Emerging challenges and opportunities for tropical pasture systems in NSW

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Abstract: *Tropical pastures have become an increasingly important component of grazing systems across New South Wales (NSW), supporting livestock production, improving resilience to climate variability, and helping address seasonal feed gaps. Over the last 30 years, the role of tropical pastures in NSW has evolved from cautious adoption to an increasingly integrated component of many grazing enterprises as knowledge of species adaptation, establishment, and management has improved. Future tropical pasture systems will need to balance productivity, resilience, sustainability and pasture persistence under increasingly variable climatic and production conditions. Emerging challenges include climate variability, maintenance of productive legume-based systems, pasture persistence, biosecurity threats, and increasing pressure to reduce livestock greenhouse gas emissions. At the same time, opportunities exist through greater pasture diversity, climate-adapted forage systems, mixed-species pastures, tropical legumes, and multifunctional systems including silvopastoral approaches. This paper discusses emerging challenges and opportunities shaping the next phase of tropical pasture research in NSW, including climate resilience, pasture diversity, sustainability, emissions reduction and emerging pest and disease threats. Current and emerging research priorities are discussed in the context of developing productive, resilient and adaptable grazing systems for the future.*

Key words: desmanthus, leucaena, C_3/C_4 transition zone, pasture rundown, pasture dieback, methane mitigation

Introduction

It has been estimated that around 1 million hectares of tropical pastures have been established across New South Wales (NSW) (Boschma *et al.* 2026b). After early reports in the 1950s (Johnson 1952, Buckley 1959) of the potential of tropical species in northern NSW, it wasn't until the 2000s that there was sufficient interest in evaluation and the resulting widespread uptake of this suite of species. Much of this interest was driven by repeated dry seasons and failed autumn breaks, which exposed the limitations of the existing pasture systems. These dry seasons, particularly dry autumns, highlighted the declining persistence of temperate pastures across the North-West Slopes of NSW (Boschma *et al.* 2010). Research addressed many of the constraints identified by producers (McCormick *et al.* 2009). With increased knowledge of suitable species for different soil types (McCormick *et al.* 1998), together with the development of recommendations for successful establishment and management, including weed control (Lodge *et al.* 2010a) and the optimum sowing time and depth (Lodge and Harden 2009; Lodge *et al.* 2010a), improved establishment success ensued. Combined with a series of favourable spring seasons, this knowledge contributed to increased confidence in tropical pasture systems and their wider adoption. Further research expanded the knowledge base through the development of grazing management principles (Boschma *et al.* 2015, 2017, 2018) and improved understanding of water use patterns and species' responses to seasonal conditions (Lodge *et al.* 2010b; Murphy *et al.* 2019, 2022).

The climate in northern NSW has long been considered inherently variable. This variability has intensified over the last few decades, with higher summer temperatures, increasingly erratic rainfall events resulting in longer and more intense dry periods, and greater storm intensity. These changes and increased variability have been widespread across NSW, generating increased interest in tropical pastures in southern NSW and other regions of temperate Australia. In these regions, tropical pastures have the potential to improve summer and autumn feed supply, support livestock productivity during warmer months, and contribute to grazing system resilience under variable climatic conditions (Badgery *et al.* 2024).

The role of tropical pastures within grazing systems continues to evolve, driven by the need for resilient forage systems comprising adapted species that can respond to changing, variable environmental conditions. While productivity remains important, there is increasing interest in how tropical pasture systems can contribute to broader goals such as sustainability, emissions reduction and long-term resilience. This paper discusses emerging challenges and opportunities shaping the next phase of tropical pasture research in NSW, including climate resilience and adaptation, legumes and pasture diversity, sustainability and emissions, emerging biosecurity threats, and future research priorities for resilient grazing systems.

Climate resilience and adaptation

The expansion of tropical pasture systems into new environments has been driven largely by the need to improve the resilience of grazing enterprises under increasingly variable climatic conditions. While tropical pastures are already well integrated into many grazing systems in northern NSW, there is increasing interest in their potential contribution to grazing systems in southern NSW and other temperate environments. This expanding interest has highlighted the need to better understand the adaptation of tropical pasture species across a wider range of environments than those traditionally associated with their use. Species adaptation, persistence and seasonal productivity remain important considerations, particularly within the C_3/C_4 transition zone where both temperate and tropical pasture species may contribute to grazing system resilience. In these environments, the challenge is often not simply whether a species can survive, but whether it can persist and contribute meaningfully to livestock production and farm sustainability over the long term.

Recent modelling studies have suggested that the potential suitability of some tropical pasture species may expand under future climatic conditions (Simpson *et al.* 2026). This has increased confidence in evaluating tropical grasses beyond their traditional production zones, including environments previously considered marginal because of cooler temperatures or frost risk. However, projected suitability does not necessarily equate to successful adoption, as factors such as soil type, fertility, grazing management and enterprise objectives will also influence pasture performance.

Field research in southern NSW has demonstrated that several tropical pasture species can establish and persist under a wider range of environments than previously recognised (Newell *et al.* 2026). However, species responses have varied across locations, underscoring the importance of matching species to the right environment and management strategies. These findings highlight that there is no single tropical pasture solution for temperate environments, but rather a suite of species that may contribute to grazing system resilience when appropriately selected and managed.

However, species adaptation alone is unlikely to determine the long-term success of tropical pasture systems. Pasture composition, particularly the successful integration of legumes within mixed-species pasture systems, will also play a critical role in maintaining productivity, resilience and persistence.

Legumes and pasture diversity

While tropical grasses can improve feed supply and system resilience, long-term pasture productivity is strongly influenced by pasture composition, particularly the successful integration of legumes into mixed pastures. Composition of future tropical pasture systems are likely to rely on greater species diversity to improve resilience, productivity, and persistence.

Legumes remain a critical yet often challenging component of tropical pastures for successful establishment and long-term persistence. Their persistence can be constrained by competition from tropical grasses, soil fertility constraints, grazing management and increasingly variable seasonal conditions. These challenges are likely to become more significant as grazing systems seek to balance productivity, resilience and reduced reliance on fertiliser inputs.

Research in northern NSW has evaluated a range of tropical legumes. Those with the most potential in perennial pastures were desmanthus (*Desmanthus* spp.), leucaena (*Leucaena leucocephala*) and stylo species (*Stylosanthes* spp.). Each species offers opportunities, but their adaptation and persistence vary across environments.

Desmanthus has shown considerable promise as a companion legume in tropical pasture systems in northern NSW (Boschma *et al*. 2021b,c). Compared with several other tropical legumes, it is better adapted to the lower rainfall environments of the North West. However, persistence and productivity can be affected by competition from vigorous tropical grasses, highlighting the importance of species selection and grazing management (Boschma *et al*. 2026a). Despite these challenges, desmanthus remains one of the most promising tropical legume options for northern NSW and continues to attract research interest for its potential contribution to productive and resilient grazing systems.

Leucaena, a tree/shrub legume grown in rows producing alleys in Queensland, has shown potential in northern NSW grazing systems. Long-term evaluations near Tamworth and Bingara have demonstrated persistence, with plantings remaining productive for more than a decade (Boschma *et al*. 2022). During the 2017–2019 drought, leucaena was one of the few species to maintain green herbage, highlighting its potential contribution to grazing system resilience. However, concerns about its weed potential in NSW have limited its wider adoption. A step change to this issue has been the development of sterile or seedless leucaena lines by breeding programs in Queensland and Western Australia (McMillan *et al*. 2019; Real *et al*. 2023). Evaluation of this material under northern NSW conditions is warranted.

Several stylo species have been evaluated on the North-West Slopes of NSW, but persistence has been poor (Boschma *et al*. 2021b). This is likely due to a combination of competition from the perennial grasses and the relatively poor adaptation of many stylo species to the acidic soils common to the region and cooler winters. New stylo germplasm has been developed in Queensland (Peck *et al*. 2022, 2026) and may provide opportunities to revisit the role of stylos in northern NSW grazing systems.

In southern NSW, the challenge is somewhat different. Temperate annual legumes are the logical choice as a companion for tropical perennial grasses, and there is existing knowledge of which legumes are best suited to different regions and soils. The question is not which legumes to use, but how to successfully integrate and manage these species within tropical grass systems to ensure the long-term persistence of both the grass and legume components.

There are two times in the year when management is pivotal, especially in favourable seasons: autumn and spring (Boschma *et al*. 2022, 2026b). In autumn, the grass pasture needs to be grazed to reduce biomass, opening the canopy to allow sunlight to enter and promoting the regeneration of annual legumes (Boschma *et al*. 2018). In spring, especially following favourable winter seasons, the legume bulk needs to be managed to prevent the grasses from being smothered whilst still allowing seed set. In more temperate environments, the legume is potentially better adapted; therefore, management needs careful consideration of the grass.

The successful integration of legumes with tropical grasses remains one of the greatest opportunities to improve the productivity, resilience, and sustainability of tropical pasture systems. However, the challenges differ between environments and have proven difficult to overcome. While progress has been made, no single species or management strategy has emerged as a universal solution, reflecting the complexity of pasture systems and the diversity of environments in which they operate. Future tropical pasture systems are likely to rely on a combination of adapted legumes, effective grazing management, and greater pasture diversity to maintain productive and persistent mixed-species pastures.

Sustainability, emissions, and future pasture systems

Beyond improving feed supply and livestock production, there is increasing interest in what role tropical pasture systems may play in supporting broader sustainability outcomes. These include greenhouse gas mitigation, improved nitrogen cycling and enhanced whole-farm system resilience. As a result, future tropical pasture systems are likely to be evaluated against a wider range of objectives than productivity alone.

Tropical legumes have attracted increasing attention for their potential to reduce enteric methane emissions from livestock. In Australia, enteric methane from ruminant livestock accounts for approximately 78% of agricultural greenhouse gas emissions (DCCEEW 2021). Given that most Australian sheep and cattle are managed in extensive grazing systems (MLA 2026), pasture-based mitigation strategies are likely to offer some of the most practical and cost-effective opportunities to reduce emissions (Badgery *et al*. 2023; Li *et al*. 2025). Plant compounds, such as tannins and saponins, can influence rumen function, reducing methane production, and legumes also contribute biologically fixed nitrogen to pasture systems (Eckard *et al*. 2010; Banik *et al*. 2013; Mueller-Harvey *et al.* 2019).

Research has identified several tropical legumes with methane mitigation potential, with desmanthus and leucaena receiving particular attention (Vandermeulen *et al*. 2018; Suybeng *et al.* 2020; Durmic *et al.* 2022; Stifkens *et al.* 2022; Mitchell *et al.* 2026). The demonstrated potential of these species in northern NSW grazing systems suggests they may contribute to both livestock production and emissions reduction. While these findings are encouraging, further research is required to better understand the consistency of methane responses under commercial grazing conditions and to ensure any emissions benefits can be achieved without compromising productivity, persistence or profitability.

Maintaining pasture productivity and persistence over the long term remains a significant challenge. Productivity decline, also known as pasture rundown, is an age-old phenomenon in which soil nitrogen is immobilised in plant material, leading to limited mineralisation and, over time, nitrogen becoming less available to pasture grasses (Myers and Robbins 1991). The initial high productivity of newly sown tropical grass pastures can halve over time, and in Queensland has been estimated to have a farm gate cost to industry of $17B over the next 30 years (Peck *et al.* 2011). A 10-year study where either 0 or 100 kg/ha nitrogen was applied annually to a digit grass pasture, while phosphorus and sulfur levels were maintained, found the nil-nitrogen pasture produced an average of 5.4 t/ha dry matter annually, while the nitrogen fertilised pasture produced 9.4 t/ha/year (Boschma *et al.* 2022, 2026b). Legumes remain one of the most cost-effective mitigation options for reclaiming 30–50% of lost production (Peck *et al.* 2011), while improving system productivity and resilience.

There is also increasing interest in the role that pasture composition and species combinations may play in supporting resilient and sustainable grazing systems. Natural grasslands comprise diverse plant communities with complementary adaptive traits and functional roles. Collectively, these species contribute to productivity, nutrient cycling, soil health and resilience under variable seasonal conditions. Greater species diversity may also improve the resilience of pasture systems by reducing the reliance on any single species and helping maintain pasture function under variable seasonal conditions (Volaire *et al.* 2014; Campbell *et al.* 2011; García-Palacios *et al.* 2018).

One method to increase species and functional diversity in grazing systems is to incorporate trees into pastures. Systems that combine trees, forages and livestock on the same land are known as silvopastoral systems. At a systems level, silvopastures have the potential to improve soil health, provide shade and shelter for livestock, enhance biodiversity, increase carbon sequestration and diversify farm production.

While many pasture paddocks contain scattered trees, the intentional selection of tree species to achieve specific production or environmental outcomes offers opportunities to improve grazing system resilience and diversify farm income. Depending on location and enterprise objectives, trees may provide timber, biomass, niche products such as oils, or additional fodder resources (Cameron *et al.* 1991; Farag *et al.* 2004; Garvie *et al.* 2021).

Further research is required to develop silvopastoral systems as practical and economically viable options for NSW grazing enterprises. The most appropriate systems are likely to vary with climate, soils, and enterprise objectives, with different opportunities across high-, medium-, and low-rainfall environments.

Emerging threats and biosecurity

As tropical pasture systems expand into new environments and become more widely adapted, there is an increasing need to better understand and manage potential biological threats. These threats may arise from three sources: changes within existing pest and disease populations; expanding the boundaries of plant species, thereby exposing them to new pests and diseases; and the threat of incursion of new biological pests and diseases from offshore.

Pasture dieback is a current and significant threat to tropical pastures. This condition affects tropical grasses, with both sown species and a range of native and naturalised species being susceptible (MLA 2023). Pasture dieback is a complex condition involving pasture mealybug (*Heliococcus summervillei*). Pasture mealybug was first identified in South-East Queensland in 1926, affecting paspalum (*Paspalum dilatatum*) (Summerville 1928). It caused productivity losses without significant spread at the time. It remained a relatively minor pest until 2015, when it was identified as part of the current outbreak, which has continued to spread across Queensland and into northern NSW (Buck 2017; Boschma *et al.* 2021a; Gibson *et al.* 2024; Buck *et al.* 2025).

Desmanthus is relatively new to North-West NSW (Boschma *et al.* 2021b,c). This extension of its range further south than previously recognised in Australia expands the boundary of adaptation of this legume. Alfalfa mosaic virus has now also been reported in this legume — a new disease for this legume in Australia (van Leur *et al.* 2019). The disease is common in lucerne stands in NSW (van Leur and Kumari 2011) and is transmitted to desmanthus by the cowpea aphid (*Aphis craccivora*) (van Leur *et al.* 2019), resulting in significant decline in growth and lost productivity (van Leur *et al.* 2019; Murphy *et al.* 2022).

The examples of tropical pasture dieback and alfalfa mosaic virus in desmanthus highlight the nature of biological threats facing tropical pasture systems. While these challenges have emerged from different pathways, they demonstrate the need for ongoing surveillance and diagnostic capability as pasture species are adopted across a wider range of environments. Maintaining productive and resilient tropical pasture systems will require not only adapted species and management but also the capacity to detect and respond to emerging biological threats.

Future research priorities

These challenges and opportunities highlight the need for research that improves the productivity, resilience and sustainability of tropical pasture systems across diverse NSW environments. While significant progress has been made over the last 30 years, several important research questions remain.

A major priority will be improving the resilience of grazing systems under increasingly variable climatic conditions. This includes identifying species and pasture systems suited to future climates, understanding the role of tropical pastures in reducing seasonal feed gaps, and developing management practices that improve persistence and productivity under variable rainfall and temperature conditions. There is also a need to better understand the role of tropical pasture species in southern NSW and other environments where they have not traditionally been used.

Successfully incorporating legumes into tropical pasture systems remains both a challenge and an opportunity. Future research should focus on improving legume persistence, identifying adapted companion species, and understanding how mixed-species pasture systems can contribute to productivity, nitrogen supply and grazing system resilience. There is also a need to better understand how tropical and temperate pasture species can be successfully combined in the C_3/C_4 transition zone. This transition zone offers a unique opportunity to utilise both temperate and tropical species within the same grazing system, enabling producers to respond more flexibly to seasonal conditions and make the most of rainfall when it occurs.

Maintaining long-term pasture productivity will remain important. Research into pasture persistence, pasture rundown and emerging pest and disease threats will be required to ensure tropical pasture systems remain productive and profitable over time. Continued investment in surveillance and diagnostics to identify new threats, and breeding programs to identify resistance/tolerant lines, will also be important for reducing the impact of future biosecurity threats.

There is increasing interest in the role that tropical pasture systems may play in supporting lower-emission livestock production. While some tropical legumes have shown promise for reducing methane emissions, further work is required to better understand these responses under grazing conditions and to ensure emissions benefits are achieved without compromising productivity, persistence or profitability in NSW.

Future tropical pasture systems will need to balance productivity, resilience, persistence and sustainability. Achieving this balance will require continued collaboration between researchers, producers and industry to ensure tropical pastures remain a practical and profitable component of grazing systems across NSW.

Conclusion

Tropical pastures have become an increasingly important component of grazing systems across NSW, driven by the need for resilient forage systems that can maintain productivity under variable climatic conditions. Supported by decades of research, development and extension, tropical pasture species are now established across approximately 1 million hectares of NSW and continue to play an important role in many grazing enterprises.

The role of tropical pastures within grazing systems is also evolving. Productivity remains a key driver of adoption, but future pasture systems will increasingly be expected to balance productivity with resilience, persistence, sustainability and adaptation to changing environmental conditions. Achieving these outcomes will require a greater understanding of how species selection, pasture mixes and management can be combined to develop productive and resilient grazing systems.

Realising these opportunities will require ongoing attention to emerging pest and disease threats, biosecurity risks, and the increasing climate variability, which present new challenges that will influence future research and development priorities. Continued investment in research, innovation and extension will be important to ensure tropical pasture systems remain productive, profitable and resilient across a diverse range of environments.

If future tropical pasture systems can maintain livestock production while improving resilience, supporting sustainability outcomes and responding to emerging challenges, they will provide significant opportunities for grazing enterprises across NSW.

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