harvest dates. It increased in severity as fruit developed from firm ripe to overripe. Its incidence was higher in fruit that was exposed to commercial handling than in that ripened directly off the tree. It can be present in the flesh without showing symptoms on the skin. RCD incidence can be higher in early-season fruit than in that picked later. RCD incidence can be higher in fruit harvested soon after a rain event. RCD symptoms may be associated with bacterial infection.

Conclusions

The observations suggest that RCD is likely to occur when field conditions result in the production of ‘sensitive’ fruit that, in turn, shows the defect when exposed to harvest and post-harvest stresses. Future research will aim to confirm the precise causes of RCD and develop reliable control measures.

Recommendations

Future research into RCD should include sequential sampling of fruit during key stages of commercial handling to identify contributing factors. Since RCD increases in severity over time as fruit develops from firm ripe to overripe, surveys at the wholesale level may under-estimate the extent of RCD reaching consumers because fruit at retail will be riper and likely to display more severe symptoms. Where an appreciation of the full extent of RCD is required, we recommend that fruit be held until ripe and then assessed. Since RCD can be present in the flesh of fruit without exhibiting obvious symptoms through the skin, the incidence of the defect is potentially higher than can be estimated by supply chain surveys based on external appearance only. To determine the full extent of RCD, we suggest fruit skin be removed when fruit is ripe prior to assessing internal symptoms. Since RCD can be misdiagnosed as another mango skin browning disorder when evaluated on external features only, a standard assessment procedure should be developed and widely shared with the industry and research personnel.

Close attention should be paid to avoid RCD by following best practices, such as maintaining orchard hygiene, harvesting fruit at optimal maturity and minimising harvest and post-harvest stress.

2.2 Manipulating Mango Flowering to Extend the Harvest Window

Contact: Cameron McConchie – Research Leader

Reference to DPIF Industry Development Plan 2013-2017:

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.2.2 Develop effective research partnerships that support innovation and efficient delivery of extension information to clients.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

This project is evaluating on-farm management systems to increase the production window for mangoes. It is evaluating the use of weather data to anticipate inductive weather conditions so that growers can respond appropriately. It is comparing growth behaviour in current industry cultivars with candidate cultivars from the National Mango Breeding Program. The response of current trees and candidate rootstock-scion combinations to the use of such chemicals as paclobutrazol, ethephon and nitrate will be assessed. Aeroponics will be used to describe chemical uptake and growth responses. The suitability of these treatments will then be validated for commercial use under orchard conditions. A selection of additional chemicals with similar actions to those currently used internationally for manipulating mango flowering will also be evaluated.

Three different mango rootstock varieties grown aeroponically through two to three vegetative flush cycles in the glasshouse. While growth of the same cultivar was comparable, all replicates of that variety developed foliar symptoms of nutrient disorders. They were rectified by lowering temperature

Mango plants growing in the cooled glasshouse free of obvious leaf nutritional disorders

Results

Low night temperatures in Darwin are associated with high pressure systems over the Australian Bight. After the use of ethephon, which removes unwanted vegetative flush, it appears that Kensington Pride trees will respond to potassium nitrate sprays to enhance flowering. The potential of heat sums to predict flushing patterns is inconsistent. A study of flush initiation found that waterlogging and irrigation deficit interfered with regular flush growth. It also showed a strong correlation between the number of hours below 20 °C and floral induction in variety B74, further validating the importance of low night temperatures. The concentration of

ethephon required in spray formulations to obtain predictable responses in treated vegetative flush has been quantified. The importance of a wetter to improve the response to ethephon has been demonstrated. To understand the effects of paclobutrazol and other growth regulators of shoot and root development, a system was developed for growing mangoes in aeroponics. Initial attempts to use aeroponics were problematic due to high temperatures, which resulted in nutrient disorders in the leaves. This was resolved by cooling the glasshouse.

2.3 Optimising Pollination in Dates (*Phoenix dactylifera*)

Contact: Cameron McConchie – Research Leader

Reference to DPIF Industry Development Plan 2013-2017:

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.2.2 Develop effective research partnerships that support innovation and efficient delivery of extension information to clients.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

Pollination and fruit thinning are critical processes in date production. The pollen parent in dates affects fruit quality and yield. As date palms are dioecious, artificial pollination allows for the number of non-fruit producing males in an orchard to be reduced. The project aims to optimise pollen collection and storage to facilitate artificial pollination of date palms in Central Australia, identify optimal timing for pollination and select pollen parents for major commercial date cultivars. Pollen parents are expected to affect fruit size, flesh, seed development and time to fruit maturation. New techniques for manual pollination and pollen dilution will be developed. This will improve the productivity of existing date farms while enabling the optimal use of the extensive germplasm that has been assembled with RIRDC support.

Barhee dates at the 'rutab' (crunchy) stage ready to be harvested

The following male palms were used:

- *Phoenix sylvestis*: Pollen was collected from palms grown from seed supplied by the US date collection, Brawley California in 1987. Since pollen collected from these seedlings was pooled, the specific productivity of individual palms was not known.
- Oliver: Panicles from male palms from an Alice Springs landscape supplier flowered prolifically. They were cut-off the palms and transported to the Arid Zone Research Institute (AZRI), Alice Springs where they dehisced and pollen was collected. The palm is now called "Oliver", after Department of Primary Industry and Fisheries officer Glen Oliver, who located it and collected the pollen.
- Fard 4: Four palms clonally propagated via tissue culture that are over 20 years old and appear physically different from the other Fard males at AZRI in having thinner trunks.
- Several other Fard palms and a single Jarvis male palm.

Results

The response of five commercial date cultivars to supplementary pollination using different pollen sources has shown that Fard 4 pollen produced larger fruit with larger seeds across all the cultivars investigated. An absolute control of pollen parents was not achieved but the consistent response to Fard 4 pollen across genotypes suggests paternity was altered. It was not possible to confirm the ability of *P. sylvestris* pollen to produce larger seedless fruit when pollinated to *P. dactylifera*. The putative *P. sylvestris* plants were originally supplied as seed and are genetically distinct from one another. Past crop losses due to bird damage have been resolved by using improved bags and tagging.

The amount of pollen produced by different male plants was recorded and stored at 4 °C. Records were also kept of the days of anthesis (flowering period).

The largest amount of pollen was collected from Fard 4, which also had the longest flowering duration, starting before and finishing after the other cultivars.

2.4 Agronomic Options for Profitable Rice-based Farming in Northern Australia

Contact: Cameron McConchie – Research Leader

Reference to DPIF Industry Development Plan 2013-2017:

1.2.1 Targeted research, development and extension to address agreed industry priorities.

1.2.2 Develop effective research partnerships that support innovation and efficient delivery of extension information to clients.

2.1.1 Improve production and environmental management through innovation.

Project Status: Continuing.

The project aims to identify locally-adapted rice varieties (including hybrid and blast disease-tolerant rice) with the required quality characteristics for wet and dry season production on a raised-bed system and compare them under flood and upland conditions.

It also attempts to identify an ideal establishment technique, sowing time, optimum sowing rate and plant population for each variety, determine crop nutrition (amount and strategy) requirements, irrigation requirements and weed/pest/disease control strategies, and evaluate the potential for rice ratooning.

Variety Opus was severely damaged by blast disease. This photo was taken 100 days after sowing. The other plants in the surrounding aromatic lines were infected but most of the plot was unaffected despite the disease

Sub-plots and whole plots being harvested at Tortilla Flats

Results

Kyeema was the most consistent yielder out of all the varieties, followed by YRF 209 SMITH, Yunlu 29 and Amber, producing consistently higher yields than the other varieties in sub-plots and whole plots.

Biomass harvests were very high in a number of varieties, with Vietnam 8 producing the highest biomass yields (>10 t/ha); PW-10, PW-7 and IR64 also produced high biomass yields (>9 t/ha), which was impressive as they have a relatively short growing period. Kyeema/Basmati, H-M-N and Vietnam 1 also produced large amounts of biomass (8 t/ha); their taller growth habit, however, makes them susceptible to lodging.

In general, yields were low this season due to:

- Nutrition. Rustica Plus fertiliser was the sole source of nitrogen (N), applied at two rates to two depths at planting. The fertiliser has 5% nitrate and 7% ammonium; it was used to raise all other trace elements as well as provide the recommended amount of N. In this form, the N may not have been available quick enough to give the plants the initial early boost they required. Previously, N was provided through urea and had been utilised as it is thought to be more freely available and quickly taken up by the plant. The slower release of N could have also contributed to the high biomass produced later in the season.
- Cooler weather at panicle initiation or flowering is known to cause sterility in panicles, affecting grain yield.

Blast disease will be a major constraint to a rice industry in the Northern Territory if the selected varieties are not tolerant.

A commercial farmer on the adjoining property planted his crop a month earlier; geese and duck pressure was relatively minor.

2.5 The National Banana Freckle Eradication Program

Contact: Cassie McMaster – Senior Plant Pathologist
Collaborating staff: Lucy Tran-Nguyen

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

Banana freckle (*Phyllosticta cavendishii*) is an economically important disease of Cavendish bananas in parts of Asia and the Pacific Islands. It reduces sales of blemished fruit, which leads to increased use of fungicides and hence production costs. In Australia, it is a pest of threat priority in the banana industry's biosecurity plan and is a Category 3 Emergency Plant Pest under the Emergency Plant Pest Response Deed. In the Northern Territory (NT), *P. cavendishii* was detected in Cavendish bananas for the first time in July 2013. This outbreak resulted in a biosecurity response, which initiated the National Banana Freckle Eradication Program to delimit, contain and eradicate *P. cavendishii* from the NT.

Symptoms of banana freckle disease on a Cavendish banana leaf

Inspecting banana plants for banana freckle disease in the field

Results

The Department of Primary Industry and Fisheries' Plant Pathology laboratory received 1430 banana leaf/fruit samples for freckle disease diagnosis from 681 premises between July 2013 and May 2015.

DNA was extracted from all infected leaf pieces from all samples and was analysed using PCR and genetic sequencing to identify the *Phyllosticta* species. In addition, the plant DNA was analysed using PCR and DNA fingerprinting to identify the banana cultivar. The results showed that 461 samples from 257 premises were positive for *P. cavendishii* and 63 premises had freckle-infected Cavendish banana plants. *P. cavendishii* was detected in six infestation zones: Darwin city and the Greater Darwin Rural Area, Batchelor, Nauiyu, Ramingining, Dundee Beach and Melville Island.

2.6 Better Fruit Fly Systems for Mangoes and Market Access (HIA MG12017)

Contact: Austin McLennan – Senior Entomologist
Collaborating staff: Brian Thistleton, Bob Williams, Mary Finlay-Doney, Michael Neal, Lanni Zhang and Bruce Dilley

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

Extensive collections of fruit from packing sheds had shown that infestation by the fruit flies *Bactrocera tryoni* and *B. jarvisi* in hard mature mangoes is extremely rare. There is therefore a potential for new market access protocols for mangoes based on hard mature mangoes being a conditional non-host, which would not require post-harvest disinfestation treatments for fruit flies. To obtain further data to support this, gravid females of both species were introduced into field cages with various varieties of mangoes at a hard mature stage. Nine trials were conducted in Darwin and Katherine on four different mango varieties. To support the cage trials, colonies of both species of fruit flies were maintained at Berrimah Farm. Monitoring of populations of the two species of fruit flies also continued using traps at several locations in the Darwin rural area.

Results

A trapping grid monitored pest fruit fly activity in and around mango orchards in the Katherine/Mataranka and Darwin regions. A series of intensive field cage trials were conducted to resolve outstanding questions about the fruit fly host status of hard mature mangoes. A farm-scale pilot trial looked at population suppression tactics (i.e. male annihilation technique) and its potential to reduce fruit fly infestation risk in the context of a systems approach to market access.

2.7 Development of Pest Lists for Mangoes in Cambodia

Contact: Brian Thistleton – Principal Entomologist
Collaborating staff: Mary Finlay-Doney and Lanni Zhang

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Commenced.

The project aims to prepare a specimen-based pest list for Cambodian mangoes for use to access international markets under the WTO SPS agreement and to identify key mango pests to facilitate their control.

Results

A pest list workshop and field surveys were conducted in Cambodia to collect specimens. The specimens will be lodged in the NT Economic Insect Reference Collection and the Cambodian General Directorate of Agriculture's insect collection.

2.8 Testing of Termites

Contact: Brian Thistleton – Principal Entomologist
Collaborating staff: Michael Neal

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

The project aims to assist plant industries by testing various products to mitigate termite attacks.

Results

The effect of various BASF growth regulators on *Mastotermes darwiniensis* and *Coptotermes acinaciformis* was noted. Various coatings were tested on fibre optic cables for resistance to attack by *Mastotermes darwiniensis* for Optimal Cable Services.

2.9 Developing Synthetic Pheromones for Mango Fruit Borers, *Citripestis eutraphera* (Lepidoptera: Pyralidae)

Contact: Brian Thistleton – Principal Entomologist
Collaborating staff: Michael Neal

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

The project aims to develop a pheromone for the mango fruit borer (*Citripestis eutraphera*), which is a pest of mangoes in the Northern Territory and in South-East Asia, including Cambodia.

Results

A series of synthetic pheromone blends were produced using information from the original pheromone extracts from Plant and Food Research (PFR), New Zealand. They were bio-assayed in a field trial using delta traps. As no *Citripestis* were captured, PFR decided to reanalyse the pheromones. A new shipment of moths will be provided by establishing a new culture during the 2015 mango season.

2.10 Characterisation and Management of Fusarium Wilt of Watermelons

Contact: Lucy Tran-Nguyen – Senior Molecular Scientist
Collaborating staff: Cassie McMaster

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

Fusarium wilt is one of the most severe diseases of watermelons caused by a fungus called *Fusarium oxysporum* f. sp. *niveum* (*Fon*). This strain, which is only pathogenic on watermelons, can be divided into four races (0, 1, 2 and 3). The disease is one of the major yield-limiting causes in watermelons worldwide. *Fon* was first detected in the Northern Territory (NT) in May 2011. The disease affected three different varieties of watermelon seedlings and plants from six different locations. To date, two of the races have been detected in Australia. However, there is limited published information about the Australian *Fon* races. It is unclear what race the NT *Fon* strain is, whether it is a new race and its level of aggressiveness.

The project intends to identify *Fusarium oxysporum* f. sp. *niveum* race(s) in the NT and compare it (them) with others in Australia and overseas, screen rootstocks and grafted watermelons for resistance to *Fusarium oxysporum* f. sp. *niveum*, assess the effect of temperature on Fusarium wilt and make recommendations to producers on its management.

Results

Trials in the NT have identified the presence of Fon strain race 3, which is the most virulent strain previously recorded to occur only in Maryland, USA.

Molecular characterisation of Fon races using the putative effector genes – secreted in xylem (SIX) showed a range of SIX genes among Australian and USA Fon isolates. SIX8 is the only common gene among all races; however, bioinformatics analyses have shown no significant differences when all Fon SIX genes are compared.

Next generation sequencing has been completed for the two NT Fon isolates. Work is underway for representatives from other Australian and USA isolates/races.

Preliminary temperature trials have shown that watermelon seedlings treated with Fon showed tolerance to the pathogen under high temperatures.

2.11 The Cucumber Green Mottle Mosaic Virus Emergency Plant Pest Incursion Response

Contact: Lucy Tran-Nguyen – Senior Molecular Scientist

Reference to DPIF Industry Development Plan 2013-2017:
3.4 Respond to biosecurity incursions.

Project Status: Continuing.

The cucumber green mottle mosaic virus (CGMMV) was reported in Katherine in September 2014. The tobamo virus infects all cucurbits; symptoms include leaf and fruit mottling, mosaic-like appearance, bleaching and soft fruit. The disease can reduce plant vigour, yield and fruit quality. The detection led to surveillance of the spread of the disease to identify the range of cucurbit hosts and weed hosts. CGMMV can be transmitted by infected seeds, plant–to-plant and by mechanical inoculation. Hence, laboratory work required the highest quarantine containment level (QC3). Diagnostics rely solely on detecting the coat and membrane proteins of the single-stranded RNA genome and sequencing them to confirm identification.

Results

Since September 2014, over 2300 samples have been submitted for molecular diagnostics. CGMMV has been found on 25 properties, 15 of which grew cucurbits and 10 had positive weed hosts. Identified hosts included nine cucurbit crops (*Benincasa hispida*, *Citrullus lanatus*, *Cucumis melo*, *C. sativus*, *Cucurbita maxima*, *C. moschata*, *C. pepo*, *Luffa* sp. and *Momordica charantia)* and four weeds belonging to the genera Amaranthus, Cucumis, Portulaca and Solanum. When the National Management Group decided that CGMMV could not be eradicated, the program changed to management in April 2015. Phytosanitary certificates are provided to growers who wish to sell their cucurbit crops interstate.

2.12 Understanding the Biosecurity Implications: Managing Cucumber Green Mottle Mosaic Virus (CGMMV) in Honeybee Pollinators of Melons

Contact: Mary Finlay-Doney – Research Entomologist
Collaborating staff: Vicki Simlesa

Reference to DPIF Industry Development Plan 2013-2017:
3.4 Respond to biosecurity incursions.

Project Status: Commenced.

Recent Department of Primary Industry and Fisheries research has shown that honeybees working within CGMMV-infected crops are exposed to the virus and are able to take virus particles back to their hives. CGMMV has been detected in brood, honey, pollen, bee bread, swabs of empty cells and adult workers inside hives in the Northern Territory (Vicki Simlesa, pers. comm., June 2015) and Queensland (Christine Horlock, pers. comm. July 2015). Preliminary results have indicated that the virus remains detectable in hives up to six months after exposure and that it is viable in pollen for at least two months after their last exposure to infected plants. The longevity of the Australian strain of CGMMV within hives and its ability to be transmitted from positive testing hives to uninfected cucurbits is unknown. Field trials are being currently conducted.

Collecting samples from hives that had been pollinating CGMMV positive cucurbits

Results

The presence of viable CGMMV has been confirmed in apiaries for the first time. This was communicated to affected apiaries and transmission trials have been developed.

2.13 Sustainable Management of Mango Leafhoppers

Contact: Mary Finlay-Doney – Research Entomologist
Collaborating staff: Brian Thistleton, Lanni Zhang and Michael Neal

Reference to DPIF Industry Development Plan 2013-2017:
3.4 Respond to biosecurity incursions.

Project Status: Commenced.

The project aims to identify how and why leafhoppers (*Idioscopus* spp.) infest mango trees in order to design cultural control methods, identify entomopathogenic fungi that are effective against *Idioscopus* spp. in Australia and develop management recommendations. The biology of these pests is not well known. They are assumed to persist in low numbers year round and to build up and move into orchards during flowering. A long-term field survey of mango trees and other potential host plants will be used to characterise their biology and identify their counter seasonal habitat(s). Leafhoppers become pestiferous (harbouring infection) during flushing and flowering. Field observations of unsprayed trees show that some plants become heavily infested whilst others remain relatively free of leafhoppers. Herbivorous insects are known to respond to changes in the secondary plant compounds of their hosts. Volatiles of infested and uninfested mangoes will be sampled throughout the season and components will be identified. Correlations will be tested with electroantennogram trials. Entomopathogenic fungi have been used to manage *Idioscopus* spp. in countries other than Australia. Although this technology has been proven, it has not been applied in Australia and local pathogens have not been identified. Field populations of *Idioscopus* spp. in the Northern Territory and Queensland will be surveyed for the pathogens, which will be isolated, cultured and tested in bioassays.

Monitoring site of orchard trees

Mango leafhoppers on new leaves

Results

Fortnightly monitoring of mango leafhoppers has been established on eight field sites and fungi from dead mango leafhoppers have been isolated.

2.14 Action on the Ground - Reducing Greenhouse Gas Emissions through Improved Nitrogen Management on Northern Territory (NT) Farms

Contact: Mila Bristow – Principal Research Officer

Reference to DPIF Industry Development Plan 2013-2017:
1.2.4 Support Industry to understand and adapt to changes in climate.

Project Status: Completed.

The project trialled and demonstrated on-farm practices and technologies to quantify greenhouse gas (GHG) exchange, improve nitrogen (N) use efficiency and yields, and reduce nitrous oxide (N_2O) emissions through better understanding and management of inorganic N in cover crops, vegetables, melons and hay.

Collecting gas samples from manual chambers in a watermelon crop

Manual gas chambers in an early rockmelon crop

Results

The project results indicated that:

- Wet season cover crops do not mitigate the risks of N_2O emissions in the wet-dry tropics, where emissions are driven by high rainfall and management events. There was no significant difference between fallow and crop-covered areas. However, cover crops do reduce soil erosion and maintain organic matter.
- Reducing the proportion of residual N left in the soil and smarter N application timing could reduce high emissions and save farmers the cost of lost N. Future research should target a detailed understanding of the N cycle in these cropping systems.
- Soil N_2O emissions in melon and vegetable crops were generally very low, except in one watermelon crop. Emissions factors calculated as a proportion of N fertiliser emitted as N_2O were generally very low.
- The proportion of N in petiole sap was poorly correlated with leaf N status and may not be an effective tool to monitor nutrients in NT crops.
- Soil moisture and farm management events, such as fertilising, slashing or cultivation, drive N_2O and methane emissions from tropical soils.
- Switching to new urea-coated fertilisers in hay production can reduce soil N_2O emissions by up to 61%, while still maintaining hay productivity and quality. Cost reduction of these enhanced efficiency fertilisers could significantly reduce GHG emissions from tropical hay production.

Conclusions

N emission factors for key NT vegetable and melon crops are generally well below the international default values of 1% (IPCC, 2006); however, some sites are irregularly high, indicating improved efficiency could be achieved with further research on N management.

Enhanced efficiency fertilisers, especially those containing nitrification inhibitors, have now been tested under NT conditions. This project demonstrates that enhanced urea fertilisers (DMPP-coated urea) work in the tropical conditions of the NT, while nitrapyrin (liquid denitrification inhibitor) was not as effective in the manner it was used (as a soil surface spray).

Wet-season grown cover crop trials showed a positive effect of cover crops to immobilise residual N in the soil compared with leaving soil bare over the wet season. Soils were generally wet and warm during this season, conditions which are conducive to high soil emissions. However, emissions of N_2O were low while the plants were growing. When conventional management events, such as crop slashing and soil disturbance via cultivation commenced, the soils shifted to very high N_2O emissions, approximately 100 times the background levels. Overall, wet-season cover crops were not effective at mitigating soil N_2O emissions due to timing and intensity of rainfall and end-of-cropping management events.

Cover crops contributed up to 16 t/ha of above-ground biomass per year; however, this did not translate into changes in soil organic carbon (C). To quantify changes in soil C from cover crop additions, it may be necessary to monitor over several years.

Recommendations

Vegetable and melon growers are using recommended amounts of fertilisers and are generally achieving efficient use of N by international standards. Before and after soil analyses indicate that large amounts of residual nitrates remain at the end of cropping, indicating further scope for refinement in N fertiliser use in some crops.

Enhanced efficiency N fertilisers significantly reduce soil N_2O emissions in wet season (rain-fed) tropical hay production, whilst still maintaining hay productivity and quality. It is recommended that more trials be conducted to demonstrate these results in other pasture varieties, soil types and rainfall regions in collaboration with commercial hay-producing farms.

Wet-season cover crops were not effective at mitigating soil N_2O emissions due to timing and intensity of rainfall and end-of-cropping management events; however, they do confer benefits in reducing soil erosion, maintaining organic matter and making plant-stored N available to subsequent crops. It is recommended that further communication of these results be made to horticultural row-crop growers in the NT.

The role of wet-season cover crops as “bio-disinfectants” was not considered in this project. Given their positive role in soil and nutrient management, it is recommended that further research be conducted to understand the effect of these crops on soil microbial and pathogen communities.

2.15 Investigate Closed Production Systems for Ornamental Ginger Production

Contact: Doris Marcsik – Research Horticulturalist

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Completed.

The focus of this project was to investigate and develop baseline production protocols for growing new ornamental ginger flowers in a closed system, both in pots and in the ground. A range of new Curcuma and inter-specific Zingiber hybrids have been identified as ideal candidates to trial in this closed production system. The project investigated the effect of storage duration and temperature on rhizome storage and production, determine optimum environmental conditions, such as photoperiod, light intensity and plant growth regulators to control shoot emergence, growth and flowering, and determine optimum nutritional levels for producing uniform, high-quality ginger flowers. The project was funded by the Rural Industries Research and Development Corporation (RIRDC).

Curcuma field walk presentation at Berrimah Farm

Potted flowering curcuma nutrition trial

Results

Curcuma rhizomes that were subjected to increased storage time and temperature resulted in a decline in days to shoot emergence in most of the hybrids evaluated. There was also a significant decrease of 20 to 30 days to flowering when rhizomes were stored for four months compared with rhizomes stored for two months.

The application of paclobutrazol at 10 and 20 mg a.i. failed to reduce the flower height of hybrids grown under 50% and 70% shade. Flower height was found to be significantly shorter in Curcumas grown under the full sun. There was no significant difference in flower height between the paclobutrazol-treated and untreated plants grown under the full sun.

A greater understanding of the optimal nutritional levels for producing potted flowering Curcumas has been quantified. In addition, the required chemical and physical properties of the growing media were found to differ between Curcuma varieties for the production of flowering potted plants.

The in-the-ground cut-flower trial indicated that light fertiliser levels have a significant effect on flower yield and stem length in some clones. A number of hybrids growing in both the full sun and 50% shade were identified as excellent cut-flower types based on stem length, colour/form, yield and vase-life. A fertigation trial has suggested levels of fertiliser needs which are currently lacking for field-grown Curcuma cut-flowers.

Conclusions

This project's results have increased our knowledge on production practices for growing Curcumas in a closed system in pots and in the ground for producing cut-flowers and potted plants in tropical northern Australia.

Recommendations

This project provides clear strategies for growing Curcumas as cut-flowers and flowering potted plants. In particular, it provides improved knowledge of the cultural requirements and the suitability of growing specific Curcuma varieties in pot culture. A number of new Curcuma cut-flower and potted plant varieties have been identified that will expand the product range of ornamental gingers for the floriculture industry.

2.16 Economic Germplasm for Improved Rambutan Production

Contact: Mark Hoult – Research Horticulturalist
Collaborating staff: Mark Traynor

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Completed.

The project aimed to identify commercial cultivars with potential for novel, high-density, clonal orchard systems and other germplasm as rootstocks and/or as pollinators. New propagation methods were evolved and subsequently developed for commercial applications. The *Nephelium* genus currently contains 22 species of which 15 are found in Borneo, of which six new unnamed species are recognised. This represents a very diverse germplasm and offers great scope for horticultural development for this emerging crop.

One-year-old high-density clonal rambutan

Results

A desk-top review of introduced germplasm, historical assessments and propagation studies has collated and collected a wealth of knowledge previously not publicly available.

Of the key economic *Nephelium* species, 131 clonal introductions were made into Australia of *Nephelium lappaceum* “Rambutan”, all of which were released, post quarantine. This comprised of 48 named cultivars. There were also eight introductions of *Nephelium ramboutan* - aka “Pulasan”, comprising six named cultivars. Currently only six of these rambutan clones dominate production and Pulasan is non-commercial.

A standard bud propagation method has been established and adopted by the industry, albeit of variable success, which is reflected in the cost of clonal trees.

Much time and resources were spent on developing clonal cuttings for the key commercial scion cultivars Jit Lee, Binjai, R134 and R167, having prepared and set over 500 cuttings incorporating diverse root initiation treatments and germplasm; however, from our investigations, we cannot recommend clonal cuttings as a viable method for rambutan.

Efficient marcottage development is the second key propagation focus area of the project and is the most encouraging alternative propagation method to date. Recovery of propagules can be as high as 90 to 100% but is cultivar and season dependant.

Several local male pollinator selections have been made and potentially can supply pollen for well over four months of the year and as such, have a capacity to greatly improve fruit-set and yields in rambutan.

Conclusions

The resolution of several industry issues in rambutan production has been achieved, based on core project activities, and more diverse and functional germplasm integrated with improved propagation systems. Key industry goals, including improved pollination, better profitability via novel production systems and reduced establishment costs, have been achieved. The project has generated unique propagule types and combinations, which have now been established on government and cooperating farms. They will be the basis for innovation and advancement in rambutan production in Australia.

Recommendations

It is recommended that further refinement of the marcottage method be conducted with industry partners. Growth and yield data of the established high-density clonal orchard systems should be gathered over the next four seasons and its cost-benefit determined. Regular field days for industry engagement with the new germplasm resource should be a priority. Further elite male pollinators should be developed and their role in the pollination of this crop should be determined.

2.17 Tropical Tree Fruit Research and Development to Increase Productivity, Resilience and Profitability in the Philippines and Northern Australia

Contact: Mark Hoult – Research Horticulturalist
Collaborating staff: Mark Traynor

Reference to DPIF Industry Development Plan 2013-2017:
1.2 Facilitate continuous improvement in production quantity and quality.

Project Status: Continuing.

The project aims to improve the livelihood of smallholder tropical fruit farmers in the southern Philippines and enhance new fruit industry development in tropical Australia. This includes developing and implementing integrated disease management in jackfruit and improving crop management to increase jackfruit productivity and quality in the Philippines and other tropical fruits in northern Australia. It also intends to develop improved processing options for jackfruit and lychee.

Jackfruit grower "best tree" survey

One-year-old jackfruit seedlings

Results

Six Northern Territory (NT) seedlings from commercial orchards were established as grafted clones for further assessment with the Queensland commercial cultivar Rajang. Also about 500 open-pollinated seedlings were established from NT germplasm for a rapid seedling selection program. Nursery performance (growth and uniformity) of a number of *Artocarpus* species was monitored.

Early assessments indicate that sexually-propagated *Artocarpus* is highly variable at the nursery stage with some species, such as *A. rigidus*, having up to 50% cull (not suitable for grafting) seedling rootstocks pre-grafting. This information will be of value in determining the commercial applicability of different potential species as rootstocks. In jackfruit, it appears that graft union differences occur between scion clones and rootstock seed sources.

A field establishment of Thai and Vietnamese lowland lychee and longan cultivars is being monitored for assessment under a marginal floral inductive environment.

External Recognition

The following is a summary of the 2014-15 internal and external awards and invitations to significant meetings and conferences.

Mila Bristow	Joyce, K. and Bristow, M., (2014). Drone Zone – developing an Unmanned Airborne System research capability. Competitive Grant Innovation@CDU, $10,000. http://riel.cdu.edu.au/research/project/ro-99999-drone-zone
Jocelyn Coventry	Invited to present a review of aspects of the breeding herd performance on the arid rangelands of the Alice Springs district at a Postgraduate Seminar on 15 August, 2014, College of Veterinary Medicine, School of Veterinary and Life Sciences, Murdoch University, WA. Invited to present the above at a DPIF Knowledge Seminar on 21 November, 2014, Darwin. Winner of the 2014-15 DPIF Knowledge Seminar Award.
Mary Finlay-Doney	Invited to the PHA fruit fly diagnostic workshop 14-15 April, 2015
Sally Leigo	Invited presenter at the Society of Precision Agriculture Australia's 17th Precision Agriculture Symposium in Adelaide, September, 2014. Invited presenter at the Ninti One 'Remote Wisdom' events in Brisbane and Darwin, November and December, 2014. Invited participant at the CRC for Spatial Information workshop, Brisbane, November, 2014. Invited presenter at the Australian Rangeland Society Conference and field tour, Alice Springs, April, 2015.
Barry Lemcke	Vice President for Oceania on the International Buffalo Federation.
Austin McLennan	Invited to the PHA fruit fly diagnostic workshop 14-15 April, 2015.
Helen McMillian	A runner-up for the 2014 Chief Minister's Award in the category of 'Building Regional and/or Remote Economies' for courses and forums conducted on the Barkly to benefit the cattle industry.
Doris Marcsik	Presented a paper on "The effect of controlled-release fertiliser on potted-flowering hybrid Curcuma growth" at the XXIX International Horticultural Congress on Sustaining Lives, Livelihoods and Landscapes (IHC2014). *In*: The International Symposium on Ornamental Horticulture in the Global Greenhouse, Brisbane, August 2014. Presented a paper on the "Promising range of new Curcuma cultivars for cut-flower and pot culture production" at the 18th Heliconia Society International Conference in Bali in August 2014. Was awarded the International Society for Horticultural Science Medal in recognition of meritorious service to the Society as co-convener of the International Symposium on Ornamental Horticulture in the Global Greenhouse, Brisbane, 2014.

External Recognition

The following is a summary of the 2014-15 internal and external awards and invitations to significant meetings and conferences.

Tim Schatz	Invited to MLA reproduction and calf loss research planning meetings.
	Presented Futurebeef Webinar on the Senepol crossbreeding project.
	Presented at the Australian Society of Animal Production conference in Canberra.
	Presented at the VRRS and DDRF Field Days, and the Fairfax Field Days at KRS.
Brian Thistleton	Attended the annual Diagnostics Workshop of the National Plant Diagnostic Network.
Lucy Tran-Nguyen	Participated in the "Developing and updating diagnostic protocols for key viticulture industry high-priority exotic pest threats" workshop, Melbourne July 2015.
	Participated in the 'Colletotrichum Workshop 1- A morphological and molecular approach to species identification', July 2015.
Dionne Walsh	Selected for the Emerging Pacific Leaders Dialogue (EPLD) 2014. The EPLD is an intensive two-week leadership program staged every four years for high calibre, mid-career men and women. I was one of only 14 Australians (and the only Territorian) to be selected from almost 700 applicants.
Jodie Ward	'Future NTCA' recipient (2014) – Leadership Program.
	Finalist for the 2014 Chief Minister's Awards in the category of 'Building Regional and/or Remote Economies'.

Staff and Students

Science Staff	Graduate Students
Pastoral Production	
Jocelyn Coventry (Pastoral Production Officer)	
Robyn Cowley (Senior Rangeland Scientist)	
Whitney Dollemore (Pastoral Research Officer)	
Jane Douglas (Pastoral Technical Officer)	
David Ffoulkes (Pastoral Officer)	
Sally Leigo (Principal Research Leader)	Collin Marshall – Precision Pastoral Management System Interface – Charles Darwin University.
Barry Lemcke (Principal Livestock Management Officer)	
Kieren McCosker (Pastoral Production Officer – Beef Cattle)	Whitney Dollemore – Master's in phosphorus nutrition in beef cattle – University of Queensland (Animal Studies).
	Tiago Alves Correa Carvalho da Silva (PhD student) Post-weaning growth in heifers – University of Queensland (Animal Studies).
Helen McMillian (Pastoral Production Technical Officer)	
Chris Materne (Pastoral Production Officer)	
Caroline Pettit (Rangeland Research Officer)	
Tim Schatz (Principal Pastoral Production Research Officer)	
Dionne Walsh (Rangeland Program Manager)	
Jodie Ward (Pastoral Production Officer)	
Plant Industries	
Mila Bristow (Principal Research Officer)	Ms Kamy Melvani (PhD student) Valuing forest gardens in Sri Lanka – Charles Darwin University, RIEL.
	Ms Pippa Featherston (PhD student) Water use in *Khaya senegalensis* plantations – Charles Darwin University, RIEL.
Mary Finlay-Doney (Research Entomologist)	
Mark Hoult (Research Horticulturalist)	
Cameron McConchie (Research Leader)	Enoche Menge (PhD student) Measurement of the invasiveness of rubber bush (*Calotropis procera*) – Charles Darwin University.

Staff and Students

Science Staff

Austin McLennan (Senior Entomologist)

Cassie McMaster (Senior Plant Pathologist)

Doris Marcsik (Research Horticulturalist)

Brian Thistleton (Principal Entomologist)

Lucy Tran-Nguyen (Senior Molecular Scientist)

Graduate Students

Victor Puno (PhD student) Fusarium wilt of watermelon - University of Sydney.

Stacey Cook (PhD student) Mango flowering targeting flower molecular markers - University of Queensland.

Research Visitors

Visitor	Affiliation	DPIF Contact
Alice Springs Steer Challenge members		Sally Leigo
Dr James W. Austin	Global Product Development Manager, BASF USA	Brian Thistleton
The Australian Rangeland Society conference field tour		Sally Leigo
Dr Fiona Constable	Department of Economic Development, Jobs, Transport and Resources	Lucy Tran-Nguyen
Ms Elizabeth Czislowsk	PhD student – University of Queensland	Lucy Tran-Nguyen
Delegations from China, Indonesia, Timor Leste and Vietnam visited buffalo and cattle paddocks at Beatrice Hill Farm.		Barry Lemcke
Dr Geoff Dickinson,	Queensland DAFF	Mila Bristow
Dr Aviv Dombrovsky	Volcani Institute, Israel	Lucy Tran-Nguyen
Dr David Elmouttie	Technical Development Specialist, Pest Control Solutions, Australia	Brian Thistleton
Dr Kathryn Everts	University of Maryland, USA	Cassie McMaster
Dr Christine Horlock	Queensland DAFF	Lucy Tran-Nguyen
Naomi King	Queensland researcher	Cassie McMaster
Cameron MacKay	Queensland banana grower	Cassie McMaster
NSW pastoralists	Various properties in NSW	Sally Leigo
Denis Persley	Queensland DAFF	Lucy Tran-Nguyen
Professor Dennis Poppi	Professor in Animal Nutrition, School of Agriculture and Food Sciences, University of Queensland	Kieren McCosker
Dr David Rowlings and Christian Brunk,	Queensland University of Technology	Mila Bristow
Dr Gregory Storey	Global Development Manager Termiticides, USA	Brian Thistleton

Research Visitors

Visitor	Affiliation	DPIF Contact
Mr. Helmut Reiter and Mr. Allan Ross visited Alice Springs	Olsson Pacific, NSW	Jocelyn Coventry
Ms Yu Pei Tan	Molecular Scientist – Queensland DAFF	Lucy Tran-Nguyen
University of Adelaide staff and Indonesian students visited DDRF	University of Adelaide	Tim Schatz

Research Service

The following is a summary of science staff participation on significant scientific, industry or policy development committees and editorial boards.

Mila Bristow	NT representative on the National Climate Change Strategy on the Primary Industries Committee. NT representative on the Steering Committee for the National Environmental Science Program, Northern Australian Environmental Resources Hub Project: Cost-effective Methods in Estimating Soil Carbon Change. Member of the editorial committee of the Australian Forest Growers Magazine. Co-organiser of a symposium at the 2014 Ecological Society of Australia conference (Sep - Oct 2014, Alice Springs) titled "Water, nutrient and carbon fluxes in tropical savannas: from plots to ecosystems" with Dr Anna Richards (CSIRO) and Dr Sam Grover (La Trobe University).
Mary Finlay-Doney	Participated in the ACIAR project HORT 2012/003 “Building a resilient mango industry in Cambodia and Australia through improved production and supply chain practices” (Cambodia). Preparation of funding applications – ACIAR funding for IMS (successful), Crawford funding for IMS (successful), HIA funding for CGMMV research (pending). Presented on behalf of DPIF at the PICSE reporting back session (work experience program for school leavers). Served on national scientific advisory panels for emergency plant pests.
Sally Leigo	Member of the organising committee for the 18th Australian Rangeland Society Conference.
Austin McLennan	Attended the Australian Mango Industry Association’s 10th Australian Mango Conference.
Cassie McMaster	National Banana Freckle Eradication Program - Plant Pathologist/ Diagnostician. Member of the National Banana Plant Protection working group. Australasian Plant Pathology Society’s Regional Councillor. National Plant Biosecurity Diagnostic Network member.
Doris Marcsik	Co-convener and member of the scientific committee of the International Symposium on Ornamental Horticulture in the Global Greenhouse at the “XXIX International Horticultural Congress on Sustaining Lives, Livelihoods and Landscapes (IHC2014)”, Brisbane, 2014.
Tim Schatz	DPIF representative on the North Australia Beef Research Council (NABRC). Member of the NABRC Management Committee.

Research Service

The following is a summary of science staff participation on significant scientific, industry or policy development committees and editorial boards.

Brian Thistleton	Participated in the ACIAR project HORT 2012/003 “Building a resilient mango industry in Cambodia and Australia through improved production and supply chain practices”.
	Member of the Sub-Committee for Plant Health Diagnostics and Diagnostic Standards Working Group.
	Attended the Australian Mango Industry Association’s 10th Australian Mango Conference.
Lucy Tran-Nguyen	Senior Editor of the *Australasian Plant Disease Notes Journal*.
	Reviewer for *Australasian Plant Pathology*, Federation of European Microbiological Societies, *Plant Pathology*, Plasmid, *Journal of Phytopathology, Annals of Applied Biology, Australasian Plant Disease Notes* and Public Library of Sciences.
	Member of the Scientific Advisory Panel for the Department of Agriculture.
	Member of the cucumber green mottle mosaic working group.
	Member of the mango malformation disease working group.
	Member of the national banana plant protection working group.
Dionne Walsh	Guest Editor – Special Issue of the *Rangeland Journal* (Climate Clever Beef) to be published in 2016.
	Lead Guest Editor – Special Issue of the *Rangeland Journal* (Fire in a Carbon Economy) published October 2014.
	Member – Program Subcommittee, 2015 Australian Rangeland Society Conference.
	Poster Program Convener, 2015 Australian Rangeland Society Conference.
	Council Member – Australian Rangeland Society from May, 2015.
Jodie Ward	Member of the Katherine Regional Weed Reference Group.
	Social media coordinator for FutureBeef.
	Social media assistant for the Australian Rangeland Society Conference (2015).

External Linkages

Industry Collaboration – details of specific collaborative industry-focused projects.
Research Collaboration - details of specific collaborative research projects or consortia.

Name	(I) Industry Collaboration / (R) Research Collaboration
Mila Bristow	(I) Collaborating with NT plantation companies to strengthen the economic development of forest plantations. (I) Maintaining a strong collaboration with NT farmers through Action on the Ground projects. (R) Strong links with CDU through guest lectures, PhD student supervision and undergraduate student placements. (R) Developing new research collaboration with QUT's Institute for Future Environments to research N management on mango and banana farms in northern Australia.
Jocelyn Coventry	(I) Collaborated with Mr. Boyd Holden (Holden Agricultural Management Systems Pty. Ltd.), Mr. Richard Cadzow (Mt Riddock Station) and Mr Richard Clivas (Mardie Station, WA) on strategies to optimise MSA compliance in cattle processing at abattoirs. (I) Collaborated with Mr. Andrew Stephens (Landmark, Alice Springs) on transporting cattle to abattoirs and the purchase of bulls in 2015. (R) Collaborated with Dr Carol Petherick (University of Queensland), Dr Paul Cusack (University of Sydney), and Professor David Pethick (Murdoch University) on strategies to optimise MSA compliance in cattle processing at abattoirs. (R) Collaborated with Mr. Tim Driver (Precision Pastoral Pty Ltd) on the use of the Remote Livestock Management System for an MSA pre-trucking trial. (R) Collaborated with Ms Cinzia Rovida and Ms Karen Timms (DPIF Water Laboratories) and Dr Peter McGilchrist (Murdoch University) on sample testing and data analyses for an MSA pre-trucking trial. (R) Collaborated with Mr. Peter Jobson (NT Department of Land Resource Management) on the botanical identification of cattle rumen contents and co-authoring of a poster paper for the 18th Biennial Conference of the Australian Rangeland Society, Alice Springs. (R) Collaborated with Ms Hong Duong (Animal Genetics Laboratory, the University of Queensland) on results of DNA testing of cattle at Old Man Plains Research Station. (R) Collaborated with Pastoral Research Officer Whitney Dollemore at the Poll Gene Field Day in Alice Springs in September, 2015.
Whitney Dollemore	(I) Collaborated in the presentation of an Indonesian student animal welfare and handling course. (R) Collaborated with the Animal Genetics and Breeding Unit on intensive genotyping and phenotyping for accelerated genetic improvement of reproduction in northern Australia.

External Linkages

Industry Collaboration – details of specific collaborative industry-focused projects.
Research Collaboration - details of specific collaborative research projects or consortia.

Name	(I) Industry Collaboration / (R) Research Collaboration
Jane Douglas	(I) Spelling, stocking rate and infrastructure development demonstration trial at Beetaloo-Mungabroom Station. (I) Presenter at the 2014 Beetaloo Field Day, the 2015 Australian Rangeland Society Conference – Alice Springs, the 2015 Barkly Rangeland Management Course – Alexandria, Mittiebah and Avon Downs stations.
Mary Finlay-Doney	(R) Dr Mark Blacket (Department of Economic Development, Jobs, Transport and Resources, Victoria) – provision of fruit fly samples. (R) Dr Mark Schutze (Queensland University of Technology) – provision of fruit fly samples. (R) Dr Sharon Van Brunschot and Dean Brookes (University of Queensland). (R) Ania Deutscher (Department of Primary Industries, NSW) – provision of fruit fly samples.
Mark Hoult	(I) NT Farmers - Rambutan growers group. (R) Queensland DAFF. (R) Visayas State University; Baybay, Leyte, the Philippines. (R) Bureau of Plant Industry, Davao, Mindanao, the Philippines.
Sally Leigo	(I) The Precision Pastoral Management Tools (PPMT) project's collaborators include the Australian Agricultural Company's Dalgonally Station in Queensland, the Consolidated Pastoral Company's Newcastle Waters Station in the Barkly region of the NT, the Grey family's Glenflorrie Station in the Pilbara region of WA, the Hayes family's Undoolya Station in Central Australia and the Hobbs family's Tarrina Station in Queensland. (I) The Advisory committee for the PPMT project includes Sharon Bell (Dulkannina Station, SA), Roy Chisholm (Napperby Station and NTCA, NT), Kurt Elezovich (Country Downs Station, WA), Bill Hawkins (Herbatvale, Queensland), Ion Hesoltine (Karratha Station and Rio Tinto, WA), Matthew Prior (Observant, Victoria) and Mick Quirk (MLA, Queensland). (I) The project has four contracted industry partners: the North Australia Pastoral Company, the NTCA, Observant P/L and Precision Pastoral P/L. (R) The PPMT project has five contracted research partners: DPIF, the Queensland Department of Agriculture, Fisheries and Forestry, the WA Department of Agriculture and Food, the South Australian Department of Environment, Water and Natural Resources and The University of New England. (R) The PPMT project has established relations with the Queensland Department of Science, Information Technology, Innovation and the Arts, Meat and Livestock Australia and Landgate.

External Linkages

Industry Collaboration – details of specific collaborative industry-focused projects.
Research Collaboration - details of specific collaborative research projects or consortia.

Name	(I) Industry Collaboration / (R) Research Collaboration
Barry Lemcke	(I) MLA-funded overseas cattle export in-country assistance (Vietnam in 2014-15). (I) Honorary member of the Australian Buffalo Industry Council Board. (I) Associate member of the NT Buffalo Industry Council. (I) Vice President for Oceania on the International Buffalo Federation. (R) Collaborated with CSIRO (Dr Alison Small) in an RIRDC-funded project to find a suitable method to stun buffalo to comply with ESCAS in overseas markets.
Kieren McCosker	(R) Collaborating scientist on the ACIAR StrawCow project.
Cassie McMaster	(I) Banana industry - Expand knowledge on the management of *Fusarium oxysporum* f.sp *cubense* - tropical race 4. (R) Horticulture Innovation Australia. (R) Banana Industry Plant Protection Group.
Helen McMillian	(I) Spelling and stocking rate demonstration trial at Alexandria Station. (R) Participant with Ninti One and the CRC-REP on the Precision Pastoral Management Tools project.
Doris Marcsik	Collaborated with Girraween Nursery on the RIRDC ornamental ginger project. Project leader for the RIRDC ornamental ginger project.
Chris Materne	(I) Provided modelled carrying capacity estimates to Neutral Junction Station (September 2014). (I) Provided modelled carrying capacity estimates for Banka Banka West Station to the Indigenous Land Corporation (February 2015).
Tim Schatz	(I) Collaborated with Elders Indonesia on a research project in a Lampung feedlot. (I) Collaborated with Helen Springs Station to implement a bull breeding PDS. (I) Contributed to Zoetis Northern Beef Management Guidelines. (R) Participated in MLA meetings on future directions in reproduction and calf loss research. (R) Participated in a collaborative genetics research project (UNE, AGBU, QDAF, UQ and QAAFI). (R) Collaborated with the University of Queensland on a new heifer phosphorus trial at VRRS. (R) Conducted research on Bopriva with Zoetis and Peter Letchford (a private vet).

External Linkages

Industry Collaboration – details of specific collaborative industry-focused projects.
Research Collaboration - details of specific collaborative research projects or consortia.

Name	(I) Industry Collaboration / (R) Research Collaboration
Brian Thistleton	(I) BASF – termite trials.
	(I) Optimal Cable Services – termite trials.
	(I) Australian Timber and Pest – termite trials.
	(I) TFS Corporation Ltd - termite control in sandalwood in the NT and WA.
	(R) Collaborated with PFR New Zealand to develop pheromones for *Citripestis eutraphera*.
	(R) Collaborated with Northern Australian Quarantine Strategy, Department of Agriculture and Water Resources, on various research projects.
Lucy Tran-Nguyen	(I) Australian Melon Association.
	(I) Horticulture Innovation Limited.
	(I) ACIAR.
	(I) Rijk Zwaan.
	(I) Monsanto Australia.
	(R) Dr Aviv Dombrovsky – Volcani Institute, Israel.
	(R) Dr Fiona Constable - Department of Economic Development, Jobs, Transport and Resources.
	(R) Denis Persley – Queensland DAFF.
	(R) Dr Herdina - South Australian Research and Development Institute.
	(R) Dr Alan McKay - South Australian Research and Development Institute.
	(R) Dr Tony Pattison - Queensland DAFF.
	(R) Dr Edward Liew – Royal Botanic Gardens.

External Linkages

Industry Collaboration – details of specific collaborative industry-focused projects.
Research Collaboration - details of specific collaborative research projects or consortia.

Name	(I) Industry Collaboration / (R) Research Collaboration
Dionne Walsh	(I) Spelling and stocking rate demonstration trial at Alexandria Station in a collaborative project between the North Australian Pastoral Company and the Commonwealth. (I) Business performance assessment and modelling at Alexandria Station as part of the Climate Clever Beef project. (I) Prescribed burning and spelling demonstration trial at Delamere Station, in collaboration with the Australian Agricultural Company. (I) Spelling, stocking rate and infrastructure development demonstration trial at Beetaloo-Mungabroom Station, in collaboration with the Dunnicliff and Armstrong families, the Barkly Landcare and Conservation Association, DPIF and the Commonwealth. (R) NT Project Manager for “Northern grazing carbon farming - integrating production and greenhouse gas outcomes (Climate Clever Beef 2)”. (R) NT Project Manager for a desktop research project to provide data on live weight and live-weight gain in the beef cattle sector in Queensland and the NT. (R) DPIF representative on the multi-state “Rubber Bush Scientific Advisory Committee”.
Jodie Ward	(I) Prescribed burning and spelling demonstration trial at Delamere Station in collaboration with the Australian Agricultural Company.

Overseas Travel

Date	Destination	Officer(s)	Purpose
July 2014	Indonesia	Tim Schatz	Conduct final data collection for a feedlot trial of steers at Lampung.
	Vietnam	Barry Lemcke and David Ffoulkes	Provide technical services to Vietnamese importers.
	South Africa	Chris Materne and Pieter Conradie	Grassland Society of Southern Africa Conference and study tour of South Africa through the AW Howard Memorial Trust.
August 2014	Indonesia	Doris Marcsik	Attend the XVIII Heliconia Society International conference in Bali and give an oral presentation on ornamental Curcumas.
	Timor Leste	Steve Davis	Attend planning workshop for the Timor Leste Poultry Health and Biosecurity Program.
	Vietnam	Scott Wauchope and Jenny Hill	Promote market development and diversification opportunities identified in the Committee of North Australian Agricultural Ministers Senior Officers Work Plan. Demonstrate coordinated engagement and a uniform northern governments messaging in Vietnam in relation to the beef industry as identified as a priority by the northern Australian beef industry, through the Committee. Explore future opportunities for collaborative projects across northern jurisdictions. Improve beef exports (both live and meat) and potential of other agricultural commodities from northern Australia through active engagement. Gain a better understanding and insight into the potential for other agricultural commodities that could be marketed in Vietnam from across northern Australia.
September 2014	Timor Leste	Barry Lemcke and David Ffoulkes	Fact finding mission to determine suitability of Timor Leste to carry out breeding and feedlot operations using NT cattle and assess abattoir compliance with ESCAS.
	China	Lorraine Corowa	Attend approved Global leadership practices program training in Shanghai China.
	Timor Leste	Steve Davis	Undertake program activities for the East Timor Village Poultry Health and Biosecurity Program.

Overseas Travel

Date	Destination	Officer(s)	Purpose
Sept cont.	Vietnam	David Ffoulkes	Provide technical support to Vietnamese cattle importers.
October 2014	Italy	Bob Williams	Participate in a side event at the 70th meeting of the committee on commodity problems at the Food and Agriculture Organisation of the United Nations.
	Vietnam	Barry Lemcke and David Frost	Provide training for Red Star employees in cattle selection and slaughter management for the commencement of abattoir operations at the Dak Lak feedlot.
	Timor Leste	David Ffoulkes	Inspect proposed ranch area (part of feasibility study to establish breeding/feedlot operations in Timor Leste using imported NT cattle).
	Italy	Lorna Melville	Attend IV International Symposium on bluetongue and related orbiviruses and present a paper on the NT monitoring for bluetongue.
November 2014	Nepal	Susanne Fitzpatrick	Attend foot and mouth disease real time training Kathmandu, Nepal.
	Philippines	Mark Hoult	Deliver milestone activities for approved ACIAR project - HORT/2012/095 - Tropical tree fruit research and development in the Philippines and northern Australia to increase productivity, resilience and profitability.
	Cambodia	Cameron McConchie and Andrew Daly	ACIAR mango Cambodia project (HORT/2012/003) - annual workshop, work plan development and research trial implementation.
	Vietnam	Scott Wauchope and Jenny Hill	A courtesy visit to further strengthen existing relations between the NT and the Central Government and industry in Vietnam. Introduction and relationship building in Cambodia and promote the NT as a supplier of choice for live cattle. To explore future opportunities for the potential for other agricultural commodities that could be exported from the NT.

Overseas Travel

Date	Destination	Officer(s)	Purpose
January 2015	Vietnam	Barry Lemcke and Malcolm Anderson	Investigate Animex (Hai Phong) issue with December shipment of buffalo/cattle.
February 2015	USA	Michael Daysh	Help the Australian Mango Industry Association to export mangoes to the US.
March 2015	New Zealand	Kitman Dyrting	Attend a Sub-committee meeting on aquatic animal health in Wallaceville, New Zealand.
April 2015	Cambodia	Bob Williams, Cameron McConchie, Mary Finlay-Doney and Brian Thistleton	Activities of the ACIAR mango project in Cambodia.
	Vietnam	Scott Wauchope and Jenny Hill	A courtesy visit to further strengthen existing relations between the NT and industry in Vietnam. Introduction and relationship building in the Philippines and Thailand to promote the NT as a supplier of choice of live cattle. To explore future opportunities for the potential for other agricultural commodities that could be exported from the NT.
May 2015	Vietnam	Barry Lemcke	Provide ongoing assistance to Vietnamese importers of NT cattle at Animex and Red Star, assess new prospect Binh Hai feedlot and inspect new cattle/buffalo importer shipment (AKK feedlot) post arrival.
	Vietnam	Neil MacDonald	Provide technical support to the Vietnamese importers for expanding live cattle trade between the NT and Vietnam in 2015, showcasing the NT Government's continued support to neighbouring countries. Increase trade activities between the NT and Vietnam.
	Philippines	Mark Hoult	Deliver milestone activities for ACIAR project HORT/2012/095 - Tropical tree fruit research and development in the Philippines and northern Australia to increase productivity, resilience and profitability.
	Timor Leste	Neville Hunt	Provide training in cold chain management in Dili, Timor-Leste.

Overseas Travel

Date	Destination	Officer(s)	Purpose
May cont.	Timor Leste	Steve Davis	Testing vaccine in Dili, Timor Leste and training laboratory staff.
June 2015	Indonesia	Scott Wauchope and Jenny Hill	Further develop the relationship between the NTG and industry with the Kalimantan Timur Provincial Government and industry.

Seminars and Lectures

Date	Officer	Seminar/Lecture
4 July 2014	Dr Raouf Kilada, University of New Brunswick, Canada	Direct age determination in crustaceans is now possible – A novel technique.
12 November 2014	Professor Simon More, University College Dublin, Ireland	A 10-year experience in the science/policy interface in animal health in Ireland.
21 November 2014	Jocelyn Coventry, Pastoral Production, AZRI	Review of aspects of breeding herd performance from beef cattle projects on the arid rangelands of the Alice Springs District.
6 January 2015	Dr Aviv Dombrovsky, Ministry of Agriculture and Rural Development, State of Israel	Cucumber green mottle mosaic virus.
25 May 2015	Tom Nichols and Michael Barritt, Parks and Wildlife Commission of the NT	CrocWise.

Publications

Scientific Papers, Peer reviewed and other Publications.

Allen, D. E., Bloesch, P. M., Cowley, R. A., Orton, T., Payne, J. E., and Dalal, R. C. (2014). Fire impacts on soil organic carbon stocks in a grazed semi-arid tropical Australian savanna: accounting for landscape variability. *The Rangeland Journal* **36:** 359-369.

Anderson, S., Bellis, G., Thistleton, B., Tran-Nguyen, L. T. T., Edwards, T., Hobern, D., Quintao, D., Halling, L. and Walker, J. (2015). New distribution records of the star fruit flower moth (*Diacrotricha fasciola*) (Lepidoptera: Pterophoridae) in Australia and Timor-Leste. *Northern Territory Naturalist* **26:** 76–84.

Arndt, S. K., Sanders, G., Bristow, M., Hutley, L. B., Beringer, J., and Livesley, S. J. (2015). Vulnerability of native savanna trees and exotic *Khaya senegalensis* to seasonal drought. *Tree Physiology* **35:** 783-791.

Ash, A., Hunt, L., McDonald, C., Scanlan, J., Bell, L., Cowley, R., Watson, I., McIvor, J., and MacLeod, N. (2015). Boosting the productivity and profitability of northern Australian beef enterprises: Exploring innovation options using simulation modelling and systems analysis. *Agricultural Systems* **139:** 50-65.

Bellis, G. A., Donaldson, J. F., Quintao, V., Rice, A., Tenakanai, D. and Tran-Nguyen, L. T. T. (2014). New records of Delphacini (Hemiptera: Delphacidae: Delphacinae) from Australia, Timor Leste and Papua New Guinea, and an updated checklist of Delphacini from Australia. *Australian Entomology* **53(2):** 167-174.

Beringer, J., Hutley, L. B., Abramson, D., Arndt, S., Briggs, P. and Bristow, M. (2014). Fire in Australian Savannas: from leaf to landscape. *Global Change Biology* **21:** 62-81.

Bithell, S. L., Tran-Nguyen, L. T. T., Hearnden, M. N. and Hartley, D. M. (2015). DNA analysis of soil extracts can be used to investigate fine root depth distribution of trees. **AoB PLANTS 7:** plu091; doi:10.1093/aobpla/plu091.

Bray, S., Walsh, D., Rolfe, J., Broad, K., Phelps, D., Cowley, R., Daniels, B., Emery, T., English, B., Ffoulkes, D., Gowen, R., Gunther, R., Hegarty, E., Houston, I., McGrath, T., Pahl, L., Shotton, P., Sneath, R., and Whish, G. (2015). Northern grazing carbon farming – integrating production and greenhouse gas outcomes 1 & 2. Climate Clever Beef Final Report. Department of Agriculture and Fisheries, Rockhampton.

Bray, S., Walsh, D., Hoffmann, M., Henry, B., Eady, S., Collier, C., Pettit, C., Navarro, J., and Corbet, D. (2015). Desktop Research Project to provide Data on Live Weight and Live-weight Gain in the Beef Cattle Sector in Queensland and the Northern Territory. Final Report. Department of Agriculture and Fisheries, Rockhampton.

Bristow M., Hutley, L. B., Beringer, J., Livesley, S. J. and Arndt S. K. (2014). Conversion of tropical savanna to agriculture releases - 100 years' worth of carbon sequestration. *In*: The Ecological Society of Australia Annual Conference, Alice Springs, 28 Sep – 3 Oct, 2014.

Chin, D., Brown, H., Conde, B., Ullyatt, L., Thistleton, B., Smith, S. and Zhang, L. (2014). Field guide to pests, beneficials, diseases and disorders of vegetables in northern Australia.

Coventry, J., Jobson, P. and Allen, C. (2015). Abnormal reproductive observations for beef cows on arid rangelands associated with a suspected increase in dietary phytoestrogens. *In*: 18th Biennial Conference of the Australian Rangeland Society, Alice Springs, (Ed. M. H. Friedel).

Cowley, R. A., Hearnden, M., Joyce, K., Valencia, M., Cowley, T. M., Pettit, C., and Dyer, R. M. (2014). How hot? How often? Getting the fire frequency and timing right for optimal management of woody cover and pasture composition in northern Australian grazed tropical savannas. Kidman Springs Fire Experiment 1993-2013. *The Rangeland Journal* **36:** 323-345.

Cowley, R. A. and Jenner, D. (2015). Is more or less fire needed in northern savannas? Fire history (and optimal management) varies with land use and land type. *In*: Proceedings of the 18th Biennial Conference of the Australian Rangeland Society, Alice Springs. (Ed. M. H. Friedel).

Cowley, R. A., Jenner, D., and Walsh, D. (2015). What distance from water should we use to estimate paddock carrying capacity? *In*: 18th Biennial Conference of the Australian Rangeland Society. Alice Springs. (Ed. M. Friedel).

Douglas, J. (2014). Beetaloo Rotational Grazing Field Day, pp. 1-3 *Barkly Beef*, December 2014.

Douglas, J (2014). Beetaloo Rotational Grazing Field Day, pp. 3-4 *Katherine Rural Review*, January 2015.

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