Emerging Bovine Tech for the Northern Australian Beef Industry

Kylie Braes, 2024 Scholar
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Scholar contact details

Kylie Braes

JCK Braes & Co.

‘Toolebuc Station’, McKinlay Qld 4823

P.O. Box 31, Charters Towers Qld 4820

M 0459 111 136

greencowco2@gmail.com

In submitting this report, the Scholar has agreed to Nuffield Australia publishing this material in its edited form.

NUFFIELD AUSTRALIA Contact Details

Nuffield Australia
Telephone: 0456 916 506

Email: enquiries@nuffield.com.au

Address: 38 Walker Drive, Worongary, QLD 4213

Executive Summary

This research paper investigates the application and potential of emerging bovine technologies within the northern Australian beef industry, with a particular focus on hormone and nutritional diagnostics. The study explores current and future innovations that aim to improve productivity, animal welfare, and sustainability outcomes for beef enterprises operating in remote and extensive production systems.

“At CPC we’re using genetics and precision agtech to better manage and improve the productivity of our herd”
- *Troy Setter, CEO, Consolidated Pastoral Company (2018)*

“Crush-side diagnostics allow graziers to make real-time decisions, not just educated guesses.”
- *Lois Braes, Cattle producer and former teacher (2025)*

“Technology doesn’t replace good stockmanship or land stewardship but data evidence does help sharpen and protect it”
- *Steven Hall, Manager, Toolebuc Station (2025)*

“Unfortunately, the rate of change in the northern beef industry only seems to occur at one generational death at a time”
- *Michael McKellar, Organic Beef Producer (2025)*

Drawing from national and international benchmarks, the research compares Australia's northern beef technological progress to leading global industries such as the United States, Japan, Brazil, and Poland. The insights gathered provide actionable recommendations for integrating cost-effective diagnostics and precision technologies into northern Australia's challenging climatic and geographical conditions.

Keywords: Agtech**,** precision farming**,** cost-effective diagnostics**,** northern beef

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Foreword

First and foremost, I am a mum to two amazing kids who inspire me every day to be better than I was the day before. I am also a cattle farmer and a registered nurse, specialising in rural and remote healthcare - I have always had a love of science.

I grew up in the remote outback of Australia with parents who dreamed of owning their own cattle station one day. My mum, a dedicated teacher for 45 years, and my dad, an incredible cattleman, worked tirelessly over their lifetime to acquire three cattle stations, across some of the most remote regions in north and north-west Queensland. Watching their triumphs and struggles was both inspiring and, at times, heartbreaking.

Every school holiday, before my parents could afford to buy their first property, my brother, sister and I would be mustering, doing hot, dusty yard work, or moving cattle to the next agistment property. Somehow, the struggles, the harsh beauty of the land, and the hope of beating the odds seemed addictive to Mum and Dad. The vast skies, the 'big wet', the sunsets - and the necessity of survival - shaped who I am today.

Figure 1. At my parents' property, Roblo Park Station, Normanton. (Source Author)

I never realised that I wasn't to be part of my parents' cattle station's succession plan - not as a 'widow', not as a single mum, until late in life. As a result, this research is also driven by a desire to find my own path in the industry. It's about keeping a foot in the door, using my voice, and claiming a sense of belonging. It also comes from a place of wanting to help others in the outback and ultimately to help protect the viable, sustainable protein source grown in the north, that helps support global food security.

Vast landscapes and lots of cattle, with very few helpers and few voices, is northern Australia in a nutshell. Often it feels like the forgotten frontier that has long been underdeveloped and underrepresented. According to LiveCorp (2022) there are only about 6,573 fulltime workers, mostly within the live export trade, compared to about 418,921 employed in the red meat and livestock industry across Australia (MLA, 2024). Surviving in the north often means low wages and for property owners – big capital, big areas to manage, big debt and limited cash flow. My reality has been not getting

paid a wage for working on my parents' properties. It was after all for the family and promised to be 'for us kids' later on. Some families fall apart though. Thankfully, to financially survive, I have always had nursing shifts to fall back on. In addition, cattle on agistment and small contracts like preg-testing heifers helped fill the gaps.

My motto has always been to strive for better. I know that my passion for the beef industry is etched in my DNA. I am a 5th generation grazier's daughter. Saying this, I do not claim to be some great cattle woman or horsewoman, for I am not. In any case, I'll always have a fair go. Sometimes I struggle knowing that some of the herd is going off to a humane slaughter – but I choose to feed people. I'm also aware it's hard to grow much else as productively or sustainably as beef in the north.

Searching for better, one night, standing in the yards, exhausted, preg-testing under poor lighting, covered in cow manure, and missing my kids - I thought, surely there's a better way of doing this. That in turn sparked a memory. I recalled the i-STAT machines we used in remote nursing clinics, small handheld, portable devices that delivered blood results within minutes. Soon after I sourced a vet i-STAT machine for cats and dogs, modified its settings to suit bovine blood parameters, and started testing on cattle in the yards. The data I collected gave the cows a chance to effectively 'speak' to me from a nutritional perspective. Rather than relying solely on grass, soil, dung, external observations, or water tests, I could get additional, accurate health data instantly, including what vitamins and minerals were lacking, infection indicators, and electrolyte imbalances.

I wanted to know more. "Phosphorus is something I don't think in 30 years we've gotten right," said Peter McHugh (Beef Nutrition Specialist). I decided I needed to start testing that. I also wanted to investigate testing pregnancy and kidney hormones via i-STAT machines, especially on cattle in remote areas, where access to labs or vets is limited. I wanted to prove how we could supplement better in the north. I started reaching out, researching, and learning. I took a keen interest to human IVF medical technologies and explored whether hormone assays could translate to bovine applications. I kept searching for practical, crush-side tools that could help producers increase profit margins, work autonomously, improve animal welfare, meet compliance requirements, and build an easier sustainable and more resilient future. That's when Brendan Kersh, a Nuffield Scholar and respected cattleman from the northwest, said, "I think you've got something" and encouraged me to apply for a Nuffield Scholarship. "Chuck your hat in the ring and have a go," he said. "But have a bloody good go".

So I did.

Acknowledgements

I extend my deepest gratitude to my parents for their tireless work, unwavering resilience, and the work values they instilled in me. Together their passion for the bush, horses, cattle, and education shaped who I am. Eventually they acquired three cattle stations on their own, which was an epic achievement, and I acknowledge all the sacrifices they have both made to achieve this.

To my independent, clever, big-hearted children, Cape and Jessica. Thank you for your constant love, belief in my abilities, and for forgiving me for the many times I've been away. I hope this work inspires you to chase your dreams and find your own voice.

To my siblings, Scott and Yasmin - thank you for the childhood memories, whether we were swimming horses across croc-infested rivers in the humid heat of the Gulf, on our Grandparents station (that they had for 40 years), or trying to find 'a few head' we'd missed in a 30,000-acre paddock, those days built our strength and shaped our resilience. I understood my sister's choice to leave early on and never pick up another branding iron or do another muster for my parents. However, like my name's Aboriginal meaning – Boomerang, I kept going back. These days it is great to see my brother and his wife, doing great things on their own station, in terms of advancing the land and stock sustainably with good data. Likewise, to see my sister flourishing in her 20-year mining career. You both remind me of what's possible, where I have come from, and how far I have come.

To Kara Knudsen and Michael McKellar - thank you for generously sharing your experiences and words of encouragement. Your stories helped light the path during my scholarship journey. To Brendan Kersh - thank you for encouraging me to have a go at a Scholarship. To Nuffield Australia - thank you for opening doors I could never have opened alone. To my sponsors - AACo, S. Kidman & Co., CPC, and Elders - thank you for your generosity and for all the work you continue to do to support leadership, innovation and research in the Ag Industry. To the remarkable people I travelled with on my Global Focus Program (GFP) - you are all simply awesome, so many memories and new friendships made, thank you.

A special thanks to Peter McHugh, Beef Nutrition Specialist at Causeway Beef Nutrition in Townsville - your insights into phosphorus types, imports, lick quality, and the real-world nutritional challenges facing northern Australian cattle production were invaluable to this research. To my Grandparents, thank you for passing down your entrepreneurial spirit and resilience. To Rob and Rhonda Lyons - thank you for letting me photograph with your beautiful Brahmans for my scholarship portfolio. To Wal (Rowan) Martin - your hospitality, generosity, intelligence and unmatched "never-give-up" attitude has inspired me and countless others. Thank you for the networking support you've shared so freely.

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To my partner, Steven Hall - for your unwavering love, strength, creativity, wicked sense of humor, and for always sharing your insights and incredible knowledge of cattle and the land, thank you. Your support for me, my children, and the young ringers at Toolebuc, is inspiring. You are one of the most hardworking, thoughtful people, and your leadership managing an 800,000-acre cattle station in remote Australia is remarkable and a credit to your tireless dedication. I'm forever grateful we met.

To those who have supported this journey, through research collaboration, shared stories and challenged me, thank you. To those who love the land and choose to endure the harshness while striving to leave it better for generations to come - thank you. And to those that choose to help supply viable, disease free, nutritious food and fiber to the world, so that people can survive and thrive, while ensuring a sustainable future – thank you! Lastly to my fellow Nuffield Scholars - keep shining, keep learning, I'm very proud to walk this path with you!

Figure 2. After some yard work was completed, I sat with my kids and an orphaned calf that they later took to the station house to bottle feed and raise. Haven Downs Station. (Source: Author)

Research Objectives

The aim of this research is to:

- Assess regional challenges and opportunities for implementing precision livestock technologies in northern Australia.
- Evaluate current and future methods for hormone and nutritional diagnostics in cattle.
- Investigate the latest smart and emerging technologies applicable to the northern Australian beef industry.
- Compare Australia's beef technology trends with global counterparts to meet evolving market demands and sustainability targets.

Abbreviations

Abbreviation	Full Term
AACo	Australian Agricultural Company
AI	Artificial Insemination
BCS	Body Condition Score
BMP	Best Management Practice
BVDV	Bovine Viral Diarrhea Virus
cDNA	Complementary Deoxyribonucleic Acid
CRC	Cooperative Research Centre
DNA	Deoxyribonucleic Acid
DSE	Dry Sheep Equivalent
ELISA	Enzyme-Linked Immunosorbent Assay
FE	Feed Efficiency
GHG	Greenhouse Gas
GPS	Global Positioning System
HGP	Hormonal Growth Promotant
i-STAT	Rapid Blood Testing Mobile Machine
IVF	In Vitro Fertilisation
M8U	Molasses-Based Supplement with 8% Urea
MLA	Meat & Livestock Australia
mRNA	Messenger Ribonucleic Acid
NAPCo	North Australian Pastoral Company
NIRS	Near-Infrared Spectroscopy
NLIS	National Livestock Identification System
NRC	National Research Council (US)
PAGs	Pregnancy Associated Glycoproteins
P4	Progesterone
PPH	Phosphorus, Protein, and Hormones
QAAFI	Queensland Alliance for Agriculture and Food Innovation
QLD	Queensland
RFID	Radio Frequency Identification
RNA	Ribonucleic Acid
R&D	Research and Development
RTU	Real-Time Ultrasound
TMR	Total Mixed Ration
UHF	Ultra-High Frequency
WQ	Western Queensland
WT	Weaning Target (Weight)
Zn	Zinc

Introduction

The northern Australian beef industry, typically described as land above the Tropic of Capricorn line, is one of the most distinctive and strategically significant production systems in the world. Characterised by vast land areas, extensive herd sizes, seasonal rainfall, and labour challenges. Regions of northern Queensland like the Diamantina Channels, the Gulf of Carpentaria, the Northern Territory, Katherine, the Barkly Tablelands and the vast Kimberley region in Western Australia, present a uniquely complex environment for livestock management. In recent years, mounting pressure from climate variability, input costs, animal welfare standards, and global market expectations has intensified the need for innovation. The focus has shifted toward tools that offer producers real-time data on individual animals, particularly around reproductive performance, nutritional status, and early disease detection. Among these, emerging technologies in hormonal and nutritional diagnostics represent one of the most exciting frontiers in cattle production.

Despite the remote northern regions' constraints, the area supplies a significant portion of Australia's live export and boxed beef markets. Nationally, the live cattle export trade employs approximately 82% of all direct employment in northern Australia, about 7000 people. It in turn supplies 74% of the 1 billion farm gate value of the live export (LE) trade (MLA, 2022). Northern cattle stations are expansive, some of the largest in the world and are often managed by only one or two people. Remarkably, a single Australian farmer feeds on average 600 people. Although cropping is constrained by pests, limited water and poor soils, cattle remain a critical and sustainable food source in the north – a resource worth protecting.

The Australian beef industry provides high-quality nutritious meat not only to people in local communities but to millions globally. Just one steer can help feed a family of four meat for up to nine months. Australia produces much more food than it consumes, exporting around 70% of agricultural production (Department of Agriculture, Fisheries and Forestry [DAFF], 2023), this includes exporting nutritious, disease-free, cost-effective beef to international markets, all while reducing waste. Beef is one of Australia's core strengths. With world-leading animal welfare standards, sustainable land practices, and strict biosecurity protocols, the industry consistently delivers premium beef while upholding some of the highest farming standards globally.

Traditional cattle management practices in northern Australia are reactive, labour-intensive, and often based on delayed feedback loops. Nutritional and hormonal blood sampling typically require mustering, processing, and laboratory submission - leading to significant time lags, animal stress, and cost. For properties across regions in northern Australia, cattle may only be mustered and 'handled' once or twice a year, these inefficiencies often result in lost productivity, missed data opportunities and management windows.

Recent advances in portable diagnostics, biosensors, and minimalised invasive sampling are creating new opportunities to monitor individual cattle in the paddock or yards - delivering data on hormones, micronutrients, and reproductive status within minutes. Technologies such as tail vein sampling by remote devices, breath pregnancy tests, hair mineral analysis, smart boluses (nanobots), and rapid phosphorus kits are reshaping how northern producers make decisions around joining, weaning, culling, and supplementing.

This research paper aims to explore the development, practical application, and investment potential of these evolving tools. Drawing on global benchmarks (such as Japan's marbling-focused blood assays, Brazil's hormonal traceability systems, and US feedlot performance sensors), the study also assesses what is realistically adoptable in northern Australia. With a focus on low-labour, cost-effective, and robust technologies suited to arid and remote conditions, the paper evaluates the feasibility of integrating crush-side diagnostics into pastoral workflows.

The research includes insights from producers, veterinarians, researchers, and industry representatives, along with data comparisons, cost-benefit analysis, and practical implementation strategies. Special attention is given to how these technologies can support the strategic objectives of major stakeholders - including AACo, Elders, CPC, and S. Kidman & Co., as well as smaller beef businesses - who collectively represent a significant share of the region's production and innovation drive.

By targeting hormone and nutrition analysis specifically, this paper highlights a set of tools that directly influence reproductive efficiency, weight gain, and overall herd health - the three most critical drivers of profitability in northern systems. More broadly, the study advocates for the integration of smart diagnostics with digital record-keeping platforms, ensuring data collected at the crush can inform both paddock decisions, further improve animal welfare, and long-term business strategies.

In doing so, this report provides a forward-looking view of the northern beef industry's readiness for precision livestock production - offering practical pathways for producers, investors, and supply chain partners to capitalise on the next wave of bovine technology.

Chapter 1: Global drivers of change in the beef industry

1.1 Rising demand for quality, traceability, and animal welfare

Consumer expectations are shifting rapidly. Global markets - particularly in Asia, Europe, and North America - now demand more than just volume; they expect transparency, traceability, and quality assurance across every stage of the beef supply chain. Hormone-free, ethically raised, and sustainably managed beef is increasingly preferred, particularly in high-value markets such as Japan, South Korea, and the EU.

For producers in Northern Queensland, Western Australia and the Northern Territory, meeting these expectations is complicated by the extensive nature of operations. However, the development of real-time hormonal and nutritional diagnostics offers a way to bridge the gap between rugged pastoral environments and sophisticated market demands. These tools improve reproductive efficiency, growth rates, and compliance with traceability systems such as the National Livestock Identification System (NLIS) and Meat Standards Australia (MSA) grading.

1.2 Climate, land use, and input pressures

Northern Australia operates under a highly seasonal climate, marked by extreme dry seasons, the ‘big wet’ seasons and erratic rainfall. This affects pasture growth, mineral availability, and energy intake - all of which are critical to reproduction and weight gain.

With land and input costs rising, producers are under increasing pressure to make more from less. Feed costs, supplement freight, diesel, and labour availability all threaten profitability. Smart diagnostics - particularly crush-side nutritional testing kits or biosensor-guided supplementation - help optimise input use by identifying when and which cattle require treatment or supplementation. This replaces “blanket” strategies with targeted management, reducing waste and improving ROI.

1.3 Convergence of technology, data, and decision-making

The digitisation of agriculture is accelerating. Advances in biotechnology, wireless connectivity, machine learning, and miniaturisation are converging to produce tools that once required laboratory settings but are now portable, affordable, and user-friendly.

In the beef industry, this is particularly transformative in the areas of:

- Reproductive management (e.g. progesterone and pregnancy detection)
- Nutritional analysis (e.g. phosphorus, trace minerals, energy balance)
- Disease prediction and early stress markers

Across northern Australia, where large distances and infrequent yarding challenge traditional management approaches, the ability to collect accurate data at the crush or

paddock has far-reaching benefits. These tools also support compliance with evolving ESG (Environmental, Social, Governance) reporting obligations, enabling companies and businesses to provide verifiable welfare and sustainability metrics to investors and export partners.

Figure 9. Medical i-STAT Analyser Handheld Unit used for blood analysis, used in rural nursing clinics. (Source: Quremed, 2020)

Summary

The beef industry is facing a dual challenge: lifting productivity while proving ethical, efficient, and sustainable production. For northern producer - operating across vast tracts of rangeland with limited labour - the development of real-time hormonal and nutritional diagnostics is more than a technical novelty; it's a strategic necessity.

As global demand intensifies and input pressures grow, producers equipped with the right tools to monitor internal animal health and condition in real time will lead the transition toward a more profitable, accountable, and competitive Australian beef.

Chapter 2: Hormonal Technologies for Reproductive & Growth Efficiency

2.1 Why hormones matter in extensive beef systems

In northern Australia, reproductive efficiency is a key driver of profitability - yet it is also one of the most variable performance indicators. Low pregnancy rates, long inter-calving intervals, and missed heat cycles can severely impact productivity, especially in large-scale herds where joining, weaning, and culling decisions must often be made with limited or delayed information.

Hormonal analysis offers a powerful tool to solve this. Reproductive hormones such as progesterone, oestradiol, and luteinising hormone (LH) govern key processes like ovulation, conception, and early pregnancy detection. Monitoring these hormone levels allows producers to:

- Confirm if a heifer or cow is cycling
- Determine if ovulation has occurred
- Detect early-stage pregnancy (as early as day 18–21 post-mating)
- Identify reproductive failures or silent heats
- Guide artificial insemination (AI) timing or controlled mating programs

In addition, stress and energy-related hormones like cortisol, insulin, and IGF-1 (insulin-like growth factor 1) offer insight into nutritional stress, growth rate limitations, and welfare status - all critical in feedlot entry, backgrounding, and breeder management.

2.2 Emerging hormonal diagnostics for crush-side use

Traditionally, measuring hormones in cattle required blood sampling, lab analysis, and several days' delay. That model does not suit the scale, climate, cost or workforce structure of most northern Australian cattle stations. However, recent innovations now allow rapid, field-deployable hormone testing using:

- Saliva-based hormone strips (like human fertility kits)
- Milk and urine hormone dipsticks
- Portable progesterone immunoassay kits (results within 10–15 minutes)
- Breath-based hormone detection (under development - detects metabolic gases linked to progesterone and oestradiol)
- Smart boluses and sensor tags (experimental - monitor internal body parameters linked to hormone shifts)
- Newly developing rumen nanobots.

These tools are particularly promising for low-labour, low-handling operations. Some are already used in intensive systems and are now being adapted to extensive grazing contexts.

Example: A 2023 Queensland pilot, discussed at Beef Week (MLA, 2023), used a progesterone dipstick kit and achieved 94% accuracy for pregnancy detection in Brahman-cross breeders between 21–35 days post-joining. Results were available crush-side within 12 minutes.

Table 2. Commercial and Research-Stage Hormone Technologies

Technology	Sample Type	Target Hormone(s)	Use Case	Status
P4 Rapid Test	Milk	Progesterone	Pregnancy detection (day 18–24)	Commercial (Dairy)
eSense Flex Tag	Behavioural	LH proxy (movement/activity)	Heat detection, oestrus alerts	Commercial (Dairy)
HormoReader (MSD)	Vaginal Mucus	Progesterone proxy	Ovulation window detection	Commercial (Japan)
Breath Biotech (trial)	Breath	Progesterone & Oestradiol	Non-invasive preg/heat testing	Research phase
Tail Sensor Patch	Thermal/Blood flow	LH proxy	Heat & mating behaviour	Early commercial use
Smart Bolus (Ceres Tag trials)	Internal	Temp & hormone-linked markers	Long-term hormone/metabolic tracking	Experimental

2.3 Cost-benefit of hormone testing in extensive systems

The key concern for many northern beef operators is cost vs. return, particularly where labour, yards access, and transport are limiting factors. Fortunately, hormonal diagnostics offer compelling benefits:

Table 3. Benefit versus Impact on Operation

Benefit	Impact on Operation
Early pregnancy detection	Shortens empty cow exposure, optimises joining/weaning
Heat cycle confirmation	Supports timing for AI, bull allocation
Nutritional-hormonal link monitoring	Identifies phosphorus or energy deficits affecting fertility
Reduced mustering frequency	Enables passive or annual-only testing strategies
Enhanced decision-making	Improves mob drafting, retention, and sale timing

Current costs range from $5–$15 AUD per i-STAT test, with results available in under 20 minutes. Compared to $300 lab-based pregnancy testing, these tools are highly cost effective. In northern Australia, large-scale herds face unique reproductive challenges including elevated rates of foetal loss, lower calving percentages, and increased incidence of early-term abortion (Smith et al, 2022). A key limitation for northern beef producers, not knowing when joining has occurred or foetal losses, using standardised hormone tests – is those based only on pregnancy-associated glycoproteins (PAGs). These hormones can stay present in the bovine blood for 60-90 days post abortion, foetal absorption or calving. Meaning cattle handled only twice a year with only 60% live calving rate have the potential to deliver too many false positive results (as the PAGs hormone stay detectable post losses). Testing more hormones together in northern herds that have low calf rates would improve accuracy in pregnancy testing.

Summary

Hormonal diagnostics are becoming less restricted to intensive or dairy systems. With new crush-side kits and non-invasive tools emerging, even extensive beef herds in remote regions can benefit from precise reproductive and growth management. For Northern operations - where breeder performance is a major driver for profit - these technologies offer a clear path to improve reproductive efficiency, minimise losses from empties, and build a more productive and resilient herd.

Chapter 3: Nutrition diagnostics in extensive cattle systems

3.1 Phosphorus deficiency: Causes and consequences

Phosphorus (P) is one of the most critical nutrients limiting cattle productivity in northern Australia. Vast areas of the northern rangelands - including regions across the Barkly Tableland, Cape York, Kimberley's and the Gulf Country - have soils deficient in plant-available phosphorus. Even when P in the soil appears adequate, much of it is locked in forms that are poorly soluble and cannot be absorbed by grazing cattle. Monocalcium phosphorus (MCP), that is highly hydro soluble, can be readily absorbed in the gastrointestinal tract, and efficiently absorbed by the small intestine into the bovine blood. Low P deficiencies are often invisible until behavioral changes (like chewing on bones), brittle bone evidence, peg leg (osteomalacia or rickets in growing cattle), or productivity losses become substantial. Therefore, getting P right, from the start, is important for improving productive herd success.

In phosphorus-deficient herds, cows suffer from reduced appetite, poor body condition, delayed puberty, anoestrus, low pregnancy rates, and high calf mortality. Scientific studies (e.g., Coates & Dixon, 2008) have shown that breeders receiving adequate phosphorus can conceive up to 30% more efficiently than those with marginal or deficient intake.

However, traditional methods to diagnose phosphorus status rely on blood sampling or faecal analysis - often delayed by the time it takes to collect samples, send them to a lab, and return results. In extensive systems, this lag can reduce the value of the information, especially when the window for decision-making is tight due to mustering cattle to the yards only once or twice a year.

3.2 Nutritional biomarkers and sample-based analysis

To overcome the limitations of delayed lab testing, researchers and companies are developing field-deployable tools to assess nutritional biomarkers on-site. These include:

- Hair analysis: Used to assess long-term mineral trends (e.g., phosphorus, copper, zinc, selenium). Practical for seasonal monitoring.
- Urine dipsticks: Measure phosphorus excretion to infer dietary adequacy, typically using phosphorus-to-creatinine ratios.
- Blood spot cards: Allow dried blood samples to be analysed without cold chain logistics, suitable for remote collection.
- Faecal NIRS (Near-Infrared Spectroscopy): Estimates diet quality, crude protein, and energy levels from dung scans. Already commercialised in some Queensland regions.
- Saliva swabs: Under investigation for energy and stress markers such as glucose and cortisol; a potential future crush-side alternative.

These diagnostic tools help identify deficiencies before visible symptoms like weight loss or reproductive failure appear. They are particularly valuable in breeder herds

where the balance between nutrition and reproduction is tight, and where underperformance often goes undetected until the loss of a calf or poor weight gain has already occurred.

3.3 Emerging Tech: Smart boluses drones, and wearables

Recent advances in smart agriculture are bringing tools previously confined to feedlots or intensive dairies into the paddock. While many of these remain in development or limited release, they are already being trialed in extensive beef systems with promising results:

- Smart boluses: Ingestible devices that remain in the rumen and monitor core body temperature, pH, and hydration. Some models are being tested for detecting changes associated with phosphorus deficiency and rumen inactivity.
- Drone-based monitoring: Used for assessing pasture biomass, surface water availability, and animal heat stress. Combined with GPS collar data, this helps model movement, grazing pressure, and nutritional risk zones across large properties.
- Wearable sensors (e.g. collars, ear tags): Track steps, rumination, head movement, and lying/standing behaviour. These are proxies for energy balance, pain, or stress, and could flag early nutritional deficits or illness.

Challenges remain, particularly around cost, durability, and connectivity. In many northern regions, LoRaWAN or satellite-linked infrastructure is still being developed to support data transfer from remote devices. Nonetheless, corporate and research investment in these tools is increasing, particularly where breeding performance and ESG reporting intersect.

Summary

Nutritional diagnostics in extensive cattle systems are evolving rapidly. From hair and urine analysis to drones and nanobot boluses, new tools are enabling producers to detect nutritional stress and mineral deficiencies earlier and more precisely than ever before.

In regions of northern Australia, where phosphorus is a primary constraint on breeder productivity, these technologies could unlock significant gains in reproductive success, calf survival, and herd efficiency. The ongoing challenge is ensuring these tools can be integrated into low-labour, cost-sensitive, and intermittent handling systems common to northern beef operations.

Chapter 4: Global industry benchmarks

4.1 United States: Feedlot sensors and predictive performance modelling

The US beef industry, particularly its feedlot sector, is a global leader in real-time performance monitoring. High-density housing and intensive finishing environments make it easier to apply technology at scale. Most large feedlots use:

- Automated bunk scanners to measure feed intake
- Wearable rumination and activity sensors to detect illness or lameness
- Computer-vision weight estimation systems
- Predictive modelling software that combines intake, weight gain, hormone levels, and environmental stress

When it comes to hormones, the US has historically relied on hormonal growth promotants (HGPs) - though consumer pushback has led some producers to shift toward natural or HGP-free lines, increasing interest in non-invasive metabolic monitoring to maximise natural growth rates.

The widespread use of implant monitoring programs also ensures optimal re-implant timing based on hormone release curves, particularly in feedlots finishing cattle for export.

Key lessons for northern Australia:

- Real-time rumen and intake tracking may not yet suit extensive systems, but predictive models for growth based on nutritional and hormonal inputs could be adapted for data-driven breeder or weaner decisions.
- US feedlots show how integrated software + sensor platforms create powerful, automated feedback loops.

4.2 Japan: Precision marbling via blood chemistry and hormonal profiling

In Japan, where Wagyu beef production is synonymous with extreme marbling and tenderness, hormonal and nutritional testing play a strategic role in quality control.

Producers use:

- Blood sampling to measure circulating IGF-1 and insulin levels during the fattening phase
- Ultrasound marbling scans combined with hormone ratios to predict carcass outcome months in advance
- Feed formulation systems guided by hormone-linked growth models

Japanese systems also implement metabolic fingerprinting, where blood or tissue samples help match individual animals to ideal feed curves. This approach ensures

each steer receives customised rations designed to align energy intake with hormonal signals that promote intramuscular fat deposition.

Figure 10. Prime Wagyu cattle carcasses with high quality marbling, hanging over the hooks and ready for the auction sale at Kobe City Central Wholesale Market, Japan. (Source: Author)

Key lessons for northern Australia:

- While Wagyu methods may be too intensive for large rangeland herds, their hormone-profiling principles can guide value-add strategies, particularly for northern herds targeting feedlots or marbling-based markets.
- The concept of “matching nutrition to hormonal profiles” could be trialed in northern finishing systems using simplified biomarker kits.

4.3 Brazil: Hormonal traceability and large-herd data management

Brazil is one of Australia’s largest competitors in live cattle and beef exports. With over 200 million cattle - many run on extensive tropical pastures - Brazil shares several production challenges with northern Australia: heat stress, reproductive inefficiency, and pasture seasonality.

Recent developments in Brazil include:

- Digital ID tags and hormone monitoring in reproduction programs, especially AI and fixed-time insemination

- Blockchain-linked hormone data, where blood test results are linked to carcass IDs to prove “hormone-free” status for sensitive export markets
- Remote cattle management apps integrating hormonal treatment, vaccination, and nutritional supplementation schedules across vast ranches

The integration of hormonal diagnostics into data transparency systems is key to Brazil’s market positioning, particularly in Europe and the Middle East.

Key lessons for northern Australia:

- Brazil shows that data collection in extensive systems is possible with mobile tools and apps - and that hormone data can add value when integrated into marketing and traceability systems.
- Northern Australia could follow similar paths using NLIS and digital supplementation records aligned with hormonal performance.

4.4 Poland: Dairy-beef integration and nutritional sensors

Although known primarily for its dairy sector, Poland’s beef industry has rapidly grown through dairy-beef integration and technology use.

Polish farmers commonly use:

- Milk sensors to measure ketone bodies, urea, and protein as proxies for energy and nitrogen balance
- NIRS (Near-Infrared Spectroscopy) in feed mixers to optimise daily TMR rations
- Blood-based pregnancy and progesterone tests in robotic milking sheds

These tools not only improve reproductive and nutritional performance but also support animal welfare auditing and digital traceability platforms that are now mandatory in some EU regions.

Key lessons for northern Australia:

- The Polish model shows how low-cost sensors, when tied to automated reporting tools, can support both productivity and compliance.
- While robotic milking is irrelevant to northern cattle, the same progesterone and ketone sensors are being adapted for beef herds internationally.

Summary

Across the world, beef and livestock producers are increasingly turning to hormone and nutrition diagnostics to drive productivity, traceability, and market differentiation.

- The US demonstrates the value of sensor-software integration.
- Japan leads in hormone-guided carcass quality.
- Brazil shows how large-scale producers can link hormone data to traceability.
- Poland highlights the power of everyday nutritional sensors for herd-level improvement.

Table 4. Global Benchmarks in Hormonal and Nutritional Technologies

Country	Primary Focus	Key Technologies	Production System	Relevance to Northern Australia
United States	Feedlot efficiency, early disease detection	- Automated feed intake sensors - Wearables for health and rumen status - Hormonal implant monitoring	High-intensity feedlots	High: Predictive modelling of growth and feed conversion can inspire similar approaches in breeder weaners or finishing paddocks
Japan	Marbling optimisation, premium beef quality	- Blood hormone profiling (IGF-1, insulin) - Ultrasound + hormone prediction - Customised rations	Wagyu, indoor or semi-intensive	Medium: Hormonal profiling could be adapted for Wagyu and composite herds in northern feedlots or backgrounding
Brazil	Reproductive efficiency, traceability	- AI & fixed-time insemination programs - Blockchain hormone records - App-based hormone treatment logs	Large-scale rangeland and semi-intensive	High: Demonstrates scalable hormone data capture, remote app use, and traceability integrations
Poland	Nutritional precision in dairy-beef systems	- Milk sensors for energy/protein - Faecal and feed NIRS - Automated progesterone tests	Small-medium dairy and dairy-beef	Medium-High: NIRS and progesterone tools are adaptable to extensive beef systems; affordable and field-ready

For producers in northern Australia, the path forward is not to replicate these systems, but to adapt them. The key is identifying scalable, crush-side, or yard-level tools that deliver high-value insights

Chapter 5: Sample the cow, not only the country: Blood Diagnostics vs. Environment

For decades, northern Australian producers have relied on pre-mixed mineral blocks, such as M8U, to address phosphorus and trace mineral deficiencies. M8U, originally formulated in the 1970s and widely adopted across Queensland and the NT, contains salt, urea, sulphur, molasses, and phosphorus - targeting rumen function and fertility. However, it is now largely obsolete in progressive US and South American production systems, due to inconsistent intake, nutrient wastage, and the inability to customise to specific deficiencies (Bell & Greenwood, 2016).

More importantly, these broad-spectrum licks assume a “one-size-fits-most” model - despite vast variation in:

- Soil phosphorus levels can differ dramatically even within a single paddock.
- Grass species can fluctuate seasonally in mineral uptake.
- Water quality, often ignored, yet critical for sodium, iron, sulphate, or magnesium load.
- Grasses. Which grass do you sample? (For example, native Mitchell grass, introduced legumes, or annuals?)
- The type of season the grass sample is collected in. (Before the wet, after seeding, post-cure, or in the dry season?)
- Animal movement across the paddocks and the varying different soil types and grasses within the same paddock.

These ambiguities mean sampling doesn't always reflect the actual nutrient intake of the herd, especially in extensive environments where cattle can roam across thousands of hectares.

Furthermore, the mineral composition of bore water, dams, or floodplain run-off can significantly alter a herd's mineral balance - sometimes negating the need for supplementation, or exacerbating deficiencies not picked up in soil tests. Yet, water is rarely included in nutrition audits.

Given the above complexities, many producers and veterinarians argue that testing the animal itself provides the most accurate insight. Blood analysis, whether via laboratory or point-of-care kits, remains the gold standard for assessing:

- Phosphorus (serum inorganic P)
- Calcium (Ca: P ratios)
- Magnesium, copper, selenium, and zinc
- Liver function, protein status, energy markers (e.g. NEFA, BHB, glucose)

This method directly reflects what the cow is absorbing and metabolising - not just what’s present in the environment. It can analyse the invisible and only a small sample (5–10%) of the herd is required to be tested for statistically meaningful data. Hormonal and biochemical markers such as Parathyroid Hormone (PTH), Fibroblast Growth Factor 23 (FGF23), Thyroid Hormone T3, Creatinine, Urea, and Alkaline Phosphatase (ALP) provide deep insights into how phosphorus is being regulated or ‘pulled’ from bone and muscle, as a survival defense by the cow placing it back into the blood stream, keeping levels looking like normal until other deficits, like foetus loss or brittle bone appear.

By including these tests in nutritional diagnostics, it enables early detection of deficiencies, more targeted supplementation, less waste and more efficient resource use in extensive production systems.

Figure 11. Mustering in the Northern Gulf of Queensland. Soil is low P. (Source: Author)

5.1 Kidman Springs phosphorus trial: Field validation in the Top End

Between 2016–2023, the Northern Territory Department of Industry, Tourism and Trade (DITT) conducted a series of phosphorus trials at Kidman Springs Research Station, located in the Victoria River District. These studies aimed to measure the impact of dry season and wet season P supplementation on reproductive efficiency, bone mineral status, and calf survival in Brahman breeder herds.

Key findings include:

- Pregnancy rates increased by up to 31% in P-supplemented herds compared to control.
- Bone biopsies showed a clear correlation between P intake and bone mineral status (measured via rib core sampling).
- Cows receiving wet season P supplementation had significantly higher calf survival and re-conception rates after the first 12 months
- Despite similar pasture biomass, cattle on non-supplemented treatments had poorer body condition and higher plasma alkaline phosphatase levels - indicative of skeletal demineralisation.

These trials confirmed that phosphorus is the most limiting nutrient in northern breeding systems, and that correct formulation, timing, and delivery of supplementation are essential. They also highlighted the need for better diagnostic tools, including faecal and blood P tests, to monitor the effectiveness of supplementation in real time.

“These results show that without phosphorus supplementation, productivity is significantly compromised, even in otherwise well-managed herds.”
- T. Dixon, NT DIIT, Kidman Springs Project Summary (2023)

5.2 Indicative map of phosphorus deficiency in northern Queensland

Phosphorus deficiency is a widespread and well-documented limitation in northern beef production systems. The following map illustrates the key soil zones across northern Australia where phosphorus availability is considered low or marginal. These regions correspond strongly with areas of reduced reproductive performance, poor calf survival, and increased skeletal demineralisation, as seen in trials such as those at Kidman Springs.

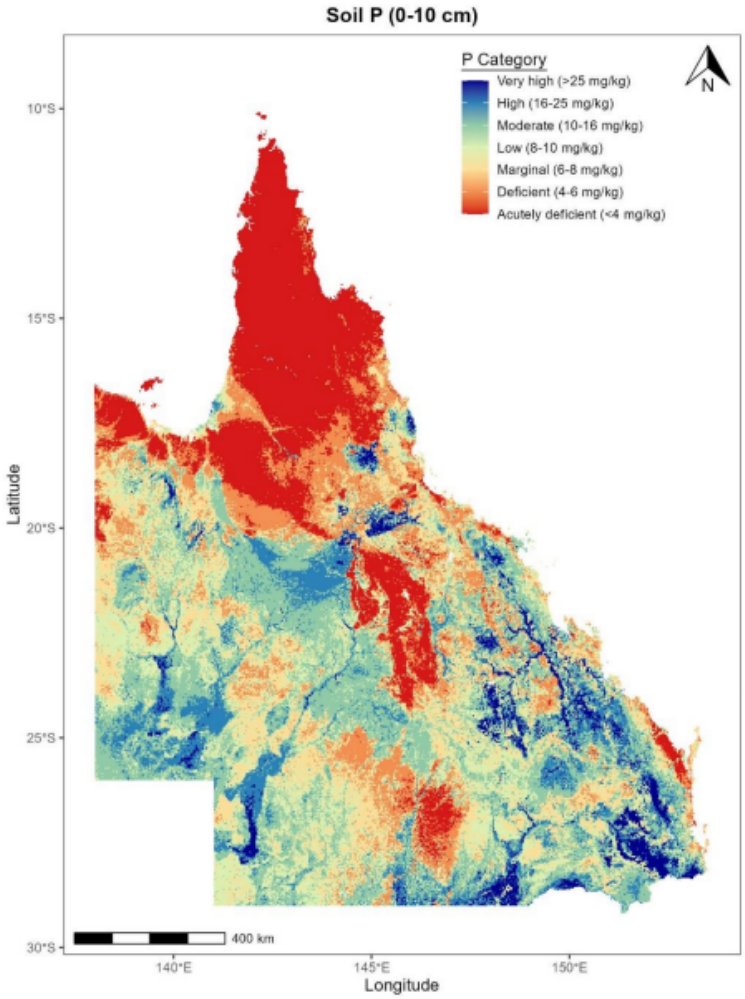

Figure 12. Soil P predictions in the 0-10 cm layer across Queensland categorised into seven P classes. (Source: Meat & Livestock Australia, 2020)

Phosphorus-deficient zones in northern Australia include:

- The Barkly Tableland and Victoria River District (NT)
- Gulf Country and Normanton–Burketown corridor (QLD)
- McKinlay, Winton, and Diamantina Channel country (QLD)
- Large parts of the Kimberley region (WA)
- Some interior pastoral zones of South Australia

Producers operating in these regions should strongly consider phosphorus diagnostics (e.g., blood ALP, PTH, FGF23), smart supplementation trials, using good quality soluble P, including strategic wet-season P feeding, to improve breeder productivity.

Figure 13. Loose Lick supplement and cattle at Amber Station, North Queensland. (Source: Meat & Livestock Australia, 2023)

5.3 Natural Nitrogen Efficiency in Cattle

Nitrogen efficiency refers to the animal's ability to convert dietary nitrogen into microbial protein with minimal losses through urine or ammonia. In northern Australian production systems - where cattle rely on low-protein, high-fibre pastures for much of the year - natural nitrogen-retaining genetics significantly influence fertility, growth, supplement costs, and emissions intensity.

Diagnostics such as Blood Urea Nitrogen (BUN), δ15N isotope testing, and faecal NIRS provide practical pathways to identify high-efficiency animals during routine musters. Incorporating these indicators into breeding programs reduces reliance on dry-season protein supplements, improves feed conversion efficiency, and lowers methane intensity per kilogram of beef produced. Feed Efficiency (FE) without compromising overall productivity remains a valuable net zero target for the beef industry. In this context, genetic selection for FE traits presents a promising yet challenging avenue for future research and development (Ojo et al., 2024).

Traditional northern cattlemen and cattlewomen often recognised these cattle as 'doers' - animals that maintained condition through dry seasons, weaned heavier calves, and consistently rejoined despite feed limitations. These traits strongly correlate with reproductive outcomes - cows with higher nitrogen efficiency exhibit improved body condition, shorter post-partum intervals, and higher conception rates even under nutritional stress (Bobbo et al., 2020).

Nitrogen isotope discrimination (δ15N) provides a reliable biomarker for long-term nitrogen retention and feed efficiency (Cantalapiedra-Hijar et al., 2022; Silva et al., 2022). Modern nitrogen biomarkers now quantify these old observational traits,

allowing producers to select genetically efficient cattle aligned with sustainability, productivity, and net-zero goals.

Summary

The pastoral regions of northern Australia are uniquely suited to benefit from innovations in hormone and nutrition diagnostics - precisely because of their scale, risk, and labour challenges.

While adoption is still in its early stages, tools like faecal NIRS, hair mineral testing, blood testing, smart supplementation, and portable hormone kits are beginning to take hold - particularly in operations with corporate backing, sustainability goals, or precision management targets.

To see widespread use, these technologies must be:

- Affordable and accurate crush-side compatible, designed for intermittent use
- Proven to deliver ROI within one breeding cycle

The opportunity now lies in taking lessons from trial sites and early adopters and translating them into commercial-scale solutions that fit the rhythms of northern beef production.

Chapter 6: Stakeholder analysis and investment potential

6.1 Strategic priorities of key northern stakeholders

The northern beef industry is dominated by a blend of corporate operators, large family enterprises, and agribusiness service providers, each with different motivations when it comes to adopting emerging technologies.

Table 6. Stakeholders focus and relevance

Stakeholder	Strategic Focus	Relevance of Hormone/Nutrition Tech
AACo	ESG compliance, sustainable productivity, export branding	Strong fit: phosphorus and pregnancy diagnostics support animal performance, data transparency, and carbon efficiency
CPC	Reproductive efficiency, genetic gain, scalable tech	Moderate to strong fit: aligns with breeding KPIs and composite herd fertility targets
S. Kidman & Co	Environmental stewardship, extensive production viability	Moderate fit: tools that improve breeder efficiency in arid zones are attractive. Strong fit: tools that help select naturally N efficient cattle.
Elders	Providing services and insights to producer clients	High relevance: offers value-add diagnostics through vet networks and regional agents
Family producers	Cost control, productivity per hectare, practical tools	Conditional fit: tools must be low-cost, mobile, crush-side, and prove ROI quickly

These stakeholders share a common goal: improve productivity under variable rainfall, animal welfare, market volatility, and resource constraints. Hormonal and nutritional diagnostics offer value across all business models - but only if delivery models and costs align with operating conditions

6.2 Investment levers and commercialisation opportunities

For these technologies to gain traction, they must move from research and trial settings into commercial deployment. Several critical investment levers exist:

Private Sector Innovation Pathways

Tech developers working on progesterone kits, phosphorus dipsticks, or smart boluses must tailor their solutions for:

- Ease of use and interpretation
- Animal welfare – not having to stand in the crush for long and limited invasiveness
- Harsh climate and yard conditions
- Intermittent animal handling
- Poor mobile coverage
- Limited wi-fi
- Extreme heat and humidity
- Dusty or wet and dirty environments
- Scale and affordability
- Quick results
- Long battery use

Partnering with stakeholders like AACo or CPC as early adopters provides testing grounds, feedback loops, and potential long-term procurement contracts.

Government and MLA Support

Meat & Livestock Australia (MLA), CRC for northern Australia, and state-based Ag departments (e.g. QDAF) play a vital role in:

- Funding feasibility and validation trials
- Supporting lab-to-crush transitions
- Providing cost-sharing for early adopters

Projects that link nutrition, fertility, and traceability - with commercial outcomes - are especially well-positioned to attract support.

- Data Integration and Digital Ecosystems

No tool operates in isolation. Investors and tech providers are increasingly looking for integrated platforms where:

- Hormone and nutrition data sync with NLIS, MSA, BreedPlan, and ESG tools
- Apps can collect and visualise crush-side results offline and upload later
- Producers can benchmark their data against regional or corporate norms, with opportunities existing for digital platforms (like AgriWebb, MaiaGrazing, Cibo Labs, or LivestockDataLink) to plug in diagnostics as live data streams.

Investor Appetite and Risk Outlook

The investor landscape is increasingly interested in sustainable, scalable, agri-tech solutions - particularly those linked to:

- Productivity per hectare

- Carbon and emissions reduction
- Animal welfare metrics
- Verified supply chains

Hormone and nutrition diagnostics sit squarely in this field, as they enable:

- Increased calving rates without more land or livestock
- Optimised supplement use (reducing cost and emissions)
- Better animal condition at sale (higher returns, less waste)
- Improved welfare and transparency - essential for ESG reporting

However, key risks remain for investors:

- Slow uptake in conservative production regions
- Difficulty in scaling from pilot to paddock
- Need for field validation under rangeland conditions

To mitigate these risks, successful products will need:

- Local champions (e.g. respected stations trialing them)
- Integration with existing workflows
- Pricing structures that match extensive beef economics (e.g. <$10 per use)

Summary

Northern beef stakeholders - from corporates to family enterprises - are ready for diagnostics that can improve reproductive success and nutritional efficiency. The challenge is delivering these technologies in formats that respect the unique constraints of remote, extensive systems.

The path forward requires public-private collaboration, producer-led validation, and investment in scalable, crush-side solutions. Those who lead the way stand to gain not only in productivity and profitability, but in market reputation, sustainability leadership, and investor confidence.

Conclusion

The northern Australian beef industry, situated above the Tropic of Capricorn, operates under some of the harshest and most complex production conditions in the world. Despite this, the region contributes a significant share of Australia's live export and boxed beef supply and faces growing international demand for traceable, high-welfare, and efficient production systems.

This research has demonstrated that emerging hormonal and nutritional diagnostics offer a tangible pathway to enhance performance, reduce operational risk, and support more precise, data-driven management across extensive rangeland herds. From crush-side progesterone test kits and phosphorus diagnostics to smart boluses and faecal NIRS, a new generation of tools is now within reach of northern producers, enabling insights that were previously unavailable or impractical in extensive systems.

The findings of this study indicate that the challenge ahead is no longer one of technological capability, but of confidence, leadership, and adoption. By shifting from broad environmental inference to directly sampling the animal, producers can make earlier and more targeted decisions that improve productivity, animal welfare, and sustainability outcomes. The opportunity for northern Australia is not to replicate overseas production models, but to adapt and lead, embedding hormone and nutrition data as core infrastructure within extensive beef enterprises. Those who move early to integrate these diagnostics into routine management will be best positioned to meet evolving market expectations and secure the long-term viability of northern beef production.

Recommendations

Based on the findings of this report, the following recommendations are made for key industry players:

For Producers

- Start small: Trial hair or faecal samples for phosphorus and protein in one breeder paddock pre-joining to benchmark herd nutritional status.
- Integrate testing with routine handling: Use pregnancy or progesterone testing at the crush during musters to add diagnostic value to existing workflows.
- Integrate blood tests on cattle to get an accurate assay of nutritional status and fertility /hormone / pregnancy
- Use data to inform decision-making: Incorporate test results into culling, weaning, and supplementation strategies - even if only at a mob level.
- Be prepared with baseline data for net zero and carbon requirements

For Corporates

- Scale pilot programs: Expand existing trials of faecal NIRS, digital supplementation, and hormone diagnostics across multiple stations.
- Link diagnostics to ESG and BreedPlan: Use these tools to provide tangible metrics on reproductive efficiency, mineral use, and animal welfare for reporting and marketing.
- Partner with tech developers: Support companies working on crush-side diagnostics by offering real-world validation environments in northern operations.

For Bovine Tech Developers

- Prioritise crush-side usability: Devices must work offline, in dust, heat, and with minimal training. Results should be available in <20 minutes, at <$5 per test.
- Bundle with extension services: Work with Elders or independent vets to deliver testing plus interpretation, not just hardware.
- Build in integration: Ensure compatibility with NLIS, BreedPlan, and farm record apps like AgriWebb or Cibo Labs.

For Policy and Research Institutions

- Fund regional validation trials: Support MLA and CRC-led projects focused on phosphorus diagnostics, pregnancy detection, and drone-based nutrition tracking in extensive herds.
- Develop economic case studies: Show the cost-benefit of diagnostics under real-world northern conditions.
- Create pathways for subsidised adoption: Reduce barriers to uptake through grants, shared-service models, or diagnostic rebate schemes.

These recommendations, if acted upon, could accelerate the uptake of diagnostics that transform how northern producers manage reproduction and nutrition - and position Australia’s beef sector as a global leader in precision pastoralism.

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Appendix 1

Plain English Compendium Summary

Project Title:

Emerging Bovine Tech for Northern Australia's Beef Industry

Scholar:

Kylie Braes

'Toolebuc Station', McKinlay, QLD 4823

Nuffield Australia 2024 Scholar

Overview of this Research

- To investigate new and emerging technologies for hormone and nutrition analysis in the northern beef industry
- To cover costs for more extensive on station trials that can be done in house by producers
- To assess suitability for bovine tech use in extensive production systems in northern Australia
- To identify global innovations that could be adapted to the Australian environment
- To provide practical, scalable recommendations for producers, corporates, investors, and tech developers

Background

Reproductive success and nutritional efficiency are the two biggest drivers of profitability in northern beef herds. Yet, many stations across the Barkly Tableland, Kimberley's, Gulf Country, Winton, McKinlay, and Diamantina still make decisions around breeder performance, culling, and supplementation without real-time diagnostic information.

Traditional tools - like rectal preg testing or scans, or lab-based phosphorus tests - are too slow, invasive, or impractical for extensive systems that handle large numbers of cattle once or twice a year. This project explored a new generation of crush-side, non-invasive, and portable diagnostic tools that are changing what's possible - from early pregnancy detection and heat detection to P and trace mineral analysis. It also compared global beef industries to understand how hormonal and nutritional data, like

natural nitrogen efficiency, is being used to boost productivity and traceability overseas.

Key Findings

Hormone Diagnostics Are Now Field Ready

- Simple dipstick-style kits can detect pregnancy from day 21 onwards using saliva, milk, or blood spot cards.
- Wearables and boluses are being tested to track heat cycles, hormone fluctuations, and stress - with early promise for remote herds.

Nutrition Can Be Measured Without a Lab

- Hair mineral analysis and faecal NIRS are already being used in parts of Queensland and the NT to monitor phosphorus and protein.
- Urine dipsticks and saliva tests are emerging for detecting energy and mineral imbalances on-site.

Northern Operations Are Ready - If the Tools Fit

- Large players like AACo, CPC, and Kidman & Co are trialling these tools, especially when linked to ESG goals, productivity benchmarks, or BreedPlan targets.
- Family-run stations are keen to adopt - but only if tools are affordable, simple to use, and provide clear results at the crush.

Global Examples Offer a Roadmap

- Japan uses blood hormone analysis to optimise Wagyu marbling.
- Brazil combines hormone data with blockchain to ensure traceability and compliance.
- The US leads in wearable tech and feedlot analytics - while Poland shows the power of small, sensor-based nutrition tracking.

Recommendations

Based on the findings of this report, the following recommendations are made for key industry players:

For Producers

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- Develop economic case studies: Show the cost-benefit of diagnostics under real-world northern conditions.
- Create pathways for subsidised adoption: Reduce barriers to uptake through grants, shared-service models, or diagnostic rebate schemes.

These recommendations, if acted upon, could accelerate the uptake of diagnostics that transform how northern producers manage reproduction and nutrition - and position Australia’s beef sector as a global leader in precision pastoralism.

Value to Industry

This research highlights that the next leap in northern beef productivity will not come from more cattle - it will come from smarter, increased precision type data-informed decisions about animal health, that includes increased nutritional and fertility insights.

Diagnostics that once required a vet, lab, or second muster are now becoming tools that fit in your pocket, with results in minutes. These technologies can:

- Improve breeder conception rates
- Avoid supplement waste
- Identify underperformers early
- Support carbon, welfare, and traceability credentials

The beef industry stands to gain economically, reputationally, and environmentally by adopting precision diagnostics that fit the rhythm of northern production.