GRASSED UP – LIVING WITH THE LEGACY

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INTRODUCTION

The grass family is a critical part of human life as we know it. This group of plant species is linked to the development and sustaining of much of human society over thousands of years. Grasses are present in almost every habitat on earth, from polar and equatorial regions including mountains, lowlands, aquatic and desert regions (Wheeler *et al.* 1982). This is observed in Australia where grass is present in salt, brackish and freshwater aquatic systems, arid and semi-arid grasslands and woodlands, tropical savannahs and alpine regions (Wheeler *et al*. 1982).

Most exotic plants including grasses are moved and introduced into new environments both intentionally and accidentally through human activities with further spread often facilitated by human disturbance (Fusco *et al*. 2022). Many grasses have become some of the most persistent and troublesome weeds in the world with their spread and survival enabled by human activities (Wheeler *et al.* 1982). This paper discusses the history, impacts and what the legacy of grass introductions might look like for future generations.

EXOTIC GRASS INTRODUCTIONS IN QUEENSLAND/AUSTRALIA IN CONTEXT

Many exotic grass introductions into Australia have an intentional and unintentional component which coincided with the increase in international human movements following the European settlement of Australia (van Klinken and Friedel 2017). It is probable that grass introductions began with the arrival of the first fleet and have continued until the present day. Grass species were deliberately introduced for crop and pasture production, amenity values such as lawns and gardens, soil erosion control and to reduce dust in drier environments (Cook and Dias 2006).

In the late 19th and throughout the 20th century the deliberate introduction of grass species into Australia became more organised. These introductions were mostly well-intentioned aiming to increase agricultural production and extend it into new regions where climate and soil were less suited to intensive agriculture using the available species at the time. Alongside agricultural development government policies aimed at increasing the population and pastoral production across most of Australia supported the introduction of more than 2,200 grass species to Australia with the intention of field testing them and selecting the best species for forage production in the many climatic regions of Australia (Cook and Dias 2006). During this period unintentional grass introductions continued however it is impossible to know how many species arrived in Australia this way.

Grass species were deliberately introduced from all continents apart from Antarctica in an effort to find suitable species for Australia's many and varied climates and soils

(Cook and Dias 2006). This was done in order to promote economic development through pastoralism and support increased population in the large sparsely populated areas away from the coastline and established agricultural areas of eastern and southern Australia. As a result, exotic grass species were planted for testing in many locations across northern Australia in order to determine if they could survive and produce at levels required for livestock production. This drive for economic development in northern Australia through pastoral development was largely a failure probably due to a lack of grass species able to out produce the native grass species without significant inputs such as nutrients and water.

Following the failure of this program in northern Australia many of these test plots were abandoned likely leaving some established exotic grass species to continue to grow and find their niche within the northern Australian climate/environment. Indeed, old test sites could be where sleeper grass weed populations are surviving while waiting for their opportunity to spread and invade landscapes away from their original plantings. These and other deliberate plantings of exotic grass species and naturalised grass plant populations that established outside planted areas have left legacy populations that continue to spread across Queensland and northern Australia (Cook and Dias 2006, Simon and Jacobs 1990). This includes exotic aquatic and semi aquatic grasses introduced for forage such as hymenachne (*Hymenachne amplexicaulis*) (Figure 1).

In the latter part of the 20th and the start of the 21st centuries there has been a shift away from 'production at all costs' to include at least some consideration of the environmental impacts of introduced grasses growing outside of the systems for which they were introduced. This has resulted in significant effort aimed at protecting/restoring high value environmental areas as well as limiting the effect of exotic grasses on production and amenity values. In the author's view, whether this effort will ultimately succeed is yet to be determined in future years.

Figure 1. Hymenachne monoculture in creek system in tropical Queensland.

IMPACT OF EXOTIC GRASS IN QUEENSLAND

Invasive plants are changing ecosystem function, reducing biodiversity and reducing the production and amenity across many landscapes worldwide (Cook and Dias 2006). In the author's experience, industry of all kinds has often favoured production values (grazing, turf, amenity) of introduced grasses over any significant environmental values and impacts except when deliberately introduced grasses threaten forage production, amenity values and habitat change. This is demonstrated by the negative response to the deliberately introduced Indian blue grass (*Bothriochloa pertusa*) (Figure 2) for pasture that was captured in recent surveys of graziers in Queensland (Spiegel 2016). Interestingly this has been recognised after the deliberate introduction and planting or invasion of Indian blue grass into native and established exotic grass pastures.

Many but not all of the identified significant problematic deliberately introduced exotic grass species are listed in Table 1. They appear to be well adapted to northern Australian conditions including low soil fertility, highly variable and seasonal rainfall, relatively frequent fire and are likely to form dense monocultures with or without disturbance. Some of these species such as signal grass (*Brachiaria decumbens*), humidicola (*Brachiaria humidicola*), and buffel grass (*Cenchrus ciliaris*) are valued as forage plants for livestock production but readily jump the fence and invade landscapes such as roadsides and environmental areas where they are considered weeds. Others such as hymenachne, aleman grass (*Echinochloa polystachya*) and para grass (*Brachiaria mutica*) are well adapted to seasonal or permanent wetlands including brackish water in coastal areas where they can be productive but readily increase their distribution and degrade wetland habitat.

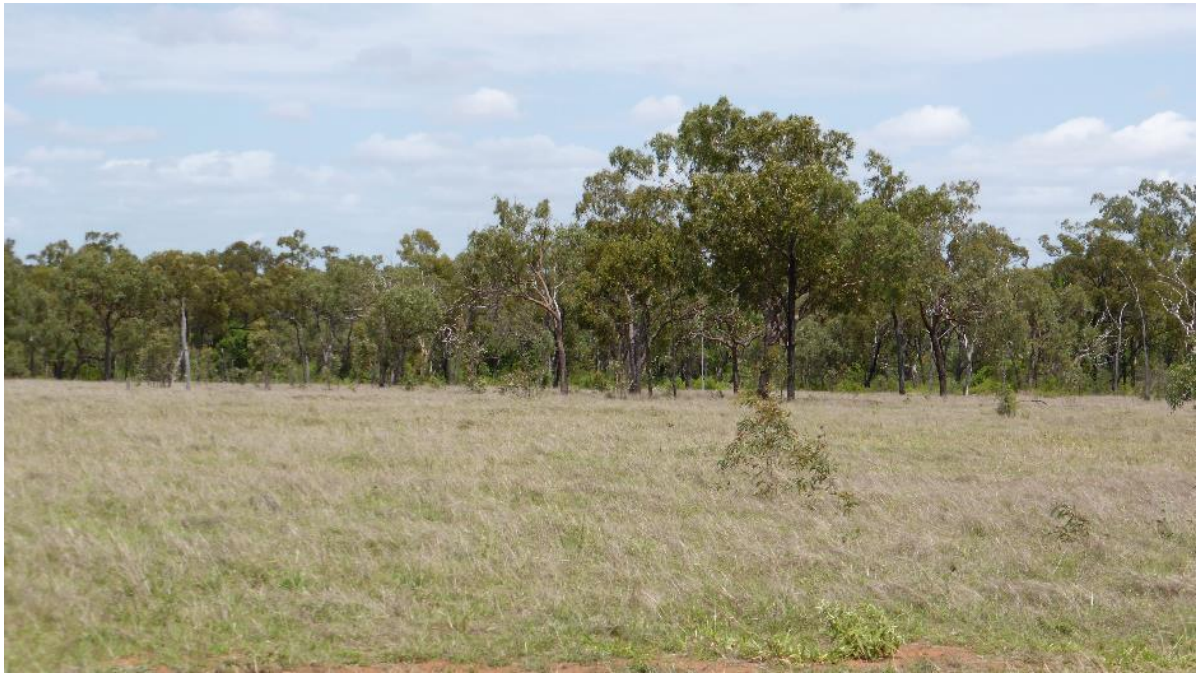

Figure 2. Indian blue grass monoculture in the dry tropics of northern Queensland.

The traits of these grasses that make them invasive (Table 1) are almost the same as what would be considered desirable for pasture species. These include easy to establish, high seed production, quick growing, able to grow in low fertility soil, seed easily spread, able to grow in a wide range of soils, with stand moisture stress and

persist through highly variable seasons. The main difference between the desirable pasture species and invasive weed is that the pasture species are also moderately to highly palatable to livestock and able to tolerate high grazing pressure.

Some of these species are also weeds in sown pastures where they can be difficult to control and generally increase in density due to the intensive grazing in these areas. Giant rat's tail grass (*Sporobolus pyramidalis/natalensis*) is probably the best example of this in coastal and subcoastal sown pastures. In these situations, it can dominate if management strategies such as slight reductions in grazing intensity to maintain soil cover and the addition of nutrients to maintain pasture species competitiveness are not adopted. Strategic herbicide application may also be required which significantly increases production costs for beef producers and requires careful herbicide residue management.

All of these grass species can invade either aquatic or native grass based ecosystems. They can have detrimental impacts in native grazing systems as well in protected or managed environmental systems with some requiring at least some level of disturbance to assist invasion and others able to invade without significant disturbance events. In either circumstance, once established and naturalised they are difficult to remove from the landscape even if there were sufficient resources available. In some cases, restoring the landscape to its pre-invasion condition will be impossible. When this is the case, the best outcome possible may need to include some consideration of the possibility that the ecosystem function will eventually be damaged which may result in native plant and animal extinctions, lowered biodiversity and native species abundance, and the development of an altered ecological state what might be called 'a new normal'.

Table 1. Widespread deliberately introduced grasses that can be considered useful pasture species or invasive weeds/ecosystem changers.

Scientific name	Common name	Pasture/Invasive
Andropogon gayanus	Gamba grass	Pasture/Invasive
Bothriochloa pertusa	Indian blue/couch grass	Pasture/Invasive
Brachiaria decumbens	Signal grass	Pasture/Invasive
Brachiaria humidicola	Humidicola	Pasture/Invasive
Brachiaria mutica	Para grass	Pasture/Invasive
Cenchrus ciliaris	Buffel grass	Pasture/Invasive
Echinochloa polystachya	Aleman grass	Pasture/Invasive
Eragrostis curvula	African love grass	Invasive
Megathyrsus maximum	Guinea grass	Invasive
Hymenachne amplexicaulis	Hymenachne	Pasture/Invasive
Hyparrhenia rufa	Thatch grass	Invasive
Pennisetum pedicillatus	Annual mission grass	Invasive
Pennisetum polystachios	Perennial mission grass	Invasive
Pennisetum setaceum	African fountain grass	Invasive
Sporobolus natalensis	Giant rat's tail grass	Invasive
Sporobolus pyramidalis	Giant rat's tail grass	Invasive
Sporobolus jacquemontii	American rat's tail grass	Invasive
Themeda quadrivalvis	Grader grass	Invasive

Gamba grass (*Andropogon gayanus*) induced changes to native woodlands via increased fire frequency and intensity is perhaps one of the better known examples of landscapes being changed to a new normal with both pastoral and environmental impacts (Figure 3). Studies of the impact of gamba grass fires on the tree layer in woodlands have indicated that native woodlands in the seasonal dry tropics of northern Australia could be turned into gamba grass grasslands in as little as a decade (Brooks *et al*. 2010; Rossiter *et al*. 2010). This will also be accompanied by habitat loss which will likely result in the local extinction of fauna and flora species.

Grader grass (*Themeda quadrivalvis*) and Indian blue grass invaded landscapes provide more examples of changes to ecosystems that exclude native fauna such as small reptiles and some bird species. In both cases it is largely the changes in vegetation structure that make invaded areas less suitable for some vertebrates and more suitable for others (Abom *et al*. 2015; Kutt and Fisher 2011). Once this occurs it is likely there is no clear path back to the previous native ecosystem.

There are also significant economic benefits from some introduced grass species due to their increased forage production in a range of environments. In Queensland it has been said that buffel grass is worth more than $1 Billion annually to the beef industry and the state's economy due to increased forage production and the resultant increased beef production particularly in the drier parts of the state.

Signal grass and humidicola are important production grasses in the wetter tropical and eastern coastal areas of Queensland where they are primarily used to support intensive beef production. While their value as production grasses is less than that of buffel grass in dollar terms they are important grasses for wet coastal areas where if well managed they form dense monocultures of forage for livestock grazing.

Figure 3. Gamba grass fire damage and reduction tree canopy in tropical woodlands

WHAT IS THE LEGACY OF EXOTIC GRASS INTRODUCTION IN QUEENSLAND

The legacy of exotic grass introduction to Queensland is clearly evident when in many cases a glance out the car window while driving results in the inability to see any native grass species due to the presence of many exotic grass species growing as weeds along roadsides or as well established stands for beef production. Roadsides are highly disturbed areas with significant opportunity of seed introduction and new plant establishment making it unsurprising that they are filled with exotic deliberately introduced grass species. Many of these grasses have invaded the land adjacent to roadsides causing loss in production, increased management costs or biodiversity loss and have transformed the ecosystem into what is a 'new normal' state which will likely stay in this altered state until disturbance forces another change.

In the author's opinion, even where pastoralists are managing for biodiversity outcomes or ecosystem function, the legacy of introduced grasses that improved production or those that invaded and caused production losses will likely be a gradual move towards an irreversible grass monoculture that does not resemble the native ecosystem present before exotic grass introduction. As these exotic grasses increase so will the pressure on native flora and fauna with the inevitable extinction of native species in at least localised areas. The endangered black throated finch is one such species which is now reliant on small isolated 'strongholds' with sufficiently intact native grass communities for its future (Grice *et al*. 2023).

Invasive grasses are considered a fine fuel source and generally increase the flammability of the total fuel for fires in invaded ecosystems. This increase in fine fuels can lead to increased fire frequency, intensity and severity (Brooks *et al*. 2004; Fusco *et al*. 2019). This increased fire frequency can lead to loss of mature and young trees with the ultimate end being an exotic grassland where there once was a native woodland with a grassy understory (Rossiter *et al*. 2003; Brooks *et al*. 2010). This may be one of the most significant legacies of introduced grasses in Queensland and Australia, particularly in the northern monsoonal tropics. Over time there may be considerable change from mostly native grassy woodlands to exotic grasslands at a landscape scale.

Fire frequency and intensity will also increase where exotic grasses have invaded drier regions. While the fires may not be as intense as those fuelled by gamba grass, they are nevertheless damaging to native flora and fauna and will not be easily extinguished due to resource limitations in these more remote regions.

The intense fires caused by the large amount of fine fuel produced by these grasses will also increase the risk of loss of infrastructure, built assets such as homes and sheds and even the loss of life. In particular this is a significant issue for lifestyle blocks on the outskirts of towns where the encroachment of these grasses causes a real threat to life and property. This is the case in more settled areas of the tropical east coast of Queensland where there are significant populations of introduced high biomass grasses such as guinea grass, thatch grass, gamba grass, grader grass and giant rat's tail grass in the landscape close to people and their property.

The legacy of deliberately introduced grasses will force society to make decisions that they will not like making or that seemed unthinkable in a previous time. Land managers

will be forced if not already being forced to choose the least worst option when it comes to introduced invasive grass management decision making. In coastal areas of tropical Queensland decisions are already being made to use humidicola to suppress gamba grass in order to reduce the risks associated with intense fires in closely settled areas. This is being done even though humidicola will form a dense low growing monoculture that will likely exclude some native fauna and with the long term ecosystem change not well understood. Other similar choices are being made in production systems where well managed signal grass is being used to reduce production losses caused by giant rat's tail grass (Figure 4) and where Indian blue grass could be used to out compete grader grass, reducing fire intensity and maintaining some level of production albeit less than the well managed native grass systems. Such choices will require a pragmatic view of the situation while determining the best way forward to maintain at least some production and/or environmental values of the land being managed.

Figure 4. Signal grass being used to suppress giant rats tail grass and to maintain production.

In the author's view the legacy of deliberately introduced grasses will force at least some recognition by government, industry and the broader community that it is likely many landscapes and ecosystems have been and will continue to be irreversibly changed due to the invasion or planting of deliberately introduced exotic grasses. Some landscapes are already dominated by exotic grasses, with many other landscapes having at least some level of exotic grass invasion. The recognition that there is no way back to the previous native ecosystem and that production systems based on native grasses will need to adapt to use grasses like giant rat's tail grass to support beef production is a real possibility due to the prohibitive cost of effective control programs.

There will need to be a similar recognition in protected landscapes where significant introduced grass invasion has and continues to occur. Management will need to change if these landscapes are to maintain some semblance of the native ecosystem that is being protected for future generations.

CONCLUDING COMMENTS

The legacy of deliberately introduced exotic grasses is one of economic benefit, economic cost and continued ecosystem change. The legacy is real and significant with the presence of these grasses a stark reminder of the impacts of decisions made with good intentions but perhaps with limited realisation of the potential of these grasses to have such significant impacts outside of the areas in which they were planted. At least several introduced grasses that are important production species have produced significant conflict between 'production at all costs' viewpoints and conservationist values. For progress to be made it will be necessary for all involved in this debate to engage in reasoned discussion to find a pragmatic middle ground and mutual understanding of the broader issues. Only once this is done can the discussion move forward to finding solutions to the conflict and working to long term mutually beneficial outcomes.

In hindsight Cook and Dias (2006) suggest that the introduction of many grass species is best viewed as a mistake. At the end of the day, it doesn't matter that much how or why these grasses were introduced into Australia. What matters is whether we have learnt anything by understanding the history of grass introductions and their impacts both beneficial and detrimental. We need to look at the big picture from all angles and ensure we have the protocols in place to balance the values of production and environment when making future decisions around species introduction.

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