BUFFEL GRASS INVASION IN CENTRAL AUSTRALIA:

IMPACTS ON HUMAN HEALTH

Arnold, J. (2025) *Buffel grass invasion in central Australia: Impacts on Human Health* Report to the *Buffel Action Network Australia*.

DESERT INDIGENOUS PROTECTED AREAS RANGERS STATEMENT ON BUFFEL GRASS 2021 (UMUWA)

Nganana Anangu tjutangku tjanpi kuranya nyanga palunya ngalya katinytja wiyatu. Palu kuwari tjanpi kuranya nganampa mantangka ngaranyi munu nganampa ngura kurani munu community munu culture kulu.

Tjanpi kuranya ngalya katingu puluka tjutaku kutju mai munu ulpuru kulu wiyanytjikitjangku. Panya kuwari tjanpi kuranya ala lipiringu munu iluntanu nganampa ngurangka. Ka nganana kuwari putu ngurini mai putitja tjuta. Panya tjala, malu, kampurarpa, wiriny-wirinypa, ultukunpa, wangunu, kaltu-kaltu, arnguli, kurku munu punu putitja kutjupa tjuta kulu panya kuwari nganana putu ngurini munu nganampa tjulpuntjulpunpa munu inunytji kulu wiyaringu. Tjanpi kuranya warpungkula pulkaringkupai warungku kampanyangka munu kapingku puyinyangka. Ka nganana nyanga palunya ngalya katintja wiyatu panya tjanpi kura nyanga paluru panya witu-witu pulka mulapa. Ka nganana mukuringanyi alpamilantjaku nganampa ngura malangkungku wiru kanyintjaku.

Ka kuwari tjilpi pampa tjuta ulanyi ngura nyanga palumpa. Panya kuwari ngura pulka tjuta anganu tjanpi kuralu panya punu wiru tjuta pakantjitjangka. Panya nganana kuwari tjitji tjuta katintja wiyaringu putikutu panya tjanpi kuralu iwara patinu munu punu nganmanypa pakantja tjuta wiyanu. Ka nganampa tjitji tjutangku kuwari putu nyanganyi panya tjanpi kuralu uwankara patinu munu kuwari witu-witu pulka ngaranyi panya nganampa tjitji tjuta nintintjaku. Ka nganana nyanga palunya ngalya katintja wiyatu. Panya nganampa culture kuwari kurani, ka anangu tjuta kuwari tjituru-tjituru nyinanyi.

Ka nyanga palunya nganana mukuringanyi tjanpi kuranya alpamilantjaku. Munu tjanpi kura nyanga paluru anu ngura winkikutu, munu tjimitiringka tjarpangu, munu tjitji tjutaku inkapaingka kulu. Ka tjitji tjuta nganmanypa para-wirtjapakalpai pukulpa munu inkapai, ka kuwari wiyaringu. Ka tjanpi kura nyanga palula, liru tjarpapai munu kumpilpa ngaripai ka tjilpi pampa tjana kulu kulira nguluringkupai tjanpi kuralu anganyangka ka nganana nyanga palula- tjanalanguru pikatjararingkupai, ngaalytjararinganyi panya tjanpi kuralanguru warungku kampara pikantangkupai. Panya nganana tjanpi kura nyanga palunya ngalya katinytja wiyatu. Panya nganampa anangu tjuta kuwari nguluringanyi pikatjararingkutjakutawara Panya nganana mukuringanyi pulkara alpamilantjaku nganampa ngurangka.

Ka nganana kuwari pulkara mukuringanyi goverment uwankarangku ngananananya kulintjaku munu alpamilantjaku tjanpi kura nyanga palunya wiyantjaku. Panya nganana rawangku wangkangi tjanpi kura nyanga palunya palu mula-mulangku ngananananya kulintja wiyatu. Ka nganana nyanga palunya mula-mula wangkara palyantjaku ngaranyi, ngura nganampa, culture munu community kulu kunpu ngaranytjaku. Ka nganana mukuringanyi, govementu tjanpi kura nyangapalulanguru alpamilantjaku. Munu nganana kuwari mayatja pulka tjutangka tjapini nyanga palunya nyakuntjaku, panya kuwari kurani tjanpi kuralu nganampa ngurangka munu nganampa ngura pulka tjuta kulu. Nyanga palunya ngura nganampangka wiyantjaku.

Ka nganana Anangu tjuta tjunguringkula tjungungku palyanma tjanpi kura nyanga palunya wiyantjikitjangku. Panya warka pulka mulapa nyangatja ngaranyi tjanpi kuranya wiyanytjaku. Ka nganana mukuringanyi governmentu kulu ngananananya mula-mulangku pulkara alpamilantjaku.

DESERT INDIGENOUS PROTECTED AREAS RANGERS STATEMENT ON BUFFEL GRASS 2021 (UMUWA)

We the First Nations people of the desert did not bring Buffel grass to this land. But it is here and it is killing our country and threatening our communities and culture.

Buffel grass was brought to our country to feed cattle and keep down the dust. But it has spread across much of our land. It is choking our country. We can't get bushfoods where we used to. Honey ant, malu (kangaroo) and our native plants are getting harder to find. Our wildflowers are disappearing. The Buffel grows too fast and burns too often for our country. It's the first plant that grows after rain and fire. It is killing our country and while we didn't bring it here, we live with the consequences. We need support to get our healthy country back.

Older people mourn for the country that used to be. The plants and animals, the special and sacred places are covered in Buffel where once many native plants grew. We can't take our kids out to learn culture, the hunting tracks are covered and the plants that sustained us for thousands of years are disappearing. Our kids are growing up seeing only country with Buffel grass and it's getting harder to teach our kids the stories for this country. It is threatening our culture, we didn't bring it here and our people are suffering the consequences. We need support to keep our culture strong.

Buffel grass is all around our communities. It grows right up to our houses, in our backyards and front yards and our kids playgrounds. Kids can't run around like they used to. The Buffel hides snakes and makes it hard for our old people to get around safely. We can't escape it. We suffer health problems like asthma from the Buffel flowers and the smoke from the fires. Our homes and communities are at threat from fire from the Buffel grass. We didn't bring it here and our people are at risk. We need support to protect our communities.

We are calling on governments at all levels to recognise the impacts and the threats that Buffel grass has on we, the First Nations people of desert Australia. For too long we have been pushed to the side when making decisions about this tjanpi kura (bad grass). We need serious action taken to reduce this threat to our country, our culture and our communities. We need support from governments and people to help us manage this dangerous weed that is taking over the deserts. We call on Federal, State and Territory Governments to recognise the threat of Buffel grass to our country, our culture and communities and do what is needed to stop the march of this weed across our country.

We stand together with desert people across Australia calling for support on this problem. Buffel grass is a dangerous threat to us and we need to be resourced to manage it.

SUMMARY

Buffel grass has invaded vast areas of central Australia. This invasion is transforming ecosystems and causing massive biodiversity loss. Much more of mainland Australia is at risk of being invaded. People living in central Australia have been speaking about the ways this loss is impacting their health for many decades. This report summarises these impacts using 'ecosystem services' framework to describe the relationship between nature and humans in terms of culture, provision, regulation and support.

Cultural

Culture is a foundation of health. Cultural beliefs, values and practices deeply influence how humans interact with and perceive their natural surrounding while nature, in turn, shapes cultural development, knowledge and identity. This relationship is especially deep for First Nations people.

By overgrowing paths, suffocating and incinerating trees, plants, animals and sacred sites, buffel grass invasion interferes with, and sometimes destroys, First Nations peoples' ability to maintain and pass down culture. This has wide ranging negative impacts on social, mental and physical health.

Most cultures in the world are embedded in healthy ecosystems, people from a range of cultures that live in central Australia are also negatively impacted by buffel grass invasion. While there is some evidence that the small subculture related to pastoralism may experience some positive cultural attachment and therefore positive health impacts from buffel grass invasion, these are arguably based on false beliefs regarding the benefits of the grass.

Provisioning

Buffel grass destroys edible, medicinal and otherwise useful native plants, animals, soils and waterways.

This report describes how buffel grass invasion leads to health issues relating to food insecurity and malnutrition, undermines creative expression and the many health benefits associated with this, limits access to best practice health care and also exacerbates health issues related to water supply and the sustainable, accessible materials used for making tools and structures that are ultimate keys to survival in inland Australia.

While it is claimed buffel grass supports the supply of beef, both the value of this supply in terms of food security and whether buffel grass does actually support supply, is debatable given the grass's moderate (at best) nutritive value and tendency to form high fuel load monocultures, prone to rundown and susceptible to pests and diseases.

Regulating

Buffel grass invasion pollutes the air in central Australia and beyond with smoke, dust and highly allergenic pollen. This pollution can cross into bloodstreams and is associated with causing and exacerbating a range of serious and costly health issues that have an extremely high incidence in central Australia populations. Buffel grass increases the spread, intensity and frequency of fire and is associated with flooding. These disasters result in injury and serious mental health issues. Buffel grass invasion also increases greenhouse gas emissions and undermines our resilience and ability to adapt to a changing climate.

Supporting

Buffel grass interferes with the services that support all life – it's invasion negatively impacts soil, and changes water and nutrient cycling.

Summary

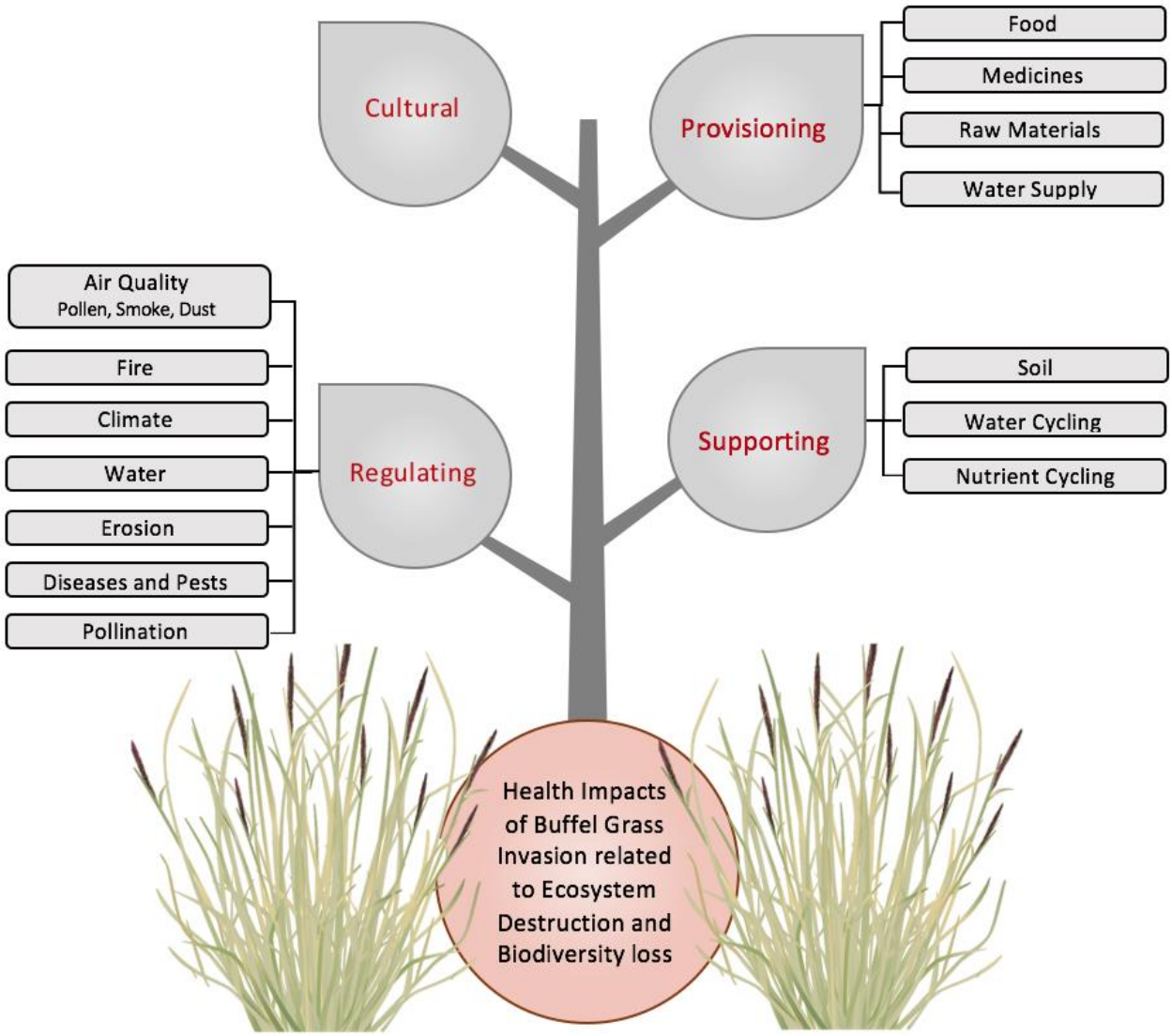
The human population of central Australia, especially First Nations peoples, people living in remote areas, and people who have low socio-economic status, already face an extremely high burden of diseases, many of which are exacerbated by buffel grass invasion. While the impacts of buffel grass invasion on this burden and the associated economic costs have not been measured, they are likely to be major.

In order to align with International, National and Territory declarations, agreements and plans, governments must abate the threat of buffel grass invasion through investment in focused research, policy, practice and advocacy.

Buffel grass poses an existential threat to the survival of this Country and it's peoples.

This report joins the rising voices of this Country in calling on academics, journalists, health professionals, policy makers and all those in positions of responsibility to immediately respond by:

1. Recognising buffel grass invasion as a major health threat
2. Calling for investment in independent research and management that prioritises public interests
3. Advocating that those in positions of power respond to this threat, including mobilising all legislative and regulatory mechanisms available
4. Demanding that health service provision, particularly environmental health services, focus on natural as well as built environments (infrastructure).


Cultural
Provisioning
Food
Medicines
Raw Materials
Water Supply
Air Quality
Pollen, Smoke, Dust
Fire
Climate
Water
Erosion
Diseases and Pests
Pollination
Regulating
Supporting
Soil
Water Cycling
Nutrient Cycling
Health Impacts of Buffel Grass Invasion related to Ecosystem Destruction and Biodiversity loss

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KEY TERMS

ATTRIBUTABLE BURDEN OF DISEASE: The reduction in fatal and non-fatal burden that would have occurred if exposure to the particular risk factor had been avoided / had been at its theoretical minimum[1].

BIODIVERSITY: Variability among living organisms. This includes diversity within and among species and diversity within and among ecosystems. Biodiversity is the source of many ecosystem goods, such as food and genetic resources, and changes in biodiversity can influence the supply of ecosystem services[2].

BUFFEL GRASS: Family: Poaceae; Species: Cenchrus ciliaris, Cenchrus pennisetiformis and other tall rhizomatous cultivars.

BURDEN OF DISEASE: Measurement of the impact of living with illness and injury and dying prematurely[3].

COMMUNITY FUNCTIONING: Term used by the *Australian Institute of Health and Welfare* (AIHW) defined as the ability and freedom of community members and communities to determine the context of their lives (for example, social, cultural, spiritual, and organisational) and to translate capabilities (knowledge, skills, and understanding) into action (to make things happen and achieve a life they value)[4].

COUNTRY: Term often used by First Nations peoples to describe the lands, waterways, seas, skies, animals and plants to which they are connected. The term contains complex ideas about law, place, custom, language, spiritual belief, cultural practice, material sustenance, family and identity[5].

> *"People talk about country in the same way that they would talk about a person: they speak to country, sing to country, visit country, worry about country, feel sorry for country, and long for country. People say that country knows, hears, smells, takes notice, takes care, is sorry or happy. Country is not a generalised or undifferentiated type of place, such as one might indicate with terms like 'spending a day in the country' or 'going up the country'. Rather, country is a living entity with a yesterday, today and tomorrow, with a consciousness, and a will toward life. Because of this richness, country is home, and peace; nourishment for body, mind, and spirit; heart's ease"* [6].

CULTURAL HERITAGE: Knowledge and lore, practices and people, objects and places that are valued, culturally meaningful and connected to identity and Country[7].

DESERTIFICATION: Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities[8].

DISABILITY ADJUSTED LIFE YEAR (DALY): Mortality does not give a complete picture of the burden of disease borne by individuals in different populations. The overall burden of disease is commonly assessed using the disability-adjusted life year (DALY), a time-based measure that combines years of life lost due to premature mortality (YLLs) and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability (YLDs). One DALY represents the loss of the equivalent of one year of full health[9].

ECOSYSTEM: Dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit[10].

ECOSYSTEM SERVICES: Benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual,

recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth[11].

FOOD SECURITY: According to the *UN Food and Agriculture Organisation*, food security exists "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"[12].

HEALTH: This paper reflects the *World Health Organisation* understanding of health as a state of 'physical, mental and social well-being and not merely the absence of disease or infirmity'[13]. In keeping with the *Millennium Ecosystem Assessment: Ecosystems and Human Well-Being* report, it is assumed health has:

> "multiple constituents, including the basic material for a good life, such as secure and adequate livelihoods, enough food at all times, shelter, clothing, and access to goods; health, including feeling well and having a healthy physical environment, such as clean air and access to clean water; good social relations, including social cohesion, mutual respect, and the ability to help others and provide for children; security, including secure access to natural and other resources, personal safety, and security from natural and human-made disasters; and freedom of choice and action, including the opportunity to achieve what an individual values doing and being."[14]

This holistic view of health is reflected in the definition of health presented in the *National Aboriginal and Torres Strait Islander Health Plan*:

> "'Aboriginal health' means not just the physical wellbeing of an individual but refers to the social, emotional and cultural wellbeing of the whole Community in which each individual is able to achieve their full potential as a human being, thereby bringing about the total wellbeing of their Community. It is a whole-of- life view and includes the cyclical concept of life-death-life."

This is reflected in a definition given by senior Eastern Arrernte woman Veronica Dobson[15]:

> *"For Aboriginal people health is not just the physical wellbeing but the social, emotional, spiritual and cultural wellbeing of the whole community.*
>
> *Five key factors have been identified in measuring Indigenous people's wellbeing*
>
> 1. *strong language and culture*
> 2. *connection and access to country*
> 3. *strong community connections*
> 4. *strong family connections*
> 5. *strong identity"*

The positive associations of health, education and employment outcomes as well as general wellbeing with languages and culture are supported by a wealth of evidence[16].

INTRODUCTION

MOTIVATION

This paper is written in response to :

- The authors first-hand experience witnessing the country where she was born, raised and resides being invaded by buffel grass
- The *Umuwa Statement*, which succinctly communicates the serious impacts of buffel grass invasion on people's health and which calls for recognition and action
- A conversation with a senior central Arrernte custodian who highlighted that in the current political context there is often a demand that First Nations' knowledge regarding the association between the health of country and human health be supported by western knowledge systems / evidence

PURPOSE

The paper seeks to demonstrate that to improve health, reduce health inequities, and reduce health care costs in central Australia health services providers must listen to First Nations peoples and heed calls for support against the threat of buffel grass invasion. Services must align their policies and practices with international, national and Territory declarations, agreements, strategies and plans and significantly invest in focused research, policy, practice and advocacy.

BUFFEL GRASS

Buffel grass is a perennial tussock grass native to parts of Africa, the Middle East and India. It is widely planted to feed cattle and in attempt to bind soils eroded by industrial processes[17]. Buffel grass continues to spread far beyond planted areas and now dominates many landscapes across central Australia.

Buffel grass invasion causes catastrophic biodiversity loss and ecosystem destruction[18]. Through a multitude of processes buffel grass transforms complex and diverse ecosystems into buffel grass monocultures. This can result in desertification [19,20].

Buffel grass:

- Invades diverse environments including grasslands, riparian zones, sand plains and rocky outcrops, displacing native grasses and small plants[21].
- Dominates light and space, reducing opportunities for native vegetation, including trees, to establish.
- Reduces soil nitrogen and exhausts the mineral pool, preventing growth through allelopathic suppression. [22 23]
- Has an extremely high fuel load and rapidly regrows after fire. Buffel grass causes very hot, widespread, frequent fires[24] which consume large amounts of biomass, alter soil properties, and substantially impact key ecosystem processes, influencing hydrological and biochemical cycles[25 26 27].
- Can erode soils by changing surface wind velocities [28] and water flows[29 30 31 32 33].
- In waterholes, rivers and floodplains changes surface water flows and severely damages aquatic ecosystems.[34] Buffel grass replaces riparian vegetation which affects bank stability, impairs ecosystem function, replaces traditional plants and creates conditions susceptible to fire[35].

Introduction

Natural environments are a major determinant of human health[36 37]. Healthy ecosystems, which include the atmosphere, land, water and diversity of all living things, provide the fluid, food, medicines, connections and relationships that underpin the physical, social and mental health and wellbeing of humans[38 39].

Buffel grass is recognised as the greatest invasive threat to country and culture across the arid lands of central Australia[40]. First Nations peoples have been speaking about this threat for a long time. Many powerful statements have been made. One of these statements is *The Desert Indigenous Protected Areas Rangers Statement on Buffel Grass* known as the *Umuwa Statement*. The *Umuwa Statement* was developed by Traditional Owners and rangers of the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands at Umuwa community in 2021. The Statement was presented by the APY Warru Rangers to the Indigenous Desert Alliance Conference in November 2022, where it received unanimous support. The statement has been published with the hope that the message would be "spread far and wide" and "galvanise environmental groups and governments across the country to step up their efforts against the insidious threat of buffel grass"[41].

METHODOLOGY

This paper aims to identify the breadth of evidence available on the health impacts of buffel grass invasion in central Australia. The aim of this review is to contribute to policy making and be a pre-cursor to a systematic review and inform further primary research.

Limitations

There is little primary research specifically on the health impacts of buffel grass conducted anywhere, let alone in central Australia.

FRAMEWORK

This paper described the relationship between human health and ecosystem and biodiversity loss caused by buffel grass invasion in the following sections. These are based on the 'ecosystem services' framework as described in the Millennium Ecosystem Assessment[42], a major assessment of the human impact on the environment, called for by the United Nations. Ecosystem services are categorised as follows:

A. Cultural - 'experiential and intangible services', which are derived from the existence or function of ecosystems, and which provide a cultural benefit e.g. identity and knowledge systems.
B. Provisioning - those providing a benefit through harvesting or extracting products from nature e.g. food and water.
C. Regulating - those arising from the ability of ecosystems to regulate biological processes and maintain environmental conditions via these processes e.g. clean air and moderating extreme events.
D. Supporting – helps to maintain biodiversity[43].

Each section of this paper attempts to describe the evidence for the impact of buffel grass invasion on the service, health impacts, burden of disease and economic impacts related to health. Apparent knowledge gaps, of which there are many, are identified throughout.

Cultural, provisioning, and regulating services are discussed in the main body of this paper. They are generally presented in four subsections:

1. Impacts of buffel grass invasion on the ecosystem service
2. Consequences for health

3. Associated burden of disease
4. Economic impacts related to health impacts. Given the impact of employment on health[44], employment impacts are also noted.

Limitations

Ecosystem service frameworks are largely a product and function of Western concepts and research[45 46]. Attempts to apply Western-based valuation methods to Aboriginal communities have the potential to harm and further disadvantage[47].

ATTRIBUTING BURDEN OF DISEASE TO RISK FACTORS ASSOCIATED WITH BUFFEL GRASS INVASION

The main reference for this report is the *2018 Australia Institute of Health and Welfare Burden of Disease Study.* 2018 is the latest year for which Australian burden of disease estimates are available at a subnational level for First Nations, remoteness area and socio-economic group.

2024 national burden of disease results have also been included however they are not compared to the 2018 results as they were arrived at using a different methodology[48].

Data on attributable risks from this source are limited to:

- Physical inactivity
- Dietary risks
- Obesity
- Air pollution.

The risk factors included met the following criteria:

- have strong evidence of causal association
- are modifiable
- can be measured in the Indigenous Australian population.

Limitations

It should be noted that results from studies indicate there is a considerable under-diagnosis of preventable chronic diseases in First Nations communities[49].

There is no data specifically linked to buffel grass invasion.

1. CULTURAL

The Millennium Ecosystem Assessment defines cultural ecosystem services as the "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences"[50].

Ecosystems transformation has profound impacts on social identity/sense of place[51].

THE MULTICULTURAL CONTEXT OF CENTRAL AUSTRALIA

Buffel grass has long been framed as a 'conflict species' in central Australia, as a species that provides positive benefits to some sectors, but imposes negative impacts on other sectors or the community[52] [53]. Different management priorities and techniques (e.g. use of herbicides) can also raise conflict.

The campaign to have buffel grass declared a weed in the Northern Territory suggests the battle against buffel grass invasion is unifying for many of the subcultures that reside in central Australia. For example, an open letter in support of weed declaration garnered support from more than 50 companies and organisations from a variety of industries and sub-cultures, including health organisations[54]. Numerous well-attended events highlighting the problems associated with buffel grass invasion also occurred in the lead up to buffel weed declaration.

First Nations Culture and Other Cultures

This division attempts to recognise the deep connection that First National peoples have to specific ecosystems and species that constitute biodiversity while also recognising that other cultures which occupy central Australia are still connected to buffel grass in demonstrable ways.

The impacts of buffel grass on culture related to food, medicine and raw materials are discussed in *Section 2 - Provisioning.*

Pastoralists and Other

Many of the subcultures at play are insular[55] and exclusionary[56], yet they play a critical role in the maintenance of a wider colonial sense of identity, place and claims on legitimacy and country[57].

Limitations

The author of this paper recognises that the stratifications used in this section are binary and simplistic.

1.1. FIRST NATIONS

IMPACTS OF BUFFEL GRASS INVASION

Many First Nations owners, custodians and community members from across central Australia have been speaking out strongly about the impacts of buffel grass invasion on culture for many decades. Example statements and testimonies include:

Cultural

KAWAKI PUNCH TESTIMONY

Kawaki Punch, a senior Pitjantjatjara man, describes the impact of buffel grass on cultural heritage:

> *"Buffel grass is not part of our heritage and we do not recognize that plant. We don't like it. All our own plants are part of our heritage and history. We grew up with beautiful plants, edible plants, sweet smelling plants, useful plants.*
>
> *Now there is just this rubbishy plant everywhere we look. Everywhere we look from horizon to horizon, is this horrible ugly buffel grass. Where did it come from? It is not part of our heritage or our land…"*

DESERT INDIGENOUS PROTECTED AREA RANGERS STATEMENT ON BUFFEL GRASS

> *"We the First Nations people of the desert did not bring Buffel grass to this land. But it is here and it is killing our country and threatening our communities and culture. Older people mourn for the country that used to be. The plants and animals, the special and sacred places are covered in Buffel where once many native plants grew. We can't take our kids out to learn culture, the hunting tracks are covered and the plants that sustained us for thousands of years are disappearing. Our kids are growing up seeing only country with Buffel grass and it's getting harder to teach our kids the stories for this country. It is threatening our culture, we didn't bring it here and our people are suffering the consequences. We need support to keep our culture strong."*

These statements are reproduced in full in Appendix A.

PAT PERRURLE-ANSELL DODDS' POEM 'BUFFEL GRASS'[58]

Do you remember
when the old people used to
burn the country – just before the rain?
To help the bush foods fruit
and the seeds sprout.
Do you remember when we used to walk
barefoot down the street
of Alice Springs? We were bony kids
back then. Do you remember
jumping in the waterholes?
Full of water

It's too dry now.
The summer is too hot.
That buffel is everywhere.

A recent study comparing the perceived threats posed by six invasive species in central Australia suggests that buffel grass poses the greatest contemporary threat to social and cultural values [59].

CARING FOR COUNTRY

Caring for Country is a term used to describe a reciprocal relationship which encompasses diverse cultural activities on country [60] [61]. Buffel grass' interference with caring for country activities offers insight into how buffel grass impacts culture.

BOX 1 – EXAMPLE CARING FOR COUNTRY ACTIVITIES IMPACTED BY BUFFEL GRASS INVASION	
Activity	Impact
Cultural burning - cultural burning has been described as 'right fire, right time, right way and for the right (cultural reasons) according to lore[62]. Some reasons for burning are cleansing, regeneration and hunting.	Due to its distribution, high fuel loads, extreme burning temperature and positive response to fire, buffel grass invasion makes it increasingly difficult to conduct cultural burning[63].
Letting country know you are there	Buffel grass impedes access to country by over-growing way markers, paths and sites[64] As Margaret Scobie a senior Anmatyerr woman states: *"Buffel is the new wave of colonial invasion, and is stopping us going on country, buffel is hiding what our ancestors left for us"[65].*
Teaching a new generation on country Example activity – Transmission of languages. Language is a foundation for learning and interaction[66] [67]. A lot of language is connected to ecosystems and biodiversity. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) states that: *"inseparable from Indigenous cultures, Indigenous languages – which embody the intrinsic relation between culture and nature – are equally threatened…The loss of access to land, territories, and natural resources – notably related to the insufficient regulation of collective ownership and use of Indigenous lands – has severely impacted Indigenous cultures and identities, which are deeply related to their natural and human environment. The major gap in life expectancy – which is some 20 years lower for Indigenous people worldwide – further testifies to the risk of cultural extinction."*	When biodiversity and ecosystems are lost under buffel grass the source of knowledge accumulated dissipates. The impact of buffel grass invasion on this connection is described by Camille Dobson, an Eastern Arrernte Woman and senior project manager at the Centre for Australian Languages and Linguistics: *"not only is the buffel affecting the environment it's also affecting our language and our culture because things that we don't see any more in our environment people don't talk about so all those words in our language are disappearing…things that are really important, really central to us being Arrernte are also disappearing because of this invasive weed"[68].*

CONSEQUENCES FOR HEALTH

The strong connection between culture and health for First Nations peoples is well recognised.

The *National Aboriginal and Torres Strait Islander Health Plan 2021-2031* states:

> "Culture is a foundation for Aboriginal and Torres Strait Islander health and wellbeing. It is a protective factor across the life course, and has a direct influence on broader social determinants outcomes."[69.]

Cultural

> "The cultural determinants of health are the protective factors that enhance resilience, strengthen identity and support good health and wellbeing. These include, but are not limited to, connection to Country; family, kinship and community; beliefs and knowledge; cultural expression and continuity; language; self-determination and leadership." [70]

The *Australian Institute of Health and Welfare* also recognises "cultural identity and participation in cultural activities, access to traditional lands along with connection to family and kinship, as protective factors and can positively influence overall health and wellbeing"[71].

The *Australian State of the Environment Report 2021* recognises that deep relationships to country and past loss of culture through disconnection from country is the evident cause of many of the negative health and wellbeing outcomes Aboriginal peoples have experienced since colonisation began[72].

Owners, custodians and community members across central Australia have spoken out strongly about how buffel grass invasion impacts on culture has affected the health of people and communities. An example testimony:

KAWAKI PUNCH THOMPSON TESTIMONY

Emphasis in bold added to highlight comments directly related to human health impacts. This statement is reproduced in full in Appendix A.

> *"We used to have so many beautiful smelling plants and flowers. Today there are very few to be seen. Because of Buffel grass.* ***This makes us feel sick inside, just the thought of it****."*
> *"How can our animals live on this awful grass? They know nothing of it. They are suffering now.* ***This makes me suffer, just thinking about our poor animals. I am sick inside at the thought*** *of them suffering and slowly starving to death.*
>
> ***Tjiturutjituru. Sad. That is me. I am tjiturutjituru trying to live amongst this ugly plant, but it is hardly possible to move through and I don't like being near it.***
>
> *I see the encroachment of this ugly grass as very similar to what is happening to our lives.* ***Our family members and our extended family members are all becoming suffocated by outside forces in just the same way that this grass is suffocating our lands. Our bodies are suffering with unknown new diseases, and we all have diabetes and renal failure, hypertension and other sicknesses I have no name for. In the same way I have no name for the new weeds that have come into our lives.***
>
> *…****What is to become of us? Will we all wither and die underneath this grass, and these people, and become yet another extinct species****?"*

VERONICA DOBSON TESTIMONY

Veronica Dobson is an Eastern Arrernte Elder, linguist and ecologist. She states:

> *"For Arrernte people everything is connected, through skin and kin. Everything is related. Recently we have been struggling to keep our connections.*
>
> *We are losing plants and animals that are important to us, and the words for those plants are being lost from our language.*

Many of our sacred sites and waters are no longer accessible, we can no longer care for them, buffel is breaking our connection to our cultural obligations to the ancestors.

Buffel is hurting Arrernte peoples' spirit.

We call buffel grass "name arrwengkwelthe" which means grass disease. It's spreading like a disease and causing harm to our people"[73].

SOCIAL AND EMOTIONAL WELLBEING

Cultural activities connected to country have been linked to a broad range of benefits that positively impact the health social and emotional wellbeing of First Nations peoples and wider Australian society[74 75 76 77].

One study of almost 300 adults in central Arnhem Land found that participation in caring for country was associated with greater autonomy, identity, self-esteem and hope[78].

Cultural connection also heals and rehabilitates[79 80 81].

MENTAL HEALTH

Research based on data from the *2002 National Aboriginal and Torres Strait Islander Social Survey* found strong identification of Aboriginal persons with traditional culture is associated with better mental health[82].

A study of almost 300 adults in central Arnhem Land[83] found that participation in caring for country was associated with:

- Greatly increased social and emotional wellbeing through healthy lifestyles[84 85 86].
- Achieving a sense of autonomy - moving people from being looked after, to looking after others, including country. When this is not possible people are likely to become frustrated. This frustration may be expressed through substance abuse and violence.
- Identity, self-esteem and hope were articulated by Aboriginal people as perhaps the greatest benefit of caring for country.

The *Australian Institute of Health and Welfare (AIHW)* reports that Indigenous Australians who visit their homelands or traditional country are more likely to self-assess their own health as excellent/very good/good (75%) than those who could not visit their homelands or traditional country (47%)[87].

CHRONIC DISEASE

Studies from Central Australia and the Northern Territory have linked caring for country to:

- lower risk and occurrence of chronic disease including diabetes, kidney disease and cardiovascular disease
- greatly increased physical health through healthy lifestyles[88 89 90]

PHYSICAL ACTIVITY

A strong link has been found between cultural activities on country and increased levels of physical activity,[91, 92, 93] which is crucial in maintaining good overall health[94]. Physical inactivity has been causally linked to the burden from type 2 diabetes, bowel cancer, dementia, coronary heart disease and stroke, as well as uterine and breast cancer in females[95].

ATTRIBUTABLE BURDEN OF DISEASE

The burden of disease related to impacts on culture associated with buffel grass invasion in central Australia has not been measured.

Northern Territorians , First Nations peoples, those living in remote areas and socio-economically disadvantaged people have a much higher burden of health issues that are related to the impacts of buffel grass on culture - see *Appendix B Table 1 Mental Health and Chronic Diseases and Table 2 Physical Activity* for details.

Mayi Kuwayu is a major new study of Aboriginal and Torres Strait Islander wellbeing that aims to provide more evidence of how culture is related to Aboriginal and Torres Strait Islander people's health[96].

HEALTH ECONOMIC IMPACTS

There are no specific reports on the health economics of buffel grass invasion related to impacts on culture. These are likely to be significant given the enormous costs of related diseases and the disproportionate burden of disease born by First Nations peoples (see *Appendix 2 Table 1 Mental Health and Chronic Disease and Table 2 Physical Activity*).

Potential methods for measuring the costs and benefits of buffel grass invasion on culture have been suggested, for example:

- a 2017 study conducted in Australia's Northern Savannah used an 'Indigenous specific framework' that included socio-cultural, capabilities-related and other wellbeing benefits for people 'being on country'. Benefits were valued by applying conventional Basic Value Transfer (BVT), and wellbeing approaches[97].

ECONOMIC IMPACTS RELATED TO CARING FOR COUNTRY

A 2011 literature review conducted by the Australian Institute for Aboriginal and Torres Strait Islander Studies on the benefits of caring for country found that caring for country leads to significant cost savings in health[98].

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE
UN resolution A/76/L.75) 'The human right to a clean, healthy and sustainable environment'[99]	The UN General Assembly (UNGA) resolution recognising the right to a clean, healthy, and sustainable environment as a hum right. The UNGA calls upon States, international organisations, businesses, and all other stakeholders to "scale up efforts" to ensure a clean, healthy, and sustainable environment for all.
UN Declaration on the Rights of Indigenous Peoples[100]	The declaration includes the following related rights: • Self-determination • Individual and collective rights • Freedom from assimilation and destruction of culture • Understanding of lore, law and traditional responsibilities • Connection to, custodianship and utilisation of Country and traditional land

	• Reclamation, revitalisation, preservation and promotion of language and cultural practices • Protection and promotion of Traditional Knowledge and Indigenous Intellectual Property.
Convention on Biological Diversity (1992)[101].	Recognises the essential link between biodiversity and human health. The objectives are "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources".
UNESCO 2001 Universal Declaration on Cultural Diversity[102]	Article 1 – Cultural diversity: the common heritage of humanity As a source of exchange, innovation and creativity, cultural diversity is as necessary for humankind as biodiversity is for nature. Article 3 – Cultural diversity as a factor in development Cultural diversity widens the range of options open to everyone; it is one of the roots of development, understood not simply in terms of economic growth, but also as a means to achieve a more satisfactory intellectual, emotional, moral and spiritual existence.
UN Global Assessment Report on Disaster Risk Reduction 2022 (GAR)[103]	To accelerate essential risk reduction and resilience building, GAR2022 calls for action to: 1. Measure what we value. 2. Design systems to factor in how human minds make decisions about risk. 3. Reconfigure governance and financial systems to work across silos and design in consultation with affected people.
GAR Special Report 2023: Mapping resilience for the Sustainable Development Goals [104]	Resilience deficit 5. Increased land degradation and biodiversity loss.

NATIONAL

DOCUMENT	GUIDANCE
National Agreement on Closing the Gap[105]	Outcome area 15: Aboriginal and Torres Strait Islander people maintain a distinctive cultural, spiritual, physical and economic relationship with their land and waters • Target A: By 2030, a 15% increase in Australia's land mass subject to Aboriginal and Torres Strait Islander people's legal rights or interests (from 3,908,387 square kilometres in 2020 to 4,498,431 square kilometres by 2030). • *Status: As at 30 June 2022, 4,138,356 square kilometres of the land mass of Australia were subject to Aboriginal and Torres Strait Islander people's rights or interests. This is higher than the target trajectory of 4,026,396 square kilometres.* • Target B: By 2030, a 15% increase in areas covered by Aboriginal and Torres Strait Islander people's legal rights or interests in the sea (from 90,252 square kilometres in 2020 to 103,790 square kilometres by 2030). • *Status: As at 30 June 2022, 91,111 square kilometres of the sea country of Australia were subject to Aboriginal and Torres Strait Islander people's rights*

DOCUMENT	GUIDANCE
	or interests. This is lower than the target trajectory of 92,960 square kilometres. Outcome area 16: Aboriginal and Torres Strait Islander cultures and languages are strong, supported and flourishing • Target: By 2031, there is a sustained increase in number and strength of Aboriginal and Torres Strait Islander languages being spoken (from 123 languages spoken, with 14 considered strong, in 2018–19 to 124 languages spoken, with 15 considered strong, by 2030–31). • *Status: Progress towards this target could not be assessed because there were no new data on Aboriginal and Torres Strait Islander languages being spoken since the baseline year of 2018-19.*
National Preventive Health Strategy 2021–2030[106]	Two of the seven priority areas for action are: • Promoting and protecting mental health • Increasing physical activity.
The National Aboriginal and Torres Strait Islander Health Plan 2021 – 2031[107]	The Plan is based on the understanding that: "Culture is a foundation for Aboriginal and Torres Strait Islander health and wellbeing. It is a protective factor across the life course, and has a direct influence on broader social determinants outcomes. Gains across these broader determinants, in turn, reinforce cultural connectedness, maintenance, resurgence, nation building and pride in cultural identity"[108] Priority 4: Health Promotion "Health promotion, literacy and prevention approaches recognise culture as a protective factor and prioritise strategies that drive improved outcomes across the cultural determinants and social determinants of health." Priority 6: Social and emotional wellbeing and trauma-aware, healing-informed approaches "Breaking the cycle of intergenerational trauma requires more than just acknowledging historical, social and political determinants. Strategies must also orient responses around healing. This will require strengths-based, holistic responses, with positive messaging grounded in culture's protective influence on Aboriginal and Torres Strait Islander social and emotional wellbeing".
National Strategic Framework for Aboriginal and Torres Strait Islander Peoples' Mental Health and Social and Emotional Wellbeing 2017–2023 [109]	1. Aboriginal and Torres Strait Islander health is viewed in a holistic context that encompasses mental health and physical, cultural and spiritual health. Land is central to wellbeing. Crucially, it must be understood that when the harmony of these interrelations is disrupted, Aboriginal and Torres Strait Islander ill health will persist. 2. Self-determination is central to the provision of Aboriginal and Torres Strait Islander health services. 3. Culturally valid understandings must shape the provision of services and must guide assessment, care and management of Aboriginal and Torres Strait Islander people's health problems generally, and mental health problems, in particular. 4. It must be recognised that the experiences of trauma and loss, present since European invasion, are a direct outcome of the disruption to cultural

Cultural

DOCUMENT	GUIDANCE
	wellbeing. Trauma and loss of this magnitude continues to have inter-generational effects. 5. The human rights of Aboriginal and Torres Strait Islander people must be recognised and respected. Failure to respect these human rights constitutes continuous disruption to mental health. Human rights relevant to mental illness must be specifically addressed. 6. Racism, stigma, environmental adversity and social disadvantage constitute ongoing stressors and have negative impacts on Aboriginal and Torres Strait Islander peoples' mental health and wellbeing. 7. The centrality of Aboriginal and Torres Strait Islander family and kinship must be recognised as well as the broader concepts of family and the bonds of reciprocal affection, responsibility and sharing. 8. There is no single Aboriginal or Torres Strait Islander culture or group, but numerous groupings, languages, kinships, and tribes, as well as ways of living. Furthermore, Aboriginal and Torres Strait Islander people may currently live in urban, rural or remote settings, in traditional or other lifestyles, and frequently move between these ways of living. 9. It must be recognised that Aboriginal and Torres Strait Islander people have great strengths, creativity and endurance and a deep understanding of the relationships between human beings and their environment.

TERRITORY

DOCUMENT	GUIDANCE
Northern Territory Health Aboriginal Cultural Security Framework 2016-2026[110]	The Framework is grounded in: "Recognising the centrality of culture to health and respecting Aboriginal people and cultures is necessary to enhance service access, equity and effectiveness. Cultural security is fundamental to improving health outcomes for Aboriginal Territorians and supporting healthy communities." Domain 1: Workforce Priority Action Area 3. Ensure NT Health staff are trained and culturally responsive. Domain 6: Quality improvement, planning, research and evaluation. Identify data requirements and sources…and research in relation to cultural security.
The Best Opportunities in Life: Northern Territory Child and Adolescent Health and Wellbeing Plan 2018–2028[111]	Vision includes: "Health begins where we are born, live learn and grow" The 10-year action plan for child and youth health includes a focus on: · promoting and protecting those factors that enable children and young people to develop well. · preventing and attending to those factors that can adversely affect and challenge healthy development and resilience. The five themes for this Plan that 'speak to what we want for our children and young people' include: 1. Children and young people are provided the best opportunities in life. 2. There are healthy, safe and sustainable communities and places.

	4. Health equity, especially for Aboriginal children and young people is increasing. Feedback from young people documented in this Plan includes: · Keep culture strong.
NT Mental Health Strategic Plan 2019-2025	Priority Area 2; Culturally secure, safe and trauma informed care focussed on recovery Person, family and community-centred treatment, care and support will be demonstrated by: · Acknowledging the range of influences that affect a person, family and community's mental health and wellbeing. · Creating environments that enable people to direct their own lives and meet the needs and priorities that they have identified. *Note: there is no mention of culture or country in social determinants of mental health except in images (p.27).*

OTHER RELATED STRATEGIES INCLUDE:

- 2013 National Aboriginal and Torres Strait Islander Suicide Prevention Strategy - requires its implementation to be in alignment with the principles of the National Strategic Framework for Aboriginal and Torres Strait Islander Peoples' Mental Health and Social and Emotional Wellbeing 2017-2023[112]
- NT Chronic Conditions, Prevention and Management Strategy 2010-2020
- NT Department of Health Stakeholder Engagement Framework, 2012
- NT Aboriginal Health Forum: Pathway to Community Control Framework
- NT Indigenous Employment and Career Development Strategy 2015-2020
- Territorians as Partners in Healthcare – Consumer and Community Participation Policy

1.2. PASTORALISTS

IMPACTS OF BUFFEL GRASS INVASION

Sociologists have described pastoralists as a subculture with a strong sense of identity and social cohesion[113] [114].

Buffel grass was planted and spread to support the pastoral industry - to provide pasture and mitigate the soil erosion caused by pastoral activity.

The pastoralist subculture is part of a wider settler colonial identity that is embedded in ideas of cultural superiority, entitlement and dominance over country in which buffel grass is a tool to transform and thereby 'improve', 'develop', 'render productive', 'remediate' and 'rehabilitate' land[115].

A 2011 study on pastoralists' attitudes to buffel grass, which included pastoralists from central Australia, found that pastoralists were highly dependent upon buffel grass in terms of their levels of attachment, attachment to place, financial dependency, environmental attitudes and the influence of their networks[116].

Pastoralists' rating of buffel grass as a pasture seems to be arrived at by 'popular opinion' rather than through any type of reliable observational study[117].

Cultural

Some pastoralists have expressed negative emotions related to recent fires in central Australia. However, there is an apparent disconnect (refusal to acknowledge, or at least minimise) the role of buffel grass in fuelling these fires[118].

Likewise industry reports on the serious limitations of buffel grass as a pasture (that warn a possible 50% loss in productivity in 10-20 years in some cases) are ignored[119] [120] [121].

CONSEQUENCES FOR HEALTH

A 2011 study on pastoralists' attitudes to buffel grass found that overall the level of positive attachment to buffel grass was high, and that the mean level of interest in environmental costs was low - 80% of pastoralists thought that, "there is no need to worry about buffel grass from an environmental point of view and most (76%) saw that 'the best thing about buffel grass is that I do not have to worry about it"[122].

The same study found that buffel grass provided pastoralists with a sense of self-efficacy and confidence in the future - 72% of pastoralists believed that they, "need buffel grass to maintain [their] business" and 73% perceived that "any reduced amount of buffel grass on my land would be risky[123]."

For some pastoralists buffel grass is an existential issue – and buffel grass is given as a key reason why pastoralism has been able to survive in the region" [124] .

The positive health benefit linked to security can be viewed as problematic given the difference in perceived vs real security offered by buffel grass as a 'future proofing' strategy given the risk of catastrophic fires (see section 3.2), climate change (see section 3.3) surface water (see section 3.4) and the issues outlined below:

BOX 2 - DOES BUFFEL GRASS INCREASE PRODUCTIVITY AND RESILIENCE OF THE PASTORAL INDUSTRY?	
Positives	Negatives
• Grows rapidly under certain conditions[125] • Extensive root system can withstand trampling and heavy grazing by stock[126] • More drought tolerant than some other introduced pasture grasses[127]	• Palatability = moderate (at best)[128] • Nutritive value = moderate (at best)[129] • Quality decreases significantly during drought[130] • Increases frequency and intensity of fires - can significantly increase risk of stock losses through fire • Can cause oxalate poisoning in stock[131] • In some soil types can accumulate levels of selenium that are dangerously high for stock[132] • Susceptible to pests and diseases such as pasture dieback[133,134] • Over time can get 'rundown' - within 20 years pasture production and animal live weight gain can reduce by as much as 50%[135,136]

Cultural

Changes to pastoral lease ownership (while official data is not available there seems to be a trend towards transnational corporate ownership and short-term ownership[137]) may have altered the cultural identity of pastoralism and it's attachment to buffel grass. This warrants further exploration.

ATTRIBUTABLE BURDEN OF DISEASE

No studies could be found on the general health status of pastoralists in central Australia though some published papers suggest farmers / pastoralists may on average experience a higher burden of mental health problems than the general public[138].

HEALTH ECONOMIC IMPACTS

There are no specific reports on the health economics of buffel grass invasion related to impacts on pastoralist culture.

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

See Section 1.3

1.3 OTHER CULTURES CONNECTED TO NATURE

A 2023 study of Alice Spring and Central region which asked questions about people's wellbeing and their connections found that over half of Alice Springs respondents scored the importance of being close to country very highly (9 or 10 on a scale of 0 to 10) with an average of 8 out of 10. Comments provided in response to open text questions suggest some of these positive feeling for the natural environment came from a deep connection to being on country, an appreciation of the landscape or through the experience of having lived on farming land (*NB: > 18 years n=3000, 91.6% of respondents were non-Indigenous, almost quarter were born overseas)*[139].

IMPACTS OF BUFFEL GRASS INVASION

The ecosystem destruction and biodiversity loss caused by buffel grass invasion negatively impacts a wide range of subcultures that are tied to healthy, intact ecosystems.

The impacts of buffel grass invasion on these cultures in central Australia have been clearly expressed and well documented in paintings, poetry and photography, in films, news articles and across social media platforms and public events[140] [141] [142] [143] [144].

CONSEQUENCES FOR HEALTH

The understanding that nature and human health and healing are inextricably connected is embedded in health discourses and practices throughout human history and across cultures [145] [146] [147] [148] [149] [150].

SOCIAL AND EMOTIONAL WELLBEING

Natural environments are associated with social skills and behaviours[151] [152].

Individual and group actions to manage buffel grass can have positive impacts as far as providing opportunities for social contact, group physical activity and time spent immersed in, and having a positive, caring relationship with natural environments.

However, wider failure to manage buffel grass can exacerbate feelings of injustice, powerlessness, frustration, and hopelessness. Hopelessness is often encouraged through common statements such as "There's no point going up against pastoral industry interests – they are too powerful" and "it's too late to manage the invasion – buffel grass is too far spread and there is no effective way to manage it at a landscape level " when little to no attempt has been made to research and develop management and the grass is still being deliberately planted and spread. Hope is an important determinant of health[153].

MENTAL HEALTH

Healthy natural environments are associated with overall happiness and perceived well-being benefits[154] as well as self-esteem, self-efficacy, resilience, academic and cognitive performance[155,156].

Studies have found that the destruction of ecosystems and biodiversity loss can cause serious mental health issues[157, 158, 159, 160, 161, 162], including 'psychoterratic' syndromes arising from negatively felt and perceived environmental change[163]. These effects may be due to both biophysiological and psychological mechanisms.

PHYSICAL HEALTH

Improved cognitive function, brain activity, blood pressure, and sleep[164].

Reduced contact with natural environments may pose a largely unappreciated risk to human health, particularly in children, through declining normal (healthy) immunomodulatory environmental exposures[165].

PHYSICAL ACTIVITY

Physical activity is essential for good health[166].

Many cultures that now reside in central Australia are attached to participation in nature based physical activities[167]. Exercising within a natural environment has proven to be extremely beneficial to human health; 'green exercise' leads to positive health outcomes, fosters social bonds, increases environmental knowledge and can influence behavioural patterns[168].

Buffel grass overgrows paths and objects associated with physical activity and creates fire risk, preventing access to a range of culturally embedded modes of physical activity such as walking and running, mountain biking, hiking, camping, and observing native plants and animals.

ATTRIBUTABLE BURDEN OF DISEASE

The burden of disease related to impacts on different subcultures within central Australia has not been measured. Given buffel grass' relationship to many chronic diseases it can be hypothesised that the attributable burden of disease may be significant.

HEALTH ECONOMIC IMPACTS

There are no specific reports on the health economics of buffel grass invasion related to impacts on culture. Given the high costs of many of the negative health states can be related to buffel grass invasion it can be hypothesised that the costs may be very high.

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE
UN resolution A/76/L.75) 'The human right to a clean, healthy and sustainable environment'[169]	The UN General Assembly (UNGA) resolution recognising the right to a clean, healthy, and sustainable environment as a human right. The UNGA calls upon states, international organizations, businesses, and other stakeholders to "scale up efforts" to ensure a clean, healthy, and sustainable environment for all.
Convention on Biological Diversity (1992)[170].	Recognises the essential link between biodiversity and human health. The objectives are "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources".
UNESCO 2001 Universal Declaration on Cultural Diversity[171]	Article 1 – Cultural diversity: the common heritage of humanity As a source of exchange, innovation and creativity, cultural diversity is as necessary for humankind as biodiversity is for nature. Article 3 – Cultural diversity as a factor in development Cultural diversity widens the range of options open to everyone; it is one of the roots of development, understood not simply in terms of economic growth, but also as a means to achieve a more satisfactory intellectual, emotional, moral and spiritual existence.
UN Global Assessment Report on Disaster Risk Reduction 2022 (GAR)[172]	To accelerate essential risk reduction and resilience building, GAR2022 calls for action to: 1. Measure what we value. 2. Design systems to factor in how human minds make decisions about risk. 3. Reconfigure governance and financial systems to work across silos and design in consultation with affected people.
GAR Special Report 2023: Mapping resilience for the Sustainable Development Goals [173]	Resilience deficit 5. Increased land degradation and biodiversity loss.

NATIONAL

DOCUMENT	GUIDANCE
National Preventive Health Strategy 2021–2030[174]	Two of the seven priority areas for action are: • Promoting and protecting mental health • Increasing physical activity.

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
The Best Opportunities in Life: Northern Territory Child and Adolescent Health and	Vision includes: "Health begins where we are born, live learn and grow" The 10-year action plan for child and youth health includes a focus on:

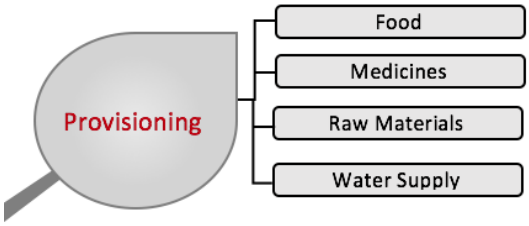
Wellbeing Plan 2018–2028[175]	· promoting and protecting those factors that enable children and young people to develop well. · preventing and attending to those factors that can adversely affect and challenge healthy development and resilience. The five themes for this Plan that 'speak to what we want for our children and young people' include: 1. Children and young people are provided the best opportunities in life. 2. There are healthy, safe and sustainable communities and places. 4. Health equity, especially for Aboriginal children and young people is increasing. Feedback from young people documented in this Plan includes: · Keep culture strong.
NT Mental Health Strategic Plan 2019-2025	Priority Area 2; Culturally secure, safe and trauma informed care focussed on recovery Person, family and community-centred treatment, care and support will be demonstrated by: · Acknowledging the range of influences that affect a person, family and community's mental health and wellbeing. · Creating environments that enable people to direct their own lives and meet the needs and priorities that they have identified. *Note: there is no mention of culture or country in social determinants of mental health except in images (p.27).*

OTHER RELATED STRATEGIES INCLUDE:

- NT Chronic Conditions, Prevention and Management Strategy 2010-2020
- NT Department of Health Stakeholder Engagement Framework, 2012
- Territorians as Partners in Healthcare – Consumer and Community Participation Policy.

2. PROVISIONING

Provisioning - those ecosystem services providing a benefit through harvesting or extracting products from nature.



2.1. FOOD

IS BUFFEL A CEREAL GRASS?

Some internet sites claim that in India buffel seeds may be harvested in order to make bread or to be eaten raw by humans, but the sources are dubious:

- *Feedipedia: animal feed resource information* - the original paper referenced to support this claim could not be found[176].
- *Purdue University 'Famine foods: plants that are not normally considered as crops but are used in times of famine'*[177] - the references used to support this cannot be found by the author. Peer reviewed published papers that reference these same sources do not mention Cenchrus ciliaris as among the cenchrus species eaten in times of famine[178].

Reliable publications on the subject of food in famine in areas where buffel grass is grown do not mention Cenchrus ciliaris [179].

BEEF

IMPACTS OF BUFFEL GRASS INVASION

Buffel grass was, and still is, planted and spread to support this single 'food service' industry.

PASTURE

Positive

Buffel grass is well regarded by some pastoralists because it grows rapidly and can withstand heavy grazing[180]. Its extensive root system and dense coverage can mitigate some forms of soil erosion that results from industrial activity, at least in the short term.[181]

Provisioning

Negative

The nutritive value of buffel grass is lower than other introduced pasture grasses and native grasses [182]. It is only moderately palatable and can cause oxalate poisoning in cows and horses. Buffel grass is susceptible to pests and diseases, most notably pasture dieback[183], has been noted to die off in extreme hot, dry periods and over time gets 'rundown'[184]. Buffel grass tends towards monoculture creation in many areas of central Australia, however it is well established that resilient, nutritious pastures need to be made up of a diversity of plants[185].

See also *Section 1.2 Box 1 - Does buffel grass increase productivity and resilience of the pastoral industry?*
For more on soil see Sections 3.2 Fire - Soil, 3.5 Erosion and 4.1 Soil Formation.

CONSEQUENCES FOR HEALTH

NUTRITION

While grass fed beef is a source of protein and provides other nutrients such as iodine, zinc, vitamins and essential fatty acids[186], diets high in beef contribute substantially to burden of chronic disease[187] [188]. For detailed data see *Appendix B Table 2 – Diet*.

The weekly consumption of red meat by Australians is estimated to be 24% higher on average than the maximum suggested by the Australian Dietary Guidelines[189] and is increasing[190].

FOOD SECURITY

Reports such as the *EAT-Lancet Commission for Healthy and Sustainable Food Systems*[191] and the *Intergovernmental Panel on Climate Change (IPCC) on Climate Change and Land*[192] which accord with UN Sustainable Development Goals (SDGs)[193] and the Paris Agreement[194], have called for the following as key action towards achieving healthy and sustainable food systems:

- A greater than 50% reduction in meat production and consumption.
- A 100% increase in consumption of fruits, vegetables, nuts and legumes.
- Access to local, diverse food sources.

Without these actions much of the population will increasingly suffer from malnutrition and preventable disease[195].

Industrial food systems, including beef production:

- Are leading contributors to the increasing health and environmental burdens experienced by human populations worldwide[196,197];
- Threaten climate stability and ecosystem resilience and constitutes the single largest driver of environmental degradation and transgression of planetary boundaries[198].

NATIVE EDIBLE PLANTS AND ANIMALS

IMPACTS OF BUFFEL GRASS INVASION

Central Australia's natural ecosystems support a large diversity of plants and animals that service a diverse and healthy diet[199]. Buffel grass drastically reduces, and in some situations eliminates, availability and access to these foods[200].

Buffel grass destroys local food sources through a multitude of processes including:

- Displacement of native grasses (grain) and small plants (fruits and seeds).[201]
- Reducing soil nitrogen and exhausting the mineral pool, preventing growth of plants through allelopathic suppression [202] [203].
- Causing very hot, widespread, frequent fires which:
    - Damage and destroy ground, mid and upper storey edible plants, seeds and soils[204].
    - Kill edible animals through incineration, starvation, dehydration and exposure[205].
    - Buffel grass also negatively impacts the use of fire by humans to promote, distribute and protect edible plant and animal communities[206].
- Changing surface water flows and severely damaging aquatic ecosystems and fringing (riparian) vegetation.[207]
- Destroying habitat, as such posing a catastrophic threat to native wildlife, including biotic pollinators (for more on pollinators see section 3.7 of this report)[208].

A study on key environmental and socio-cultural threats in central Australia[209] found buffel grass has:

- Massive socio-economic impacts stemming from permanent and irreversible disappearance of bush food for at least a decade.
- Major socio-economic impacts stemming from local disappearance of hunting from all or part of the affected area (though change likely reversible within a decade if buffel grass is controlled).

These findings are supported by other reports[210], statements[211] and testimonies[212,213, 214].

CONSEQUENCES FOR HEALTH

NUTRITION

Good nutrition contributes to quality of life, helps maintain healthy body weight, protects against infection, and reduces the risk of chronic conditions and premature death. Chronic conditions—often linked with a poor diet—are the major cause of ill health in Australia[215].

Central Australia's natural ecosystems include extremely diverse and healthy food sources. Many plants and meats are extremely rich in vitamins, minerals and antioxidants[216].

Traditional diets appears to have been low in energy density and high in nutrient density – high in protein, low in sugars, high in complex carbohydrate, and high in micronutrients[217].

At present Australians of all ages generally:

- Eat too much food that is high in energy density and low in nutrients;
- Do not eat enough vegetables or fruit;
- Eat too much sugar, saturated fat, and sodium.

While overall the diets of Indigenous and non-Indigenous Australians are similar, Indigenous adults in some age groups eat less fruit, vegetables and have a lower intake of fibre and a higher intake of discretionary food and added sugars than non-Indigenous adults[218].

Senior Eastern Arrernte Woman Veronica Perrurle Dobson speaks of the health impacts of changes in diet:

> *"Now there's lots of other, new illnesses that make people from this country sick. The food that is eaten is fatty…Nowadays there are lots of sweet things that our elders never ate or drank. Our elders never got these sicknesses – blood pressure, or no kidney problems, no lung or liver problems, or overweight*

> *problems. They didn't know about these, didn't know about these sicknesses. The younger generation is always with these types of sicknesses."*[219]

FOOD SECURITY

Reduction in food supply is by far the most frequently reported impact (more than 66%) of invasive species globally[220].

The National Strategy for Food Security in Remote Aboriginal and Torres Strait Islander Communities[221] recognises:

> "The ongoing disruption of traditional food systems is a root cause of food insecurity for many Aboriginal and Torres Strait Islander people. In remote and very remote areas of Australia, Aboriginal and Torres Strait Islander communities continue to experience a loss of access to land and waterways."

FOOD SECURITY FOR ABORIGINAL PEOPLES IN CENTRAL AUSTRALIA

The following information is presented in the *Aboriginal Medical Services Alliance Northern Territory (AMSANT) Northern Territory Food Summit Food Security Information Sheet*[222].

NT Food security Information:

Food security refers to people's food **access**, meaning financial and other resources people need to obtain appropriate food for a nutritious diet; food **availability**, meaning sufficient quantities of nutritious food consistently available; **and use**, meaning the appropriate use of food, based on knowledge of basic nutrition and care (2).

- **Food insecurity in the NT**

Food insecurity affects Aboriginal people as much as 12 times more than non-Aboriginal people (5). Rates of food insecurity are worse in remote areas.

Thirty-one percent of Aboriginal people living in remote areas are at high risk of food insecurity, regularly running out of food (1). In the NT 34% of Aboriginal people live in a household that had run out of food in the previous 12 months compared to 4% in the non-Aboriginal population(3).

- **Access, Availability & Use**

Aboriginal people in the NT are impacted heavily by limited food access and affordability, restricted availability and often restrictions on means to prepare and obtain healthy, nutritious meals. Aboriginal people in the NT reported a less nutritious diet compared to non-indigenous people, 97% reporting inadequate vegetable intake and 49% inadequate fruit intake (3).

Food is considered affordable when no more than 30 % of household income is required for its purchase (4). In a remote NT community an average family receiving government allowances would use 34-80% of household income on food alone (45.5% on healthy basket of groceries) (9).

In the last 10 years price difference between remote stores and town supermarkets have increased from 36% ($710 vs $522) to 60% ($854 vs $535) (5). During this same time Newstart allowances have increased by less than 15 % (5, 11).

In Aboriginal communities as little as 6% of houses have all of the functioning health hardware needed to store, prepare and cook food, such as cupboards, bench space, refrigeration and a functioning stove and sink (9).

- **Health impacts**

Food insecurity is explicitly linked to health and health outcomes, leading to higher rate of gestational diabetes, low birth weight, malnutrition in infants and children, anaemia in children and young women and higher rates of chronic disease (2).

Aboriginal women in the NT are 10 time more likely to have type 2 diabetes in pregnancy and twice as likely to have low birth weight babies (14). Children health impacts are also higher 15% of aboriginal children under 5yo in the NT suffer from chronic malnutrition, compared to 2% nationally. 15% are anaemic, which can be strongly link to poor diet and a lack of nutritious food, however large improvements have been seen in this area in the last 5 years (12). Rates of diabetes in aboriginal people in the NT are 4.7 times higher than non-aboriginal people. They are also 4.4 times more likely to have a preventable hospital admission for chronic diseases (13)

These health issues linked to food insecurity have lifelong effects including poor education, employment as well as impacts of overall health. The life expectancy gap between indigenous and non-indigenous people is still around 8 years (8).

Provisioning

The UN Human Rights Office states:

> *"Indigenous peoples are among the most vulnerable to hunger and malnutrition. Hunger and malnutrition among them are largely the result of a long history of social, political and economic exclusion, including centuries of expropriation and despoliation of their lands."*[223]

In remote communities commercially, available food intake is still sometimes supplemented by procurement of traditional foods. A study on traditional food availability and consumption in the Northern Territory found that seventy-six percent of people reported being food insecure, with 40% obtaining traditional food during these times[224].

SOCIAL AND EMOTIONAL WELLBEING

Food insecurity causes stress, with the need to obtain food through means that compromise cultural safety and induce feelings of shame [225]. Children in food-insecure households are likely to have emotional or behavioural difficulties and are more likely to miss days of school[226].

MENTAL HEALTH

The *Australian Institute of Health and Welfare (AIHW) 'Food Security and Indigenous Mental Health'* report found evidence that food insecurity is linked with depression, with suicidal behaviour[227].

CHRONIC DISEASE

Poor diet is a leading risk factor contributing to cardiovascular disease, diabetes, renal disease, some cancers and many other conditions[228]. For detailed data see Appendix B Table 2 – Diet.

A recent report by the Australian Institute of Health and Welfare concluded that "colonisation has led to a loss of traditional food sources and dependence on highly processed European food, which contributes to a higher predisposition to chronic illness"[229].

OVERWEIGHT AND OBESITY

A diet low in nutrients and high in processed food can contribute to overweight and obesity.

Excess weight is a major risk factor for many diseases, such as cardiovascular disease, type 2 diabetes, kidney disease, some musculoskeletal conditions, and cancers. In 2018–19, 63% of First Nations people in central Australia were overweight or obese[230]. For detailed data see Appendix B Table 3 – Overweight and Obesity.

CULTURE

Food, food knowledge and culture are closely linked with empowerment, self-determination and healthy eating[231].

In 2014 the International Congress on Nutrition declared:

> *"Food is the expression of values, cultures, social relations and people's self-determination, and the act of feeding oneself and others embodies our sovereignty, ownership and empowerment. When nourishing oneself and eating with one's family, friends and community, we reaffirm our cultural*

> *identities, our ownership over our life course and our human dignity. Nutrition is foundational for personal development and essential for overall well-being"*[232].

A systematic review of qualitative literature describing Aboriginal and Torres Strait Islander peoples' concerns and priorities regarding food and nutrition identified key food and nutrition issues across each level of an ecological framework. One of the main themes to emerge was that traditional food is central to health and wellbeing:

> *"Connection to culture, particularly via traditional foods, was reported to be associated with positive health and wellbeing. Conversely, disconnection from traditional food systems was reported as a barrier to healthy eating and psychosocial wellbeing, as participants reported a sense of loss and imbalance when away from their homelands. Some participants expressed concern that cultural knowledge was not being passed down to younger generations and could be lost. The role of culture in guiding children's food choices was also demonstrated through storytelling to pass down knowledge from Elders to children."*[233]

> *"Participants associated traditional foods with their identity and culture as well as with healthy eating. "Bush tucker" was highlighted as a way of incorporating healthy foods into the diet, and promoting wellbeing, although access to traditional foods was often limited…Discussion of traditional foods was more common among participants in remote areas; however, concern regarding access to traditional foods was shared in both remote and urban communities."*[234]

CHILDREN

Children are especially vulnerable to a lack of adequate food, as they need safe and nutritious food for mental and physical growth. Malnutrition, including during pregnancy, has long-lasting consequences, including mental and physical impairment, chronic illness, and weak immune systems and reproductive health[235].

Veronica Perrurle Dobson, a senior Eastern Arrernte Woman, botanist and ecologist asserts:

> *"That's why the young children of today are always sick, because they haven't been taught to eat green vegetables like bush banana, bush orange yams and other foods like witchetty, kangaroo, perentie, goanna. That's just some of the bush foods – there's lots more."*

BURDEN OF DISEASE

The burden of disease related to loss of local food sources through buffel grass invasion in central Australia has not been measured. Related burden of disease measures that are currently available suggest the attributable burden may be significant.

UNHEALTHY DIETS

Unhealthy diets are a leading preventable risk factor contributing to the burden of death and disease globally[236].

Dietary risks were responsible for 5.4% of the burden of disease in Australia in 2018. They contributed 50% of coronary heart disease total burden, 26% of bowel cancer burden, 26% of type 2 diabetes burden, and 26% of stroke burden[237].

Provisioning

DIETS HIGH IN RED MEAT

In 2018-19 0.9% of the total Australian burden of disease attributed to diets high in red meat was 0.9%. This included 5.5% of coronary heart disease, 7.9% of stroke, 8.6% of type 2 diabetes mellitus and 5.8% of bowel cancers[238].

Between 2018–19 to 2022–23, the number of serves available per person from food purchased (apparent consumption) increased for meat[239] and decreased for vegetables, fruit, grains and cereals[240].

FIRST NATIONS PEOPLES

In 2018 all dietary risks were responsible for 5.7% of the burden of disease among non-Indigenous people in Australia and 6.2% among First Nations peoples, making it the fifth leading risk factor contributing to total burden of disease[241]. All dietary risks combined contributed 67% of coronary heart disease total burden, 37% of stroke burden, 32% of bowel cancer burden, and 31% of type 2 diabetes burden.

REGION

Diets are affected by what foods are affordable and readily available. For example, fresh fruit and vegetables can be difficult to access by people with low incomes and in more remote areas[242]. On average, Australians living in remote and very remote areas have less favourable food and nutrient intakes[243] and a higher burden of diseases related to poor diet[244].

SOCIO-ECONOMIC POSITION

On average, Australians with more socioeconomic advantages have more favourable food and nutrient intakes[245]. For detailed data see *Appendix B Table 3 – Diet.*

OVERWEIGHT AND OBESITY

9.7% of the total disease burden in Australia was due to overweight (including obesity), in 2018 making it the 3rd leading risk factor contributing to total disease burden among First Nations peoples (after tobacco use and alcohol).

Overweight (including obesity) contributes to the burden of 30 diseases, including: 17 types of cancer, four cardiovascular diseases, three musculoskeletal conditions, type 2 diabetes, dementia, asthma and chronic kidney disease[246].

For detailed data see *Appendix B Table 3 – Overweight and Obesity.*

HEALTH ECONOMIC IMPACTS[247]

The economic impact of poor nutrition related to loss of traditional food sources through buffel grass invasion on people in central Australia has not been measured. It is likely to be significant given the estimated costs of poor diet to Australia through health system spending on conditions attributable to diet. According to the Australian Institute of Health and Welfare:

- Diet related illness cost Australia approximately $1.2 billion per year in 2018-19[248].
- Overweight (including obesity) cost approximately $4.3 billion per year in 2018-19.

For detailed data see *Appendix B Table 3 – Diet and Table 4 – Overweight (Including Obesity)*.

Provisioning

IMPACTS ON OCCUPATION AND EMPLOYMENT

Employment can impact health in both positive and negative ways[249] [250].

Food production has historically been a rich source of occupation and employment across communities.

The Northern Territory agricultural sector (including pastoralism, horticulture, forestry and fisheries) currently employs only about 2,500 people[251]. Beef production on arid and semi-arid land would account for a minor fraction of this employment. In central Australia the entire agricultural industry only employs about 270 people[252].

Australian native food sources provides great opportunities for less industrialised, more secure food production occupation and employment[253, 254]. These opportunities are undermined by buffel grass invasion.

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

Policies related to nutrition that support a health service response to buffel grass invasion include those related to beef consumption, nutrition and obesity and associated diseases such as cardiovascular disease.

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
UN Right to Adequate Food	The right to adequate food and right to be free from hunger is a human right recognized under international law that provides entitlements to individuals to access adequate food and to the resources that are necessary for the sustainable enjoyment of food security[255]. Human rights are interdependent, indivisible and interrelated. This means that violating the right to food may impair the enjoyment of other human rights, such as the right to health, education or life, and vice versa. Examples of these correlations can be found at https://www.ohchr.org/sites/default/files/Documents/Publications/FactSheet34en.pdf Indigenous peoples "The realization of indigenous peoples' right to food depends crucially on their access to and control over the natural resources on their ancestral lands, as they often feed themselves by cultivating these lands or by collecting food, fishing, hunting or raising animals on them." [256]
GAR Special Report 2023: Mapping resilience for the Sustainable Development Goals [257]	Resilience deficit 2. Increasing drought risk and food insecurity
International Covenant on Economic, Social and Cultural Rights[258]	Article 11 (a) To improve methods of production, conservation and distribution of food by making full use of technical and scientific knowledge, by disseminating knowledge of the principles of nutrition and by developing or reforming agrarian

	systems in such a way as to achieve the most efficient development and utilization of natural resources.
Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security[259]	States are encouraged to use the Right to Food Guidelines for drafting their national strategies and programmes to fight hunger and malnutrition. Guideline 8 States should take measures to "prevent the erosion of and ensure the conservation and sustainable use of genetic resources for food and agriculture", including for the protection of traditional knowledge and equitable participation in sharing benefits through the participation of local and indigenous communities in relevant decision-making".
UN Declaration on the Rights of Indigenous Peoples[260]	Article 31 Recognises Indigenous peoples' right to maintain, control, protect and develop the manifestations of their sciences, technologies and cultures, including genetic resources, seeds, and knowledge of the properties of fauna and flora.
The Convention on the Rights of the Child[261]	Protects the child's right to food in the context of the right to life, survival and development, to health, to nutrition and to an adequate standard of living.
UN Convention to Combat Desertification (1994)[262] Ratified by Australia 2000	Covers a number of themes related to buffel grass invasion including desertification, land degradation, sustainable development, sustainable land management, drought mitigation and adaptation to climate change. The parties to the Convention recognise that desertification is related to important social problems such as poverty, poor health and nutrition, and lack of food security.

NATIONAL

Food security has been identified as an objective in closing the gap between Aboriginal and Torres Strait Islander people and non-Indigenous Australians[263].

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
National Strategy for Food Security in Remote Aboriginal and Torres Strait Islander Communities [264]	Pillars of the Strategy Country and Culture Goal 1. Aboriginal and Torres Strait Islander people are supported to increase participation in on-Country activities and knowledge sharing related to food security. Health and Nutrition Goal 2. Aboriginal and Torres Strait Islander people living in remote communities have equitable access to nutrition services and the knowledge needed to support improved health and wellbeing. Housing, Infrastructure and Environmental Health: 3.2 Aboriginal and Torres Strait Islander people in remote communities are supported by a culturally responsive environmental health workforce that prioritises local community members Families and Communities Goal 4. Aboriginal and Torres Strait Islander families and communities are supported by services and facilities that provide access to culturally appropriate and nutritious food.

	Healthy Economies Goal 7. Aboriginal and Torres Strait Islander people in remote communities have the same purchasing power, job and economic opportunities for food security as non-remote communities
National Aboriginal and Torres Strait Islander Health Plan 2021-2031[265]	Priority 7: Healthy environments, sustainability and preparedness Food security Embedding cultural knowledge and practice can help address food insecurity and related health challenges for Aboriginal and Torres Strait Islander people. For example, collecting and consuming traditional bush foods is linked to improved diet, exercise and physical, spiritual, social and emotional wellbeing. The annual accessibility and availability of traditional foods enhances this objective. Take action to improve food security Solutions to food security (including through traditional food sources) must both enable self-determination in diet and nutrition-related decision making, and address the factors that contribute to low intake of nutritious foods. This includes consideration of issues related to supply, access, affordability, demand and barriers to consumption. Action must support stores to act as an important community service that is pivotal to community members' health and wellbeing.
The Aboriginal and Torres Strait Islander Health Performance Framework[266].	Measure 2.22 Overweight and Obesity
Australian Dietary Guidelines[267]	Includes specific recommendations for Aboriginal and Torres Strait Islander people: ● to enjoy traditional foods whenever possible. ● when choosing store foods, to choose those most like traditional bush foods, such as fresh plant foods, wholegrain (cereal) foods, seafood, and lean meats and poultry.
National Preventive Health Strategy 2021–2030[268]	Improving access to and consumption of a healthy diet is one of seven priority areas for action.
National Obesity Strategy 2022-2032[269]	Ambition 1: Creating supportive, sustainable and healthy environments 1.1 Build a healthier, more sustainable food system. 1.2 Make sustainable healthy food more accessible. Ambition 2: Empowering people to stay healthy 2.1 Improve knowledge, skills and confidence. 2.3 Establish lifelong healthy habits from childhood. 2.4 Harness young people's passion for sustainability and better health. 2.5 Support communities to lead their own solutions. 2.6 Address systemic barriers to health. "Community consultations clearly identified the need for community leadership, shared decision making and community-driven approaches.

	These were particularly important for Aboriginal and Torres Strait Islander communities where local community leadership in all aspects of design, development and delivery of actions is critical to achieve change." This statement is compelling in light of community statements regarding the impact of buffel grass on availability and access to healthy food. Ambition 3: Access to early intervention and care Addressing wider determinants of health and sustainability: Strategies 3.1, 3.2, 3.3, 3.4, 3.5 include the need to consider social, cultural, economic, structural and environmental factors, and multi-sector collaboration and partnerships to improve obesity.

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
AMSANT Food Summit Report[270]	Local Food Production "The Northern Territory and Australian Governments to provide long term investment in community controlled local food production and critical infrastructure to support greater food production, including the harvesting of traditional foods, in and around Aboriginal communities". This should include; ii. Assistance for Aboriginal communities to harvest traditional foods for community consumption and sale to both local and national markets. "Growing and harvesting food in and around Aboriginal communities potentially has multiple benefits and cost savings through increased physical activity, improved access and affordability of healthy food, connection and management of land and the benefits to the whole community through social and economic opportunities."

2.2. MEDICINE

BUFFEL GRASS IMPACTS ON MEDICINE

TRADITIONAL HEALING

Cenchrus ciliaris is traditionally used to treat several inflammatory disorders, to alleviate pain and as a diuretic and emollient in areas of Asia and Africa[271].

In central Australia traditional medicine and healing is interconnected with natural ecosystem health and biodiversity in complex ways[272]. In the book *Arelhe-kenhe Merrethene* (Arrernte Traditional Healing)[273], Senior

Provisioning

Eastern Arrernte Woman Veronica Perrurle Dobson describes the source of *Angangkeres'* (Traditional Healers) healing powers and lists native plants, animals and other methods used in traditional healing:

> "The healing comes from lots of things like the goanna, emu, wasp, kangaroo and others. The *awelye* healing song is sung from the country".

> "Medicine was collected and made up to use, plant medicine especially was used regularly".

As the *Healing Poster* produced by Akeyelerre states:

> "Healing comes from the land. We go back to the land to feel better. Through the land we strengthen and improve our health"[274].

'WESTERN' MEDICINE

Animal, plant and microbial biodiversity are a critical source of medicinal compounds and materials used in 'western' medical research[275]. Over 40% of pharmaceutical formulations are based on natural products[276], 'uncultivable' microorganisms are a major source of drug discovery[277].

Recent studies suggests that Cenchrus ciliaris (a species of buffel grass found in central Australia), may be used to treat inflammation and associated oxidate stress[278], bacterial and fungal infections[279] [280] and cancers[281].

While there is no shortage of buffel grass in the world as a source for these innovations, central Australia's natural ecosystems support a large and diversity of plants and animals that have a small range and offer unique opportunities for innovation in health care [282]. Buffel grass reduces the availability and access to these animals and plants[283].

CONSEQUENCES FOR HEALTH

The impacts of destroying the sources of traditional healing are not currently measured but are likely to be profound especially given the relationship healing has with other determinants of health including maintenance of knowledge, skills and culture.

One South Australian research project[284] found a number of benefits to providing a 'holistic two-way health care model' incorporating 'traditional medicine in primary health care within Aboriginal Australia'. These included:

- broader view of a patient's condition
- lesser chance of misdiagnosis
- better patient experience
- greater compliance rate with western medical treatments

A review of literature by the Healing Foundation found consistent evidence that effective healing programs combined both western methodologies and traditional healing in their treatment theory base[285].

Native plants and animals may be the source for new pharmaceutical and therapeutic products, the opportunities that are being lost are not known.

ATTRIBUTABLE BURDEN OF DISEASE

Provisioning

No information on the burden of disease associated with destruction of the sources of traditional medicine and healing was found in the literature searches conducted for this paper. It is clear these would be disproportionately borne by First Nations peoples.

HEALTH ECONOMIC IMPACTS

The economic contribution of traditional medicine to health systems is not known.

The World Health Organisation states that the use of traditional medicines for health promotion, health care and disease prevention may significantly reduce healthcare costs[286].

Traditional medicine workers, facilities, expenditures and products are largely not accounted for[287]. Markets for some Traditional medicines are already expanding[288]. In central Australia, some government and non-government health services are incorporating medicines into their products and services. For example:

- Bush rubs made at Akeyulerre[289] and Western Desert Nganampa Walytja Palyantjaku Tjutaku Aboriginal Corporation (Purple House)[290].
- Ngangkari / Angangkere employment at Ngaanyattjarra Pitjantjara Yankunytjatjara (NPY) Women's Council[291] [292], the Anangu Ngangkari Tjutaku Aboriginal Corporation (ANTAC).

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
WHO traditional medicine strategy: 2014-2023[293]	The strategy aims to support Member States in developing proactive policies and implementing action plans that will strengthen the role traditional medicine plays in keeping populations healthy.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
National Aboriginal and Torres Strait Islander Health Plan 202-2031	Priority 11: Culturally informed and evidence-based evaluation, research and practice. The experiences, knowledge and expertise of Aboriginal and Torres Strait Islander people is embedded across policy and program development.

2.3. RAW MATERIALS

Testimonies like the Umuwa Statement highlight how buffel grass destroys and limits access to the many places, plants and animals that provide raw materials required for inspiration and completion of numerous activities including arts and tools.

A study of key environmental and socio-cultural threats in central Australia found buffel grass has massive socio-economic impacts stemming from permanent and irreversible disappearance of materials[294].

MATERIALS FOR MAKING ART

IMPACTS OF BUFFEL GRASS INVASION

As a raw material buffel grass has inspired, featured, and been used as a material in art (note the references below represent just a small number of examples):

- poems, paintings, songs, films have been produced as a response to the negative impacts of invasion [295] [296] [297].
- art has been used in campaigns calling for better management[298] [299] and to document community action[300]
- though buffel grass cannot be woven it has been used to create sculptures (of other invasive species)[301]
- by the pastoral industry, who depict buffel grass dominated environments as ideal landscapes[302]

While these artistic endeavours are to be appreciated, they are part of an artistic heritage that is not existentially threatened by the absence or presence of buffel grass in central Australia.

FIRST NATIONS ART

Buffel grass destroys and limits access to the raw materials: places, plants and animals that are need to inspire and complete of many artistic activities. These impacts have been communicated by artists[303] [304] and art centres[305].

CONSEQUENCES FOR HEALTH

The crucial links between art and health for many Aboriginal people are described by Professor Michael Dodson, a Yawuru man and respected leader:

> "To understand our law, our culture and our relationship to the physical and spiritual world, you must begin with land. Everything about Aboriginal society is inextricably woven with, and connected to, land. Culture is the land, the land is spirituality of Aboriginal people, our cultural beliefs or reason for existence is the land. You take that away and you take away our reason for existence. We have grown that land up. We are dancing, singing, and painting for the land. We are celebrating the land. Removed from our lands, we are literally removed from ourselves"[306].

A comprehensive scoping review published by the World Health Organisation on the role of art in improving health and well-being concluded that the arts play a major role in the prevention of ill health and promotion of health, and management and treatment of illness across the lifespan[307] as described below.

PREVENTION AND PROMOTION

- Affects social determinants of health (e.g. social cohesion and social inequalities and inequities)
- Supports child development (including bonding, speech and language acquisition, and learning)
- Helps prevent ill health (including enhancing well-being and mental health, reducing the impact of trauma, and reducing the risk of cognitive decline, frailty and premature mortality)
- Supports caregiving (including enhancing our understanding of health, communicating knowledge and supporting the well-being of formal and informal carers).

MANAGEMENT AND TREATMENT

- Helps people experiencing mental illness
- Supports care for people with acute conditions

- Helps to support people with neurodevelopmental and neurological disorders
- Assists with management of non-communicable diseases (including cancer, respiratory disease, diabetes and cardio-vascular disease
- Supports end-of-life care (including palliative care and bereavement).

MATERIAL FOR CONSTRUCTION AND MAKING TOOLS

IMPACTS OF BUFFEL GRASS INVASION

In Kenya, where buffel grass is native, it is used for thatching[308]. In Australia there have been some isolated incidences of buffel grass being used by artists and hobbyists to engage in novelty activities such as making paper[309] and as fuel for kilns[310].

Buffel grass destroys the raw materials requires to make traditional structures and tools – wiping out local woods, grasses, resins that are used for making weapons, containers, shelters.

CONSEQUENCES FOR HEALTH

SOCIAL AND EMOTIONAL WELL-BEING

Traditional tools and structures often carry deep cultural meaning and are intertwined with a communities identity and heritage[311]. A loss of ability to make and use tools and structures can lead to a loss of independence, cultural identity and sense of disconnection from ancestral practices.

PHYSICAL HEALTH

Knowledge passed down through many generations on how to survive extreme climate shifts and weather events is intertwined with raw materials. For example – soils and plants that can be used to build structures that protect from extreme weather – rain, wind, heat and cold.

Many traditional tools are designed to be accessible, sustainable and environmentally friendly. Their destruction may lead to increased reliance on modern, often less accessible or sustainable, alternatives, thereby contributing to environmental degradation and associated health risks.

One study found that the safety of hunting practices has been associated with loss of traditional knowledge and skills and use of non-traditional tools[312].

ATTRIBUTABLE BURDEN OF DISEASE

The burden of disease related to loss of raw materials as a result of buffel grass invasion in central Australia has not been measured.

HEALTH ECONOMIC IMPACT

A study of key environmental and socio-cultural threats in central Australia found buffel grass has massive socio-economic impacts stemming from permanent and irreversible disappearance of materials[313].

The Northern Territory government has described the art and craft sector as being of “crucial importance to the NT economy”. One recent valuation concluded that art centres and related retailing of First Nations art and craft in central Australia equals or exceeds the value of the local pastoral industry[314].

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
UN Declaration on the Rights of Indigenous Peoples[315]	The declaration includes the following related rights: • Self-determination • Individual and collective rights • Freedom from assimilation and destruction of culture • Understanding of lore, law and traditional responsibilities • Connection to, custodianship and utilisation of Country and traditional land • Reclamation, revitalisation, preservation and promotion of language and cultural practices • Protection and promotion of Traditional Knowledge and Indigenous Intellectual Property.
Convention on Biological Diversity (1992)[316].	Recognises the essential link between biodiversity and human health. The objectives are: "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources".

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Australian Government's National Cultural Policy[317]	Principles include: • The opportunity to access and participate in arts and culture. • Arts and culture are generative (creating new works and supporting emerging artists) and preservative (protecting heritage and conserving cultural memory).

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Arts NT[318]	"A strong and vibrant arts and cultural sector is integral to the health and well-being of our communities".

2.4 WATER SUPPLY

IMPACTS OF BUFFEL GRASS INVASION

Healthy, biodiverse ecosystems are critical for maintaining clean water supply. This section describes how buffel grass invasion negatively impacts the availability and quality of both surface and ground water on Country in many ways including:

1. Erosion and sedimentation
2. Altered hydrological cycles
3. Increased frequency and intensity of wildfires.

Buffel grass invasion also impacts people's ability to fulfil responsibilities to care for water. For more on the health impacts of buffel grass on culture for more see *Section 1: Cultural*.

Provisioning

WATER AVAILABILITY

Surface water

Buffel grass growth interferes with surface water flows, rivers, waterholes and soakages including:[319]

- Dense stands change the way water flows overland to water bodies[320]
- Changing flow rates, sediment loads and vegetation within waterways, all of which are fundamental to erosion, scouring and sedimentation[321] [322] [323] [324].
- Destroys tree cover. This loss of canopy shading increases surface temperatures and evaporation[325].

Groundwater

Buffel grass interferes with groundwater recharge:

- Changes the way water flows across the surface and therefore the places where it infiltrates to ground levels[326, 327].
- Increased sediment movement can block flow routes to the subsurface[328].

WATER QUALITY

Surface water

Buffel grass impacts water quality by affecting both the diversity and abundance of species, and characteristics of specific species, that live in riparian zones (within or near aquatic environments)[329] [330]. These species play a key role in maintaining water quality by protecting surface waters from pathogens, turbidity, and nutrient-enriched run-off. Alterations in biological diversity can lead to what is known as a trophic cascade resulting in major shifts in ecosystem structure and nutrient cycling[331].

Groundwater

Alluvial aquifers frequently occur along waterways, relying on recharge from episodic flows. Any dissolved contaminants in surface water flows arising from the impacts of buffel grass invasion can therefore also contaminate these aquifers.

IMPACTS OF BUFFEL FUELLED FIRES ON WATER SUPPLY

Buffel grass has a very high fuel load and increases the intensity, spread and frequency of fires. Such fires are known to be responsible for swings in water yield and quality at local and regional scale. Fire can affect the quantity and quality of water produced at the catchment.

SURFACE WATER

Following intense bushfire:

- Runoff becomes more responsive to rainfall events with river flows generally increasing. As a result, there is an increased potential for sediment movement by up to several orders of magnitude, especially if a severe fire is followed by rainfall events of high intensity and erosivity[332]

- Many nutrients and pollutants are absorbed into fine-grain organic and inorganic sediments. Therefore increased sediment movement from catchments generally corresponds with an increase in nutrients and other pollutants delivered to waterholes[333].

Provisioning

- Increases in nutrients along with loss of shading creates conditions suited for eutrophication with toxic algal blooms. Increases in suspended organic material, especially after fires, can lead to hypoxic black-water events, with associated fish-kills[334].

- Although prescribed hazard reduction fires are generally understood to have a lesser environmental impact than wildfires, there is concern that frequent burning may cause cumulative degeneration of soil and catchment hydrological characteristics. [335]

GROUND WATER

Ash is burnt vegetation rich in carbon, nutrients and trace metals which can be moved after heavy rainfall. Heavy rainfall events are most likely to cause groundwater recharge. As the rainfall makes it way down to the water table it can be expected that nutrients and carbon are also mobilised downwards towards the water table[336].

A study conducted by UNSW on the impact of wildfires on limestone aquifers observed increased evaporation and decreased recharge in the years immediately after an intense wildfire[337].

IMPACTS OF BUFFEL GRASS MANAGEMENT ON WATER QUALITY

HERBICIDES

Herbicides can contaminate surface water through processes such as direct application in riparian areas (against manufacturers and regulators advice), surface runoff and drift. Some herbicides can leach from root zones and soils into drainage water and groundwaters[338].

FIRE

Fire is sometimes used to reduce buffel grass fuel loads. This has the same impacts as wildfire (see above). These fires should be followed up with herbicides (otherwise they are counterproductive in the mid-long term[339].

GRAZING / SLASHING

Grazing and slashing is sometimes used to reduce buffel grass fuel loads. Grazing / slashing should be followed up with herbicide application otherwise it is counterproductive in the mid-long term (though this follow up often does not occur)[340].

Grazing in itself is also associated with widespread negative water quality impacts from erosion and sediment transport into surface waters, nutrients from urine and faeces dropped by the animals and fertility practices associated with production of high-quality pasture, and through pathogens from the wastes[341]. Vegetation buffers should apply close to estuaries, reservoirs, watercourses, wetlands and production wells (drawing from the water table aquifer).[342] Within such buffers grazing and slashing should restricted or excluded.

CONSEQUENCES FOR HEALTH

Safe and readily available water is fundamentally important for health, whether it is used for drinking, domestic use, food production or cultural purposes[343].

The spiritual, cultural, environmental, social, and economic significance of water for First Nations people means that having access to good quality water, and to be able to look after that water supply, is vital for the health

and wellbeing of people and communities, particularly in remote areas where water can be scarce [344] [345] [346] [347] [348].

Safe water supply is a persistent challenge across many remote and very remote communities in central Australia[349] [350].

WATER AVAILABILITY

Inadequate water supply can have:

- Mental health impacts – stress and anxiety associated with worry of accessing clean water[351]
- Cascading impacts related to provisioning (food, medicine) and culture (limit access to country).

WATER QUALITY

- Increased risk of water contamination increases the risk of diseases caused by bacteria, viruses and parasites including gastrointestinal, eye and skin infections[352] [353]
- Chemical contamination can lead to a broad range of chronic health issues[354]
- Herbicide used in managing buffel grass may also persist in the environment and water and are also associated with water quality risks. For example the guidelines for drinking water for the commonly buffel herbicides glyphosate and flupropanate are:
  - Glyphosate – 1000 µg/L[355] [356] [357]
  - Flupropanate - 9 µg/L[358] [359].

ATTRIBUTABLE BURDEN OF DISEASE

Though the health impacts of water availability and quality in relation to buffel grass have not been measured, existing water quality and quantity issues faced by many remote and very remote central Australian communities and the cultural significance of water for Aboriginal peoples suggests any impacts of water availability and quality in central Australia are likely to be disproportionately borne by Aboriginal peoples.

HEALTH ECONOMIC IMPACT

Spending on delivery of reliable water supply to communities across central Australia is already considerable[360].

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
UN Sustainable Development Goals	Goal 6: Australia has committed to ensuring the availability and sustainable management of water for all.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION

National Water Initiative	Framework agreement among the Australian Government and state and territory governments to promote sustainable water management across the country.
Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act includes provisions for protecting water resources and ecosystems that support public health and biodiversity. It addresses water-related impacts of development activities and requires environmental assessments to minimise adverse effects on water quality and ecosystem health.
National Aboriginal and Torres Strait Islander Health Plan 2021-2031	Priority 7: Capacity building and development is undertaken to ensure that Aboriginal and Torres Strait Islander people have access to safe and healthy environments with water security,
Australian Drinking Water Guidelines[361]	Appendix 1: Additional guidance on elements 2 and 3 of the Framework for management of drinking water quality. A1.2 Water supply system analysis. Assessment of the drinking water system provides an important information base and is a prerequisite for subsequent steps in which strategies for prevention and control of hazards are planned and implemented. Characterisation of the water supply system should be fully documented and should be a collaborative effort between relevant agencies. Table A1.1 provides examples of some key characteristics to be considered in assessing drinking water supply systems from catchment to consumer, including: • Soils • Riparian conditions • Vegetative cover • General catchment and river health. Table A1.3 Examples of hazardous events and their potential sources including: Catchment: • Poorly vegetated riparian zones, failure of sediment traps and soil erosion • Bushfires Waterholes: • Soil erosion • Inadequate vegetation • Bushfires. Table A1.4 Hazard identification - Identify and document hazards, sources and hazardous events for each component of the water supply system. A1.5 Risk assessment

FEDERAL

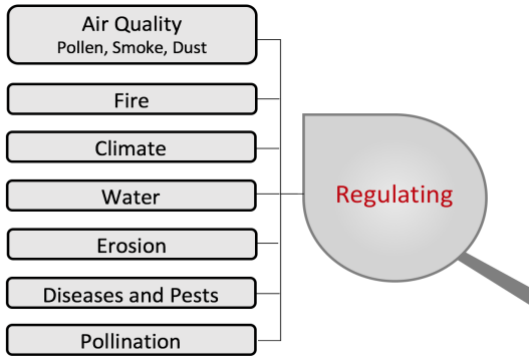
DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
United Nations Sustainable Development Goals (SDGs)	Goal 6 of the SDGs focuses on ensuring availability and sustainable management of water.

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Territory Water Plan[362]	Priority actions include: • Prioritise safe drinking water for all Territorians • Deliver good governance, transparency and accountability in water management • Protect environmental and cultural values • Support the Territory's resilience to climate change and its impacts on water security.

3. REGULATING

Regulating ecosystem services are those arising from the ability of ecosystems to regulate biological processes and maintain environmental conditions via these processes e.g. clean air, moderate extreme events.



3.1. AIR QUALITY

Buffel grass invasion is associated with increased air pollution from pollen, smoke and dust.

The reduction of diverse ground storey, mid and upper storey vegetation that results from buffel grass invasion reduces the ecosystem's capacity to:

- Physically alter the pathways through which airborne particles travel (barriers are removed).
- Filter airborne pollutants through the deposition, uptake, fixing and storage of pollutants (buffers are removed)[363]. Areas with greater complexity in vegetation – such as those with trees, shrubs and herbaceous species provide better air filtration capabilities than more homogenous vegetation such as paddocks of buffel grass[364, 365, 366].

POLLEN

BUFFEL GRASS INVASION AND POLLINOSIS

- Most pollens that cause allergies are produced by airborne pollen from northern hemisphere grasses, trees and weeds[367]
- Introduced pasture grasses are more allergenic than Australian native grasses[368].
- Buffel grass is part of the Poaceae family. Pollen allergens of the Poaceae family comprise one of the main causes of pollinosis worldwide[369].
- The amount of damage caused by an environmental agent such as pollen depends on several factors, including the degree of exposure[370].

Buffel grass has highly allergenic pollen [371, 372, 373, 374, 375]. There is a large amount of anecdotal support for the claim that buffel grass pollen allergens have a significant impact on people living in central Australia[24 25]. Despite this, buffel grass allergy in central Australia has not been studied and has received little attention in Australia.

Only one Australian study was found on this topic - a 1983 survey of clinically important pollens in Queensland which was 'the result of 30 years of clinical experience from an allergist in Queensland, involving close collaboration with the staff of the Department of Primary Industries (Plant Industry Laboratories)' ranked buffel grass as number one in order of clinical importance of grass pollens for allergenicity in Queensland. It reported that buffel grass "is a potent cause of hay fever, and all growers producing it appear to become sensitive after a couple of seasons"[376].

In 2003 Dr John Weiner, an allergy specialist at Alice Springs Hospital, stated that "couch and buffel grass cause enormous allergy problems in about 20% of the central Australian population"[377]. In 2011 Weiner wrote: "Alice Springs in Central Australia is, in my opinion, the WORST place in Australia for pollen allergy"[378]. Buffel grass distribution, and therefore allergenic pollen exposure, has increased dramatically since this time.

Buffel grass allergy in central Australia needs further study /investigation.

CONSEQUENCES FOR HEALTH AND BURDEN OF DISEASE

Pollens are significant sources of clinically relevant outdoor aeroallergens, recognised as both a major trigger for, and cause of, allergic respiratory diseases[379].

As a highly allergenic pollen, buffel grass can trigger allergic rhinitis (hay fever), and allergic asthma. Allergic rhinitis and allergic asthma are important chronic diseases posing serious public health issues in Australia with associated medical, economic, and societal burdens. See Box 3 for details on Allergic Rhinitis and Box 4 for details on Asthma.

BOX 3 - ALLERGIC RHINITIS

Allergic rhinitis is an allergic immune system response to inhaled pollen, resulting in chronic inflammation of the eyes and nasal passages.

Allergic rhinitis symptoms include:

- Runny, itch, congested nose
- Irritable, itchy, watery and red eyes
- Itchy ears, throat and palate
- Headaches.

Health Impacts

- Sleep disturbance
- Daytime tiredness
- Decreased alertness
- Poor concentration
- Increased depression and irritability.

Moderate or severe allergic rhinitis can:

- Impair learning
- Decrease participation in activities including work, social and cultural events.

Allergic rhinitis has been related to other significant upper and lower respiratory conditions including:

- Sinusitis
- Upper respiratory tract infection
- Otitis media, with effusion
- Chronic obstructive pulmonary disease (COPD)
- Bronchiectasis.

It has also been associated with increased risk of cardiovascular disease.

Burden of disease

According to Australian Institute of Health and Welfare (AIHW) in 2017-18[380]

- Nearly 1 in 5 Australians had allergic rhinitis
- 14% of people living in the NT had allergic rhinitis.

The condition is likely to be under reported.

There are many serious health conditions associated with allergic rhinitis that have a high incidence in central Australia, these include:

- Chronic sinisitus[381, 382]
- Otitis media[383 384]
- Chronic obstructuve pulmonary disease[385 386 387 388 389]
- Bronchiectasis[390 391 392]
- Cardiovascular disease[393 394]
- Trachoma[395].

BOX 4 - ALLERGIC ASTHMA

Asthma is a long-term condition of the airways. People with asthma have sensitive airways. These airways become inflamed when they are exposed to triggers such as pollen, smoke and dust . When the airways become inflamed they narrow. This narrowing causes symptoms such as a persistent cough, wheezing, breathing difficulties, chest tightness / pain. It can sometimes lead to a medical emergency .

Health Impacts

Asthma can impact the physical, mental and social wellbeing of people living with the condition. The triggering of symptoms can significantly decrease quality of life.

Burden of Disease

Around 11% of Australians have asthma.

- 18% of Aboriginal and Torres Strait Islander people had asthma in 2018–19.
- Asthma accounted for 2.5% of the total disease burden in 2024.
- Mortality rates for asthma are higher for people living in remote areas, in areas of lower socio-economic status and for Aboriginal and Torres Strait Islanders.
- The mortality rate for asthma among Aboriginal and Torres Strait Islanders is over twice that of non-Indigenous Australians.

Data on the burden of disease of asthma in central Australia could not be found.

Economic Impact

- Asthma cost the Australian health system an estimated $899.9 million, representing 19% of disease expenditure on respiratory conditions and 0.6% of total disease expenditure.

ATTRIBUTABLE BURDEN OF DISEASE

- About 1 in 5 (20%) of people in Australia have a pollen allergy[396].
- Pollen allergies are increasing in prevalence and severity across the world[397]. The reasons for this observed growth are unclear[398].
- Though there is anecdotal support for the claim that buffel grass pollen allergens have a significant impact on people living in central Australia[399,400], no research conducted into the impact of this pollen on the population has been identified by the authors of this report[401].

A recent study in central Queensland found that First Nations people are twice as likely as other Australians to present to hospital with allergy related illnesses[402] (see Appendix B Table #5 – Air Pollution).

HEALTH ECONOMIC IMPACTS

The latest estimates (from 2007) allergic diseases cost the Australian economy about $30 billion per year in direct financial costs and lost wellbeing[403]. Medication costs alone related to allergic rhinitis was estimated to cost Australia $226.8 million in 2010[404].

The economic impact related specifically to the health impacts of allergic reactions to buffel grass have not been measured, however they are likely in areas heavily invaded with buffel grass given the existing burden of diseases that are exacerbated by allergen exposure in central Australia.

SMOKE

BUFFEL GRASS INVASION AND EXPOSURE TO SMOKE

Buffel grass infestation increases the frequency, intensity and spread of wildfires in central Australia[405].

The smoke generated by such fires can affect health over large geographical areas[406].

In late 2023, the air quality in central Australia was measured at unsafe levels due to smoke from fires that were largely fuelled by buffel grass[407].

CONSEQUENCES FOR HEALTH AND ATTRIBUTABLE BURDEN OF DISEASE

In late 2023 central Australia experienced particularly intense, widespread fire that were largely fuelled by buffel grass. At this time *Alice Springs Hospital* published a *Smoke and Air Quality Warnings for Central Australia Region* which stated:

> *"Alice Springs Hospital has seen a significant number of presentations to ED as a result of respiratory distress due to smoke from fires in the region. The poor air quality and particle concentration will be affecting all areas including remote locations.*
>
> *Many of the patients presenting with respiratory conditions are improving much more slowly than under normal conditions. It is expected that length of stay, bed occupancy and patient flow may be affected as well as attendance to ED and remote community clinics.*
>
> *NT Health staff are encouraged to consider the risk of smoke inhalation to themselves and their patients and take appropriate precautions. Health Clinics should also plan for increased presentations."*[408] [409]

For more on health impacts see Box 5 – Health Impacts of Particulate Matter below

HEALTH ECONOMIC IMPACTS

A large body of evidence[410] [411] indicates that bush fire smoke increases rates of

- Respiratory medication use
- Ambulance calls
- Emergency department visits
- Hospital admissions
- All-cause mortality.

The economic impact related specifically to the health impacts of fires fuelled by buffel grass have not been measured, however they are likely in areas heavily invaded with buffel grass given the existing burden of diseases that are exacerbated by smoke exposure in central Australia.

DUST

BUFFEL GRASS INVASION AND INCREASED EXPOSURE TO DUST

Buffel grass is deep rooted and quick to spread. It is used to bind soils in areas where native vegetation has been removed through disturbance, which is often industrial, for example through stocking and clearing for mining and 'development'.

However, in the medium – long term buffel grass invasion may lead to erosion of soils through a number of processes:

- Changing soil structure
- Changing water flows
- Destroying drought resilient biological crusts and native vegetation
- Increasing the frequency and intensity of fires
- Loss of lower and mid-storey vegetation.

Furthermore, given dust emission is enabled above a critical value of wind (shear) velocity at which the aerodynamic force is enough to dislodge particles from the surface[412], reduction in the diversity of ground, mid and upper storey vegetation can result in removal of:

- Barriers that physically alter the pathways through which airborne particles travel and
- Buffers that filter airborne pollutants through deposition, uptake, fixing and storage[413].

The US Forest Service reported research demonstrating that in buffel grass pastures "[s]oil loss caused by hydrologic factors is positively correlated with plant density, soil surface micro-relief, and erosion features. It correlates negatively with soil crust development and pasture management index…analyses make evident the effect that soil surface erosion features, pasture management practices, and density of buffel grass plants have on the soil loss rates of these grazing lands."[414]

Research into the medium-long term impacts of buffel grass invasion on dust pollution is required.

CONSEQUENCES FOR HEALTH AND ATTRIBUTABLE BURDEN OF DISEASE

INFECTIOUS DISEASE RISK

Microorganisms are transported with desert dust particles. A systematic review of the association between non-anthropogenic desert dust pollution, dust microorganisms, and human health found a significant association of dust events with infectious disease outbreaks, most outbreaks investigated were respiratory tract infections[415]. A recent study found that dust storms can not only significantly enhance the spread of potential pathogens and but also transport multidrug resistant genes[416].

See Also Box 5 – Health Impacts of Particulate Matter.

HEALTH ECONOMIC IMPACTS

The economic impact related specifically to the health impacts of dust associated with buffel grass invasion has not been measured.

A recent review of the literature related to health benefits derived from air filtration conducted by the AHIW showed air filtration provided by vegetation led to substantial avoided health care costs in all cases[417].

BOX 5 - HEALTH IMPACTS OF PARTICULATE MATTER

Particulate matter represents the main component of dust and bush fire smoke[418] and poses the primary threat to health. Particulate matter is a complex and heterogeneous mixture of organic and inorganic solid particles and liquid droplets suspended in air that vary in chemical composition[419]. Particulate matter is classified according to size:

- PM_{10} – particles smaller than 10 microns in diameter. These contribute to visible dust and smoke haze, can irritate the eyes, throat and lungs[420].
- $PM_{2.5}$ – particles smaller than 2.5 microns in diameter. These particles are too small to be seen. When inhaled, $PM_{2.5}$ can penetrate disrupted epithelial layers of a person's lungs, enter the bloodstream and trigger oxidative stress and systemic inflammation within the cardiovascular system and organs such as the kidneys[421] [422] [423] [424]. $PM_{2.5}$ may also directly enter the brain and central nervous system via the olfactory mucosa that separates the nose from the brain[425].

SHORT TERM EFFECTS

The inhalation of particulate matter (PM) can irritate the lining of the nasal cavity, thereby inducing runny nose and cough.

Respiratory

Inhaled PM can also travel deep down the airways and enter the lungs, thus triggering inflammation and causing shortness of breath, as well as worsening pre-existing respiratory diseases such as asthma and COPD[426].

LONG TERM EFFECTS

Cardiovascular

When $PM_{2.5}$ cross from the lungs into the bloodstream in vulnerable people they can contribute to inflammation and narrowing of blood vessels, as well as increasing the chance of blood clots. While the evidence for an association between air pollution from bushfire smoke and heart, stroke and vascular conditions not as comprehensive as for respiratory conditions, several studies have found associations [427] [428] [429].

Type 2 Diabetes Mellitus

Exposure to air pollution can significantly worsen the management of Type 2 Diabetes Mellitus. The fine particulate matter can negatively impact blood glucose levels and increase the risks due to its inflammatory effects on the body [430].

A multinational study that included Australia found that compared with non-bushfire $PM_{2.5}$, bushfire-specific $PM_{2.5}$ posed greater risks of all-cause, type 1, and type 2 diabetes and were responsible for 38.7% of $PM_{2.5}$-related diabetes hospitalizations, with Australia having one of the highest observed associations[431].

Haemodialysis

Bushfire fire smoke exposure has been positively associated with all-cause mortality among patients receiving haemodialysis[432].

DUST AND SMOKE - ATTRIBUTABLE BURDEN OF DISEASE

Data on the burden of disease attributable to dust and smoke related to buffel grass invasion in central Australia is not currently available.

The Australian Burden of Disease Study 2018 showed that outdoor $PM_{2.5}$ is a significant environmental risk factor in Australia, responsible for 1.8% of the total burden of disease, and 1.4% for First Nations peoples[433].

Socio-economic disadvantage, existing chronic cardiovascular and respiratory disease, and diabetes increases the impact of particulate air pollution on health outcomes [434]. First Nations peoples have a high prevalence of

these health risks and have been recognised as more likely to be at greater risk from poor air quality than other Australians[435].

Remote Aboriginal Australian communities are likely to be exposed to high levels of fine particulate matter, in remote communities in arid regions of Australia, air quality targets are regularly surpassed[436]

For more details see Appendix B Table 5 – Air pollution.

AIR QUALITY IMPACTS RELATED TO BUFFEL GRASS MANAGEMENT

HERBICIDES

Herbicides (glyphosate and flupropanate) released to the air from aerial and ground equipment have the potential for downwind transport. Aerial applications may result in considerable transport depending on climate conditions. Wind erosion is one pathway in which herbicides, are transported into the atmosphere[437] [438].

Glyphosate has been detected in dust samples from homes near glyphosate application sites[439].

BURNING

See *Section 3.2 – Fire*.

SLASHING / GRAZING

Grazing and slashing is sometimes used to reduce buffel grass fuel loads. (Grazing / slashing should be followed up with herbicide application otherwise it is counterproductive in the mid-long term though this follow up often does not occur)[440].

Grazing strongly associated with wind driven soil erosion[441].

HEALTH ECONOMIC IMPACTS

The economic impact of air pollution attributable to buffel grass invasion has not been measured.

In 2018-19 health spending attributable to air pollution in Australia was $352 million (for more details see Appendix B Table #5 – Air Pollution).

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

GLOBAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
World Health Organisation	The WHO states that to protect respiratory health, people should have access to safe environments free from risk factors such as allergens, smoke and dust[442].
GAR Special Report 2023: Mapping resilience for the Sustainable Development Goals	Resilience deficit 7. Increased air pollution and mortality

[443]	

NATIONAL

The Federal department of health has committed to supporting programs and initiatives that help prevent respiratory diseases[444].

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
National Clean Air Agreement[445]	Desired Outcomes: • Human and environmental health outcomes are improved through actions implemented. • Communities are empowered to better deal with air pollution through greater awareness of air quality issues and access to reliable information. • Air quality policy development and implementation is underpinned by up-to-date and robust information and evidence.
The National Asthma Strategy 2018[446]	This Strategy is "Aligned with the National Strategic Framework for Chronic Conditions, and the Implementation Plan for the National Aboriginal and Torres Strait Islander Health Plan 2013-2023, the Strategy outlines a targeted and comprehensive approach to optimise asthma diagnosis and management. With an emphasis on Aboriginal and Torres Strait Islander people and other priority populations". Sections particularly relevant to better management of buffel grass include: *Section 4.2* Raise awareness for exposures that can trigger asthma symptoms and flare ups and drive policy and practice change to reduce exposure to known agents harmful to asthma. *Research agenda priority areas 5.1* The social and environmental determinants of asthma, particularly in priority populations including Aboriginal and Torres Strait Islander people.
Environmental Health Standing Committee: Guidance for public health agencies *Managing prolonged smoke events from landscape fires*[447]	Aims to support a nationally consistent approach to the health protection measures advised by public health agencies when landscape fires cause community smoke impacts lasting for a prolonged period (typically more than two to three days).

3.2. FIRE

BUFFEL GRASS INVASION AND FIRES

Buffel grass has an extremely high fuel load, up to five times that of native vegetation. Fires fuelled by buffel grass ignite easily, are hotter, more frequent, and cover very large areas with a uniform intensity[448].

Buffel grass is well adapted to such fires which form a positive feedback loop for the plant, favouring its own regeneration and significantly accelerating its modification of the invaded system [449, 450, 451 452].

Buffel invasion also impacts natural fuel reduction activities by reducing numbers of native animals, many of which would process fuel loads through eating, scratching/clearing, digging/burying and moving plant matter[453], as well as inhibiting the ability of people to carry out traditional fire management[454].

CONSEQUENCES FOR HEALTH

The health effects of bushfires include physical, mental, social and cultural effects.

POLLUTION

See sections:

- 3.1.2 Air Quality – Smoke and Dust
- 2.4 Water Supply
- 3.5 Soil.

DIOXINS

Dioxins, furans and dioxin-like PCBs are a group of chemicals which are highly persistent in the environment and which can pollute the soil and air and accumulate in the bodies of animals. If exposure to these chemicals is sufficiently extensive, they can cause a range of toxic effects in animals and humans, including skin lesions, reproductive disorders and cancer[455].

A major study on bushfires in Australia showed that prescribed burning and wildfires may account for around 20-30% of total dioxin emissions to the environment. Savannah fires in northern Australia account for 83% of these emissions[456].

INJURY

Buffel grass fires burn very hot – they have been recorded at 900°C [457] and can produce large flames and generate more than enough heat to quickly destroy giant trees like river red gums, buildings and even crack bedrock[458]. These fires fuelled fires can cause serious injury and death. Physical injuries can occur during firefighting efforts, evacuations, and from burns caused directly by the fire.

Grass fires are particularly dangerous because of their rapid growth, speed, and unpredictability[459]. Standing grass is:

- surrounded by oxygen so the fire can ignite easily and grow rapidly
- directly affected by wind speed and direction so can fires spread very quickly over many kilometres.
- a slight wind change can steer the fire in many different directions.

MENTAL HEALTH

Bushfires can trigger new, and exacerbate existing mental health problems[460]..

Bushfires impact the mental health of responders and the wider community[461]. Lived experience of bushfire has been found to increase the occurrence of psychological and behavioural disorders such as anxiety, depression, post-traumatic stress disorder and substance misuse. The effects can persist for years after the impact[462].

ATTRIBUTABLE BURDEN OF DISEASE

Specific data directly linking wildfires to health burdens in central Australia is not available and requires localised studies, the broader Australian context highlights significant health challenges posed by wildfires.

A recent estimate of the burden of bushfires in Australia over 10 years from 2021 to 2030[463] predicted:

- 2,418 lives would be lost to bushfires
- 8,590 years of life would be lost.

HEALTH ECONOMIC IMPACTS

The health and environmental impacts of bushfires results in substantial economic costs to society. A recent estimate of the burden of bushfires in Australia over 10 years from 2021 to 2030 predicted[464]:

- Healthcare costs arising from deaths for smoke-related conditions, hospitalizations would amount to $110 million.
- The impact on gross domestic product (GDP) totalled AUD $17.2 billion.
- A hypothetical intervention that reduces the impact of bushfires by 10% would save $11 million in healthcare costs and $1.9 billion in GDP.

Costs also include the lost benefits and opportunities that buffel grass invasion has on interfering with traditional fire management regimes. A study conducted in northern Australia[465]

- Assessed the total value of well-being benefits, at AU $280.40 million a year, for Indigenous peoples who play a vital role in managing fire.
- Emphasised the importance of Indigenous land and fire management practices for informing health, social, economic and other policy sectors.
- Supported payments for ecosystem services mechanisms to enhance Indigenous well-being and conserve rapidly degrading natural resources.

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
UN Global Assessment Report on Disaster Risk Reduction 2022 (GAR)[466]	To accelerate essential risk reduction and resilience building, GAR2022 calls for action to: 1. Measure what we value. 2. Design systems to factor in how human minds make decisions about risk. 3. Reconfigure governance and financial systems to work across silos and design in consultation with affected people.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
Intergovernmental agreement on bushfires, floods and extreme events[467]	Aims to improve forecasts and warnings.

National Disaster Risk Reduction Framework[468]	Purpose - The National Disaster Risk Reduction Framework ('the framework') guides national, whole-of-society efforts to proactively reduce disaster risk in order to minimise the loss and suffering caused by disasters.
National Health Emergency Response Arrangements[469]	4.1.1 Office of Health Protection. The Office of Health Protection (OHP) is a division within DoHA with the objective to manage, prevent and respond to health risks faced by the Australian population. OHP leads the prevention policy agenda at a national level. OHP designs and implements evidence-based and targeted programs, which contribute to the sustainability of the Australian health system by reducing preventable illness and mortality during an emergency. OHP supports the administration of the AHPC and maintains the National Incident Room (NIR).

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
Alice Springs Regional Bushfire Management Plan[470]	Nil
Health disaster management[471]	NT Health is responsible for two key functional groups in the Northern Territory's (NT) emergency management arrangements - the Medical Response Group and the Public Health Response and Recovery Group.

3.3. CLIMATE

Climate change in central Australia is increasing the occurrence of extreme climatic conditions including:

- Higher mean temperatures
- Increased heavy rainfall with decreased effective rainfall (the amount of rain that soaks into the ground and is available for plants to use)
- Extended droughts.

These extreme conditions are associated with natural disasters including fires and floods[472] [473] [474].

BUFFEL GRASS INVASION AND CLIMATE

Buffel grass invasion reduces plant diversity and alters ecosystem functions. This disrupts carbon and nutrient cycling processes that are important for regulating the climate. For more see Appendix C – Supporting Services.

BUFFEL GRASS - GREENHOUSE GAS (GHG) EMISSIONS

In areas of central Australia where buffel grass displaces native vegetation, there is likely to be a positive net ecosystem GHG exchange (more GHGs will be released into the atmosphere than are absorbed) based on the following:

Intrinsic net carbon exchange

Buffel grass has been found to exhibit a positive net CO_2 exchange (it releases more carbon into the atmosphere than it absorbs) though after rain events that result in substantially increased biomass buffel grass may reach a negative net CO_2 exchange for short periods (approximately 20 days)[475].

Fires

Buffel grass promotes more frequent and intense fires compared to native vegetation. These fires release large amounts of GHG emissions into the atmosphere. The balance of central Australia may be most changed when woodlands are altered to become frequently burnt grasslands[476].

Vegetation

Buffel grass invasion destroys native plants including trees, shrubs, ground story plants. This diversity of plants play a critical role in maintaining the carbon balance, especially in drought conditions and across seasons[477].

Soil

Buffel grass invasion decreases native plant biodiversity and alters nutrient cycling, which progressively affects soil carbon storage dynamics.

A study on carbon sequestration potential of semi-arid mulga lands of Australia found that the carbon contents of soil under mulga were significantly greater in the top 5 cm compared to areas cleared and sown to buffel grass pasture for 20 years[478]. Other studies found soil organic carbon is maintained, but soil nitrogen may decline, this impacts long-term carbon sequestration potential[479].

Beef production

The main reason buffel grass has been planted and spread is to support the beef industry. There is a fundamental conflict between maintaining this agricultural activity in inland Australia and balancing GHG emissions. Each step of beef production, including transportation, growth, processing, distribution, preparation, consumption and disposal, emits high amounts of GHGs[480].

Enteric methane (CH_4) is a greenhouse gas that is produced when ruminant animals digest food. In Australia a large proportion of agricultural GHG emissions are enteric methane[481]. Buffel grass is low in protein quality and high in fiber content. When grazed it is likely to result in higher methane from enteric fermentation relative to other grasses[482]. Studies have found enteric methane mitigation potential (up to 90% for some species) in native Australian forage[483] [484] [485].

Almost all the beef produced in central Australia is exported long distances interstate or overseas. Most of it is live exported[486]. These exports contribute to GHG emissions through fuel consumption.

BUFFEL GRASS INVASION AND THE THREATS POSED BY CLIMATE CHANGE

Climate change is predicted to increase the threat posed by buffel grass invasion in central Australia[487] [488] [489] [490] [491]

UNDERMINES CLIMATE CHANGE ADAPTION RESPONSES

The shifts in fire regimes and vegetation and soil structures that come with buffel grass invasion disrupts entire ecosystem function making it far more difficult for people to adapt and survive under changing climate conditions. Buffel grass monocultures may become more unstable with climatic variability, potentially giving rise to unvegetated states, whereby buffel grass invasion is followed by drought, grass mortality and intense soil erosion[492].

For impacts related to fire and flooding see sections *3.2 – Fire* and *3.4 – Water Regulation*

BOX 6 - HEAT

Buffel grass response to heat

As a C_4 plant buffel grass is considered to have an advantage in warmer climates because it can adjust its CO_2 assimilation rates and photosynthesis in response to higher temperatures[493].

Research has shown that CO_2 uptake and water use efficiency are great at day/night temperatures 30/20°C and decreases at higher temperatures until death at 45/35°C day/night temperature though it has been known to survive day temperatures approaching 50°C[494].

How buffel grass invasion undermines ways of coping with extreme heat

Buffel grass invasion destroys tree cover. This loss of canopy shading increases surface temperatures and evaporation[495].

Destroys refugia including riparian areas and ground water dependent ecosystems. See Section *2.4 Water Supply*.

Social and cultural adaptations to hot weather are potentially powerful mechanisms for protecting human health.

In central Australia the continuous culture that has inhabited it for tens of thousands of years has faced times of extreme climate change and heat. The author of this paper had the privilege of spending a few days in a car listening to two senior Ketyetye Warlpiri women discussing climate change preparations and what they knew about how their ancestors coped with extreme heat. This included knowing where to go, what soils to burrow into, what plants to overlay yourself with.

The impacts of buffel grass invasion on culture (see Section 1) and raw material (see Section 2.3) may interfere with many of these adaptations.

Health Impacts

Exposure to extreme or prolonged heat can have social, mental and physical impacts ranging from rashes to mild heat stroke to death. Heat can exacerbate chronic diseases, impact treatment, lead to injuries and increase risk of violence [496] [497]:[498] [499] [500] [501] [502] [503].

Burden of Disease

Heat is the most frequent cause of extreme weather-related injury hospitalisations and deaths in Australia[504].

A study on the impacts of heat in central Australia published in 2023 found non-Indigenous people in the Northern Territory were 18% more likely to die in hot weather than First Nations peoples despite First Nations severe health disadvantages[505].

However, this is not to say First Nations peoples are not impacted by extreme temperature as Josie Douglas, a Wardaman woman and Executive Director of Policy at the Central Land Council states[506]:

"Central Australian Aboriginal people are very resilient. They have evolved to cope with the harsh and variable desert climate, but there are limits"

The Northern Territory Department of Health is working on a project which aims to establish a public health surveillance and response system for extreme heat events in the NT[507].

BOX 7 – DROUGHT

Buffel grass response to drought

Tolerates wide ranging annual rainfall averages, establishing in regions that receive less than 250 mm of rainfall, annually[508].

Health Impacts

The pathways which drought can impact health mainly involve indirect connections including those associated with food insecurity (see section 2.1) water scarcity (see section 2.4) and dust (see section 3.1)[509].

Burden of Disease

The burned of disease associated with drought in central Australia has not been measured but it is likely to disproportionately impact First Nations, remote and low socioeconomic groups who are already at higher risk of food insecurity and unsafe water supply and have a higher burden of diseases that drought conditions may exacerbate. For more see food insecurity (see section 2.1) water scarcity (see section 2.4)

BOX 8 - MIGRATION, PLANNED RELOCATION AND FORCED DISPLACEMENT

Migration from and within central Australia is being (and will increasingly be) influenced by climate change[510,511].

Buffel grass significantly decreases the places where people can find refuge in terms of protecting from heat, safe water supply and food.

Burden of disease

The burden that climate-related migration on people's health is related to their levels of place attachment and place identification

Health impacts

Health issues related to climate-induced migration can include:

- Psychosocial ill-health
- Food insecurity
- Inadequate housing/shelter
- Inadequate access to services[512] [513]

Josie Douglas, a Wardaman woman and Executive Director of Policy at the Central Land Council states[514]:

"Without action to stop climate change, people will be forced to leave their country and leave behind much of what makes them Aboriginal. Climate change is a clear and present threat to the survival of our people and their culture."

- The population of central Australian includes a large proportion of people that have a very low level of place attachment and identification, as many as two thirds of the population choose to stay less than 5 years[515] [516].
- Most First Nations peoples have an extremely close physical and spiritual relationships with their Country (traditional homelands) and are therefore disproportionately affected by the impacts of forced migration and displacement[517,518,519].

HEALTH ECONOMIC IMPACTS

The economic cost of natural disasters in Australia exceeded $9 billion in 2015[520].

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
United Nations Framework Convention on Climate Change (UNFCCC)	Article 2 – main objective of the convention is stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The treaty calls for continuing scientific research into the climate. Aims: • allow ecosystems to adapt to climate change • ensure there are no threats to food production
Paris Agreement	Overarching goal to pursue efforts "to limit the temperature increase to 1.5C above pre-industrial levels."
Intergovernmental Panel on Climate Change (IPCC)	United Nations body for assessing the science related to climate change.
Alliance for Transformative Action on Climate and Health	Community of Practice Network hosted by the World Health Organisation Provide practical guidance, tools and other material to support implementation of COP26 commitments.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
National Health and Climate Strategy[521]	Objective 4: Health in all policies Support healthy, climate-resilient and sustainable communities through whole-of-government action Principles 1: Health Equity and the Right to Health Principle 2: One Health and Planetary Health Principle 3: First Nations Leadership Principle 4: Population Health and Prevention

	Principle 5: Evidence Informed Policymaking.
National Climate Change and Health Framework (NCCHF)[522]	Adopts a 'Health in All Policies' perspective, recognising that collaboration across different policy areas is crucial to the development of just and equitable responses to address the impact of climate change on health.

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE
Climate Change Response: Towards 2050[523]	Action Item 2.5.1 Identify and prioritise risks to human health associated with climate change 3.1 Community/environment

3.4. WATER REGULATION

BUFFEL GRASS INVASION IMPACT ON WATER REGULATION

WATER AVAILABILITY AND QUALITY

See section 2.4 Provisioning - Water Supply

FLOODING

Long-term observations show that floods will become more severe in central Australia[524].

Large and dense populations of buffel grass impede overland flow of water, increasing the extent of local flooding[525].

In colonising and stabilising otherwise unstable sand 'islands' in arid river beds buffel grass may lead to choking of river channels and an increase in flooding of the surrounding plains[526].

Buffel grass's own tolerance for flooding depends on the duration and depth of the flood. The grass generally does not tolerate extended periods or complete submersion. One source states that "in Australia five days of continuous flooding resulted in no loss of C. ciliaris, while twenty days of flooding resulted in a loss of 20-85% [527]. The plants must be completely submerged for flooding to be effective, and taller varieties appear to be more flood tolerant and several Buffel cultivars have been developed to withstand flooding [528].

CONSEQUENCES FOR HEALTH

The health impacts of floods are wide ranging, and depend on a number of factors. Health impacts can include[529] [530] [531]:

- Immediate - drowning, injuries, and animal bites (due to displaced and scared animals).
- Medium term - infected wounds, complications of injury, poisoning, poor mental health, communicable diseases, and food insecurity.
- Long term - chronic disease, disability, poor mental health, and poverty-related diseases including malnutrition[532].

Heavy rainfall and flooding can affect the quality of water resources, for example through pollution with run-off. For more see section 2.4 Provision – Water Quality.

There are also health risks associated with the evacuation of patients, loss of health workers, and loss of health infrastructure including essential drugs and supplies[533].

ATTRIBUTABLE BURDEN OF DISEASE

Remoteness increases risk of death from flooding. Widespread flooding contributed to a notable rise in the rate of unintentional drowning deaths in Remote and Very remote areas between 2015–16 and 2016–17[534].

HEALTH ECONOMIC IMPACTS

Healthcare costs are predicted to rise significantly due to the increased physical and mental health impacts of flooding events[535].

Healthcare systems and infrastructure are vulnerable to flooding. For example, floods may compromise health care delivery through damage to buildings, interruption of supply chains, and power outages.

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Associated Programme on Flood Management[536]	Supports countries in the implementation of Integrated Flood Management (IFM) within the overall framework of Integrated Water Resources Management (IWRM) to maximize net benefits from the use of floodplains and to minimize loss of life and impacts.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management[537] in Australia.	1.2.3 A proactive approach involves actively managing the risks of occupying the floodplain.

3.5. EROSION

BUFFEL GRASS AND EROSION

Soil erosion is the process of detachment and subsequent removal of soil particles and small aggregates from land surfaces[538].

Root Structure

A rationale for planting buffel grass is that the extensive root system enables it to bind soil, reducing erosion caused by industrial activity, including stocking[539] [540].

However, as it spreads and forms monocultures buffel grass displaces and destroys native plants that may have deeper root systems and greater soil-binding capacity (through the comparative soil binding capacity of native vegetation and buffel grass has not been studied in central Australia).

Wind

Soil erosion by wind is enabled above a critical value of shear velocity at which the aerodynamic force is enough to dislodge particles from the surface[541]. The reduction in the diversity of ground, mid and upper storey vegetation that results from buffel grass invasion removes:

- Barriers that physically alter the pathways through which airborne particles travel; and,
- Buffers that filter airborne pollutants through deposition, uptake, fixing and storage[542].

Water

Forest Service U.S. Department of Agriculture proceedings found research demonstrating that in buffel grass pastures soil loss caused by hydrologic factors is:

- Positively correlated with plant density, soil surface micro-relief, and erosion features
- Negatively correlated with soil crust development and pasture management index.[543]

Fire

Buffel grass is highly flammable and can increase the frequency and intensity of fires[544]. Post-fire, the loss of above-ground biomass and changes in vegetation structure can leave soil surfaces vulnerable to erosion by wind and water[545] [546].

CONSEQUENCES FOR HEALTH

See sections

3.1 Regulation – Air Quality – Dust

2.4 Provisioning – Water Supply

4.1 Supporting - Soil

3.6. PESTS AND DISEASES

BUFFEL GRASS INVASION IMPACT ON PESTS AND DISEASES

Buffel grass transforms ecosystems and reduced biodiversity[547]. Intact ecosystems and biodiversity protect against the emergence and spread of diseases that harm humans, plants and animals. The mechanism for this are complex, they include: [548] [549] [550] [551]

- Natural predator, parasites and pathogen regulation that balance populations: predators feed on other species, reducing their numbers and mitigating damage. Species abundance is particularly important for pest regulation[552] [553].
- Diverse habitats and landscapes create physical barriers and segmented environments that limit the movement and spread of pests and pathogens[554].
- Ecosystems regulate microclimates, influencing temperature, humidity, and moisture levels. Optimal microclimates for pests and pathogens may be disrupted or moderated by natural vegetation, limiting their proliferation[555].
- Soil microbes and fungi can suppress or compete with plant pathogens, reducing disease incidence[556]. Studies in central Australia show buffel grass changes the composition of the microbiome[557] [558].
- Healthy ecosystems are more resilient to environmental stresses such as extreme weather events and increase regenerative capacity after natural disasters[559].

BUFFEL GRASS MANAGEMENT

Pests and diseases may potentially be introduced as:

1. A biological control for buffel grass[560]
2. To control that pests and diseases that threaten buffel grass[561].

CONSEQUENCES FOR HEALTH

Pests and diseases can have significant health impacts on human populations, affecting individuals directly through infectious diseases or indirectly through impacts on food security, and the environment.

According to the 2022 Australian State of the Environment report, the emergence of pandemics is "entirely driven by human activities, which disrupt natural interactions between species and their microbes"[562].

BURDEN OF DISEASE

The epidemiology of pests and diseases related to buffel grass invasion in central Australia that directly impact humans has not been studied. However, it is well established that changes in ecosystems and biodiversity are associated with changes in disease prevalence[563].

HEALTH ECONOMIC IMPACTS

The health economic impacts of pests and diseases related to buffel grass invasion in central Australia has not been investigated.

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
International Health Regulations[564]	Obligates signatory countries including Australia to develop and maintain capacities for disease surveillance, risk assessment and response.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Outbreak[565]	Alerts and advice on how to respond to, prevent and prepare for plant pests and disease outbreaks
Plant Pests and Diseases[566]	Information and resources

TERRITORY

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Plant pests and diseases[567]	Reporting and advice

3.7. POLLINATION

Pollination is the transfer of pollen (a fine powder that plants produce as part of their reproductive process. Pollen is made up of tiny seeds that can be carried by agents or vector). Pollination allows flowering plants to

reproduce and enables them to produce seeds and fruit[568]. This is essential for the continuation of many flowering plants species found in central Australia[569].

Pollinating agents or vectors can be:

- Biotic (insects such as bees, beetles, butterflies, wasps, moths and ants, birds such as parrots, reptiles such as skinks and mammals such as bats)
- Abiotic (wind and rain)[570,571].

Buffel grass does not need biotic vectors to pollinate[572] but many native plants do, including those important for culture and that people use for food and medicine in central Australia.

BUFFEL GRASS INVASION IMPACT ON POLLINATION

Camille Dobson, an Eastern Arrernte woman describes the impact of buffel grass on native bee populations in central Australia, she quotes her mother Veronica Dobson who is a senior Eastern Arrernte woman and renowned botantist and ecologist:

> *"It's really sad to see what buffel is doing, it's really a mono-ecology. One of the big things was when we were kids we used to go out with the uncles and the aunties and they used to get honey from the trees you'd see bees everywhere, you'd go into the creeks and wherever there was a hollow there was basically a nest of bees but we don't see the same thing anymore and mum always says "Oh, you never see bees hanging around buffel plants" The buffel flowers because they don't need bees and so we see a reduction in the bees. Everything is reducing because the buffel is just taking over everything".*

The impacts of buffel grass on pollination results largely from its negative impacts on biotic agents [573,574,575, 576, 577, 578, 579, 580]. These impacts are associated with a number of processes:

Competitive exclusion

Buffel grass forms dense monocultures outcompeting native plant species for resources such as water, nutrients and sunlight[581]. The consequent reduction in plant diversity can diminish the availability of flowering plants that provide nectar and pollen for pollinators.

Altered habitat structure

The growth of buffel grass can alter the physical structure of habitats, reducing the availability of suitable nesting sites shelter and water sources for pollinators. Changes in vegetation structure composition may disrupt the behaviour of pollinators.

Feedback loops

More mobile pollinators may move to 'cleaner' sites rather than try to find very sparse flowers amongst a sea of buffel grass. If there are fewer pollinators, seed set is also likely to be impacted. Fewer seeds set will result in a reduced seed bank, which will in turn impact recruitment of these species[582] .

Indirect effects

Buffel grass can indirectly affect pollination by influencing ecosystem processes, such as nutrient and water cycling, and predator-prey interactions. These indirect effects can further impact the abundance and distribution of plants and pollinators in invaded ecosystems.

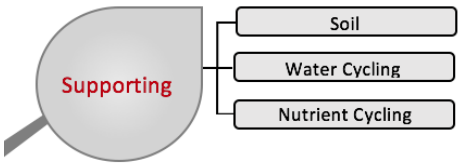
Buffel grass management techniques such as mowing, grazing, digging and use of herbicides can also potentially negatively impact pollinators.

HEALTH IMPACTS

For the health impacts related to buffel grass invasion's impact on pollinators see *Section 1 - Culture and Section 2 – Provisioning.*

4. SUPPORTING

Supporting ecosystem services maintain the conditions for life on Earth include soil, nutrient and water cycling.



4.1 SOIL

"Soil silently provide us with almost all ecosystem services and functions that enable life to exist on Earth.[583]"

These services include[584]:

- Cleaning, filtering and storing water
- Recycling nutrients
- Removing carbon dioxide and other gases from the atmosphere. (Soils constitute the largest terrestrial carbon pool and play a crucial role in the global carbon balance by regulating dynamic biogeochemical processes and the exchange of greenhouse gases with the atmosphere. The top one metre of soil contains nearly twice the quantity of atmospheric carbon and over twice as much as is stored in vegetation.)
- Hosting about 25% of animal species on Earth.

Soil is a physical, chemical and biological matrix, it is the most complex biological material on the planet and one of the most biologically rich and diverse habitats on earth. One teaspoon of soil contains billions of living organisms. Soil formation is a slow and complex process, but degradation can happen quickly. Soil is essentially a non-renewable resource [585].

BUFFEL GRASS INVASION AND SOIL FERTILITY

Buffel grass affects soil in a number of ways:

- Causing erosion – see section 3.8
- Directly or indirectly modifying the soil microbiome[586], soil anthropods (such as ants and termites)[587] and other animals such as mammals[588] that influence soil formation
- Reducing soil nitrogen and exhausting the mineral pool[589]
- Preventing growth of other plants through allelopathic suppression (Allelopathic plants release chemical compounds from their roots into the soil, and these chemicals suppress or kill the neighbouring plants when they are absorbed)[590].

FIRE

For fire and erosion see section 3.8.

Fire typically results in the reduction of fuel and soil organic nutrient pools by oxidation, volatilisation, convection, leaching, and erosion of nutrients from a site[591].

Impact of Fire Intensity and Frequency

- Intense bushfires such as those fuelled by buffel grass generally considered to have more impact on soil erosion than lower intensity fires[592].
- For any given burn severity, soils that are the most susceptible to erosion are erodible sandy soils or soils, that are thin, stony, and massive, with high bulk density.[593]

BUFFEL GRASS MANAGEMENT

Some forms of buffel grass management can negatively impact soil:
- Grazing - compaction, erosion and contamination
- Burning – see content on fire above
- Herbicides – potential poisoning of lifeforms that exist in soils.

HEALTH IMPACTS

"A nation that destroys its soils destroys itself."

Quote attributed to Franklin D Roosevelt in the context of the Dust Bowl of the 1930's.

DIRECT

Low-level exposure to the natural microbial diversity of healthy soil is increasingly seen as necessary for the priming and education of the immune system in infants and for maintaining immune fitness into adulthood.

For health impacts related to soil erosion and dust see section 3.1 – Air Quality.

INDIRECT

Soil supports:

- 95% of the world's food production. The United Nations Food and Agricultural Organisation has declared soil nutrition as the basis for human nutrition. Soil nutrients provide the food needed for plants and animals to survive, and these nutrients are transferred to humans once consumed[594].

- Fibre production

- Water storage and filtration. Contaminants are removed by soil through physical capture as water moves through pore spaces, through chemical sorption to solid surfaces, and through biodegradation carried out by microorganisms living in the soil[595].

- Resilience against the impact of natural disasters[596] including floods, droughts, landslides and sand/dust storms and fires and protect[597] through providing services such as:
    - promoting water flow through the soil
    - decomposing litter
    - mineralising nutrients.

- Ongoing First Nations traditions and deep cultural relationships with Country.

MEDICINES

Soil is also the source of many medicines such as antibiotics, anticancer, anti-inflammatory and immunosuppressant drugs[598].

HEALTH ECONOMIC IMPACTS

The benefits of sustainable soil management are well understood and far outweigh the costs associated with the impacts of soil degradation. It is less expensive to adopt sustainable soil management practices to maintain soil health than to remediate soil after it has been degraded[599].

The Australian Government is working on an environmental-economic accounting framework which organises information to better understand to better quantify in economic terms the value of all services that soil provides and how the environment, including soil, and the economy interact[600].

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION - SOIL

INTERNATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
World Soils Charter[601]	Soils are fundamental to life on Earth but human pressures on soil resources are reaching critical limits. Careful soil management is one essential element of sustainable agriculture and also provides a valuable lever for climate regulation and a pathway for safeguarding ecosystem services and biodiversity.

NATIONAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
National Soil Strategy [602]	"Soil health is linked to nutrition and food security, contamination, pharmaceuticals and mental, respiratory and immune health".

POLICY GUIDANCE ON RESPONSE TO BUFFEL GRASS INVASION – SUPPORTIVE ENVIRONMENTS

GLOBAL

DOCUMENT	GUIDANCE ON HEALTH SERVICE RESPONSE TO BUFFEL GRASS INVASION
Ottawa Charter	The concept of supportive environments is one of the Ottawa Charter's five core action areas.
UN Sundsvall statement	"A supportive environment is of paramount importance for health. The two are interdependent and inseparable. We urge that the achievement of both be made central objectives in the setting of priorities for development, and be given precedence in resolving competing interests in the everyday management of government policies".

4.2 WATER AND NUTRIENT CYCLING

The water, or hydrologic cycle, is the continuous movement of water on, above and below the earths surface. Key processes include evaporation, transpiration (water released from plants), condensation precipitation, infiltration and runoff.

Nutrient cycling is the continuous movement and reuse of essential elements like carbon, nitrogen and phosphorus between living organisms and their non-living environment within an ecosystem[603].

BUFFEL GRASS IMPACTS ON WATER AND NUTRIENT CYCLING

Buffel grass invasion causes catastrophic biodiversity loss and ecosystem destruction[604]. Through a multitude of processes buffel grass transforms complex and diverse ecosystems into frequently burnt buffel grass monocultures. This can result in serious disruption of water and nutrient cycling and ultimately cause desertification [605,606].

Buffel grass:

- Invades diverse environments including grasslands, riparian zones, sand plains and rocky outcrops, displacing native grasses and small plants[607].
- Dominates light and space, reducing opportunities for native vegetation, including trees, to establish.
- Reduces soil nitrogen and exhausts the mineral pool, preventing growth through allelopathic suppression. [608 609].
- Has an extremely high fuel load and rapidly regrows after fire. Buffel grass causes very hot, widespread, frequent fires[610] which consume large amounts of biomass, alter soil properties, and substantially impact key ecosystem processes, influencing hydrological and biochemical cycles[611 612 613].
- Can erode soils by changing surface wind velocities [614] and water flows[615 616 617 618 619].
- In waterholes, rivers and floodplains changes surface water flows and severely damages aquatic ecosystems.[620] Buffel grass replaces riparian vegetation which affects bank stability, impairs ecosystem function, replaces traditional plants and creates conditions susceptible to fire[621].

For more on this, including related health impacts see *Section 2.4 Water Supply* and *Section 3.5 Erosion* and *4.1 Soil.*

APPENDIX A - STATEMENTS REGARDING THE IMPACT OF BUFFEL GRASS INVASION

STATEMENT ABOUT BUFFEL GRASS – BY RENE KULITJA ON BEHALF OF THE CUSTODIANS OF ULURU-KATA TJUTA, KATITI-PETERMANN AND WATARRKA

Kuwarila tjunguringu, piranpa munu anangu, munula tjukurpa pulka wangkanyi, palu pulkarala kulini panya nganampa pulka mulapa ngaranyi. Nganana tjituru-tjituru pulka panya nganampa manta winkingka buffel grass pulka pakanu, munu anu ngura winkikutu. Kala nyangapalunya nyanganyi nganana mukuringanyi pulkara nyangapalunya tjunguringkula ngananala wiyantjikitja buffel grass pulka pulkara warkaringkunytjikitja.

Irititjala kulini panya nganampa walytjapiti iriti nyinantja katja mama ngunytju kuntili paluru tjana nyinangi munuya para-ngarangi ngura winkingka, ma-pitjangi, ngalya-pitjangi, wati-pitjangi. Ngura wirungkaya para-pitjala nyangangi manta wirungka tjanpi tjuku-tjukungka, buffel grass wiyangka. Munuya kuka wakara ngalkuningi, minyma tjutangku manta tjawara mantjiningi.

Ka nyara-palula malangka, ngururpa, ngura wiru ngarangi panya, kuwaripatjara community, kuwari kutju missionaryngka nyinara, nyakunytja, tjitji tjutangku nyakunytja, ngura wiru, buffel grass wiya, putipulawa kutjupa kutjupa kutjupa wiru tjuta, winki wiru ngarangi. Ka anangu tjuta pukulpa nyinangi palu palula. Ka kuwari panya, kuwari ngaranyi, tjituru-tjituru pulka nganampa - buffel grass pulka. Tjungu tjungu tjungu pakanu, putu ankunytjaku, ma-pitjantjaku wiya patingku.

Nganana mitingi nganganka wangkangi panya kuka iritja tjuta, iriti nyinantja ankunytja malaku pitjantjaku, pulkarala mukuringanyi. Panya tjitji malatja-malatja tjutangku irititja tjuta nyakunytjaku. Kuka irititja tjutakula pulkara mukuringanyi. Nyaakula pulkara mukuringanyi? Wiya nganampa tjitji tjutangku ngurpangku nyakunytjakula mukuringanyi. Ka mitingi wiru tjungungkula tjunguringkula ngapartji ngapartji wangkara kulininginganampa mantangka ngurangka tjungungku palyantjikitjangku. Warka kutjupa kutjupa buffel grass kulukulu.

Pirukula kulininginganka irititjala tjinguru mantjilku munu nganampa ngurangka tjunkuku munula kulini palumpa tjanampa tjinguru mai wiya panya buffel grass-pangku manta uwankara angatjunu mai wiru tjuta pakalpai tjuta. Kuka panya irititja paluru tjana panya ngalkunytja ngalkunytja. Kala kuka mantjini, buffel grass kiliinanangi, kuka palumpa tjanampa pitjanyangka mai wiru tjutalta pakani, mantangkalta.

This week we've come together, some non-Aboriginal people together with we custodians, and we've been discussing matters of great import. It's come up during these discussions that we share a very significant concern. We are incredibly upset that buffel grass has spread across so much of our country, invading a multitude of places. And we have been coming to understand that we need to collaborate and work together to do the immense labour of trying to rid the country of the huge invasion of buffel grass.

We've been reflecting on the past and how our relatives lived, traveling around their country. The country they inhabited was abundant and beautiful, the ground was covered in various small grass species, not buffel grass. They hunted different kinds of meat and women would dig for meats that were underground.

Since that time, since the time of living in the healthy abundant country, more recently - before the establishment of communities and in the time of the missionaries - the children witnessed country that was in

its glory, before the arrival of buffel grass. There were all different kinds of wildflowers, a multitude of wonderful species. Our people lived very contentedly when it was like that. But now we are contending with an issue which brings us great sorrow - the invasion of buffel grass. It's choking up the land and preventing free movement, blocking the natural processes of the country.

In this meeting we have been discussing our passion for the reintroduction of special animals that used to live in our country but became locally extinct some time ago. We would love for our descendants to once again be able to experience these creatures. We feel very strongly about these animals. And why is that? We desire that our young people who have no experience with these important elements of our culture be able to become familiar with them. It's been a wonderful meeting, coming together and sharing a lot of different ideas about how we might collaborate with ecologists and others to achieve this on our country. There's a lot of work to do, and the control of buffel grass forms a part of that.

If we were to reintroduce these species back into our country, we are concerned that the buffel grass is having a large impact on the available food sources for them. Buffel grass grows where a lot of significant food sources used to grow. The kinds of foods that we know the locally extinct species used to eat. So eliminating buffel grass forms an important part of making a viable habitat for the return of these animals and the restoration of the food sources in the areas where they could again live.

BACKGROUND AND CONTEXT:

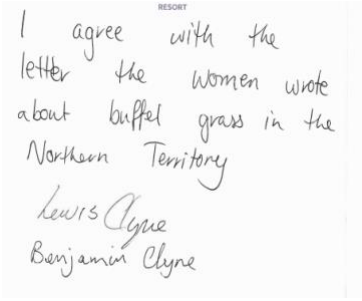
The problem of buffel grass was a strong theme that emerged during a 3- day consultation meeting with Anangu and non-indigenous ecologists facilitated by Parks Australia in August 2022 to discuss potential reintroductions of endangered mammals into Uluru-Kata Tjuta National Park (UKTNP). Discussion of buffel grass was not an intended focus of the meeting but considering the strong shared concerns expressed by Anangu throughout it was agreed a statement representing those concerns would be made separate from and after the meeting for the purpose of being shared with people who may have influence and be able to help Anangu in dealing with this problem.

Anangu present at the meeting (listed below) gave unanimous support for Rene Kulitja and the other women present at the meeting to make this statement reflecting the concerns discussed during the meeting. The recording of the statement was also supported by piranpa (non-indigenous) ecologists and land managers at the meeting. This statement was spoken in Pitjantjatjara to Dr Christine Schlesinger (buffel grass researcher, Charles Darwin University) and Beth Sometimes (interpreter) after the meeting closed and then transcribed and translated by Beth Sometimes.

ANANGU PRESENT ENDORSING THE STATEMENT:

Malya Teamay - - UKTNP Board member, Traditional owner , CLC Tjakura Ranger
Sammy Wilson - UKTNP Board member , Traditional owner
Rene Kulitja – UKTNP Board member, Traditional owner Director NPY WC , Director Maruku Arts , Member of the Central Australian Women's Choir
Elise Taylor - UKTNP Board member, Uluru Traditional owner
Cyril Mackenzie – Uluru traditional owner, Uluru Cultural Heritage Scientific Working Group member
Valarie Brumby - Mutitjulu Community Ranger, Traditional owner
Samantha Brumby - Mutitjulu Community Ranger, Traditional owner
Michael Cullinan – UKTNP NCR Ranger, Traditional owner
Malcom Coulthard – Mutitjulu Community Ranger
Lewis Clyne – Watarraka Traditional owner

Anne Lucky – Watarraka Traditional owner
Ben Clyne - Watarraka Traditional owner
Saddie Williams - Watarraka Traditional owner
Kevin Ungwanaka - Watarraka Traditional owner
Sonia Williams - Watarraka Traditional owner
Vera Williams - Watarraka Traditional owner
Daniel Breadon – CLC Tjakura Ranger
Glenn woods – CLC Tjakura Ranger
Bernard Bell – CLC Kaltukatjara Senior Ranger Katiti Petermann IPA
Raymond James - CLC Kaltukatjara Senior Ranger Katiti Petermann IPA Robin Kunia - CLC Kaltukatjara Senior Ranger Katiti Petermann IPA Philemon Kumantja- Katiti Petermann Traditional owner
Two participants particularly requested this, their own additional supporting statement be recorded and added:



YAMI LESTER TESTIMONY ABOUT BUFFEL GRASS

16 April 2012. Summarised translation from Pitjantjatjara by Linda Rive.

Buffel grass has taken over our lands, while Anangu culture has gone down. Raise this important issue at the next General Meeting. We need to be able to continue to keep control of our own land and culture. We are at risk of being smothered by outside forces, just as the environment is being smothered by buffel grass. Young people need to pay more attention to our traditional culture. When I think of how much we have lost and all we fought for, I despair. We are up against mining companies too. We have a three-day General Meeting coming up and I want this subject to be on the agenda. Our environment is being smothered by buffel grass - and whitefellas are smothering us too. They are proliferating like weeds on our lands. We are losing our biodiversity of pretty flowers and blossoms. It is not looking good on the lands. Our Tjukurpa continuity is broken now. The Government is intervening too much. I am sick now, just like the land and the Tjukurpa. We were once a healthy people with a healthy culture on a healthy land, but we are now the opposite.

CONTEXT FOR THE TESTIMONY PROVIDED BY LINDA RIVE:

There were still some radios around then, and Nganampa Health had reinstalled one at 3 Wilkinson Street and a few across the Lands, and Yami Lester had one. The idea was to keep using them because anybody could tune in if they wanted instead of it being private one to one on the mobile phone. A lot of communication power was lost when mobiles took over from the UHF radio.

So on that day, Punch Thompson came in to see me and said he wanted to talk to Yami Lester on the UHF radio so that anyone listening could hear and get the message that buffel grass was a serious problem and somebody needed to do something about it. I said to him, 'Well I really want to record that conversation.' and Punch said 'no problem. You record it and put it on Ara Irititja. We need to spread the word about buffel grass because it is

such a serious problem.' So that's what happened. So we went into the small radio room and Punch called up Yami, who always kept the radio beside him when he was at Walatinna, and they launched into this unscripted conversation. I recorded it and a NPYWC staff member took photos.

KAWAKI PUNCH THOMPSON TESTIMONY ABOUT BUFFEL GRASS

16 April 2012. Summarised translation from Pitjantjatjara by Linda Rive.

We used to have so many beautiful smelling plants and flowers. Today there are very few to be seen. Because of Buffel grass. This makes us feel sick inside, just the thought of it.

We used to have so many different plants, and all the insects that went with them, such as butterflies and moths. Where are they all now?

Buffel grass is not part of our heritage and we do not recognize that plant. We don't like it.

All our own plants are part of our heritage and history. We grew up with beautiful plants, edible plants, sweet smelling plants, useful plants.

Now there is just this rubbishy plant everywhere we look. Everywhere we look from horizon to horizon, is this horrible ugly buffel grass. Where did it come from? It is not part of our heritage or our land? How come it is here, spreading everywhere?

How can our animals live on this awful grass? They know nothing of it. They are suffering now. This makes me suffer, just thinking about our poor animals. I am sick inside at the thought of them suffering and slowly starving to death.

Tjiturutjituru. Sad. That is me. I am tjiturutjituru trying to live amongst this ugly plant, but it is hardly possible to move through and I don't like being near it.

I see the encroachment of this ugly grass as very similar to what is happening to our lives. Our family members and our extended family members are all becoming suffocated by outside forces in just the same way that this grass is suffocating our lands. Our bodies are suffering with unknown new diseases, and we all have diabetes and renal failure, hypertension and other sicknesses I have no name for. In the same way I have no name for the new weeds that have come into our lives.

There are now hundreds and hundreds of new white people all over our lands, working in various jobs. Jobs that we once did ourselves. We now have no work at all, and any work is taken over by white people. Even our homelands are being rented and leased to white workers who come in from somewhere else. And yet we were once the owners and tenants of our own homelands and we did our own work. We are capable of working and doing everything that they are doing, but we are losing confidence in our abilities, and becoming unable to work ourselves, and we are all slowly sinking underneath this sea of white people. In the same way that our lands are slowly sinking under the sea of buffel grass - this dry, stiff, yellow grass, that is all we can see right across our lands, from end to end.

All our biodiversity is being lost amongst our plants and insects from buffel grass. And the diversity and beauty and intelligence of our own people is also being lost and drowned out by the huge and rapid encroachment of white people who have come and taken over everything we have. Our people cannot get above all these strange white people. And our beautiful flowers and plants and traditional food grasses cannot raise their heads

above this large and dominating grass, buffel, which is squeezing them all out of existence. All these white people are just like that: they are like the buffel grass, squeezing Anangu out of existence.

What is to become of us? Will we all wither and die underneath this grass, and these people, and become yet another extinct species?

CONTEXT FOR THE TESTIMONY PROVIDED BY LINDA RIVE:

There were still some radios around then, and Nganampa Health had reinstalled one at 3 Wilkinson Street and a few across the Lands, and Yami Lester had one. The idea was to keep using them because anybody could tune in if they wanted instead of it being private one to one on the mobile phone. A lot of communication power was lost when mobiles took over from the UHF radio.

So on that day, Punch Thompson came in to see me and said he wanted to talk to Yami Lester on the UHF radio so that anyone listening could hear and get the message that buffel grass was a serious problem and somebody needed to do something about it. I said to him, 'Well I really want to record that conversation.' and Punch said 'no problem. You record it and put it on Ara Irititja. We need to spread the word about buffel grass because it is such a serious problem.' So that's what happened. So we went into the small radio room and Punch called up Yami, who always kept the radio beside him when he was at Walatinna, and they launched into this unscripted

APPENDIX B – BURDEN OF DISEASE AND HEALTH SYSTEM SPENDING TABLES

The following data is taken from the Australian Institute for Health and Wellbeing burden of diseases sturdies 2018 and 2024.

For discussion on Attributing burden of disease to risk factors associated with buffel grass invasion please refer to the introduction of this paper.

Stratifications included in the tables (National and Territory, First Nations, Remoteness and Socio-economic position) are included to illustrate inequities in burden of disease across populations in central Australia.

TABLE 1 - MENTAL HEALTH AND CHRONIC DISEASE	
EXISTING BURDEN OF DISEASE (DALY PER 1000)[622] [623]	HEALTH SYSTEM SPENDING 2022-2023
Mental Health and substance use disorders	
2024 National – 32.79 2018 National – 29.76 NT – 23.7% First Nations – 65.3%[624] Major cities – 26.6 Remote and very remote – 25.3 Most Advantaged – 20.1 Most Disadvantaged - 27.8	2022-23 - $11.9 billion[625]
Chronic disease	
2024 National – 187.38 2018 National – 186.40 NT - 254.8 First Nations – 399.6 Major cities – 173.7 Remote and very remote – 243.9 Most Advantaged – 142.1 Most Disadvantaged – 222.7	2022-23 - $82 billion[626]

TABLE 2 - PHYSICAL ACTIVITY		
BURDEN OF DISEASE – VULNERABLE PRE-EXISTING CONDITIONS (DALY PER 1,000) [627]	BURDEN OF DISEASE ATTRIBUTABLE TO PHYSICAL INACTIVITY (TOTAL DALY %)[628] [629] [630]	HEALTH SYSTEM SPENDING ATTRIBUTABLE TO PHYSICAL INACTIVITY 2018-19[631]
ALL DISEASES		
See Table 1	2024 National – 2.1% 2018	2.4 billion[634]

	National – 2.4% Non-Indigenous 2.6% Indigenous 2.4% DALY rates per 1000[632] Non-Indigenous – 3.88 Indigenous – 13.26 Most advantaged 2.5 Most disadvantaged 5.5[633] (DALY per 1000)	
CORONARY HEART DISEASE		
National – 10.5 NT - 21.8 First Nations – 28.9 Major cities – 9.5 Remote and very remote – 21.3 Most Advantaged – 7.2 Most Disadvantaged – 14.7	2024 National – 14.0% 2018 National - 15.9% First Nations – 21.2%	$140.6 million
STROKE		
National - 4.2 NT - 4.5 First Nations – 7.9 Major cities – 4.0 Remote and very remote – 4.9 Most Advantaged – 3.3 Most Disadvantaged -5.2	2024 National – 7.8% 2018 National - 9.2% First Nations – 12.8%	$31.4 million
TYPE 2 DIABETES MELLITUS		
National – 4.8 NT - 9.1 First Nations – 14.5 Major cities – 3.7 Remote and very remote – 7.4 Most Advantaged – 2.4 Most Disadvantaged – 5.8	2024 National – 19.0% 2018 National - 20.5% First Nations – 24.0%	$206.8 million
BOWEL CANCER		
National – 3.4 NT – 4.2 First Nations – 4.4 Major cities – 3.1 Remote and very remote – 3.3 Most Advantaged – 2.6 Most Disadvantaged – 4.0	2024 National – 10.7% 2018 National - 11.8% First Nations – 15.1%	$89.2 million
DEMENTIA		
National – 6.1 NT – 8.9 First Nations – 13.0 Major cities – 6.3 Remote and very remote – 5.7 Most Advantaged – 5.7 Most Disadvantaged – 6.6	2024 National - 11.3% 2018 National – 11.7% First Nations – 12.0%	$45.7 million

TABLE 3 - DIET			
BURDEN OF DISEASE – VULNERABLE PRE-EXISTING CONDITIONS (DALY PER 1,000) [635] [636]	BURDEN OF DISEASE ATTRIBUTABLE TO DIETS HIGH IN RED MEAT (TOTAL DALY %) 2018[637]	BURDEN OF DISEASE ATTRIBUTABLE TO ALL DIETARY RISK FACTORS* (TOTAL DALY %) 2024 AND 2018[638] [639] [640] [641]	HEALTH SYSTEM SPENDING FOR VULNERABLE CONDITION ATTRIBUTABLE TO DIET 2018-19[642]
ALL DISEASES			
See Table 1	0.9%	2024 National – 4.8% 2018 National 5.3% Non-indigenous 5.7% Indigenous 6.2% DALY rates per 1000[643] Non-indigenous - 8.82 Indigenous – 30.18	Total $1.2 billion
CORONARY HEART DISEASE			
National – 10.5 NT - 21.8 First Nations – 28.9 Major cities – 9.5 Remote and very remote – 21.3 Most Advantaged – 7.2 Most Disadvantaged – 14.7	5.5%	2024 National – 49.9% 2018 National - 50.6% First Nations - 66.8%	$516.4 million
STROKE			
National – 4.2 NT - 4.5 First Nations – 7.9 Major cites – 4.0 Remote and very remote – 4.9 Most Advantaged – 3.3 Most Disadvantaged -5.2	7.9%	2024 National – 49.9% 2018 National - 25.7% First Nations - 37%	$84.1 million
CHRONIC KIDNEY DISEASE			
National - 1.7 NT – 8.4 First Nations peoples Major cities –1.6 Remote and very remote – 5.0 Most Advantaged – 1.1 Most Disadvantaged – 2.4	Not available	2024 National – 6.6% 2018 National - 6.6% First Nations - 9.7%	Not available
TYPE 2 DIABETES MELLITUS			
National – 4.8 NT - 9.1 First Nations – 14.5 Major cities – 3.7 Remote and very remote – 7.4 Most Advantaged – 2.4 Most Disadvantaged – 5.8	8.6%	2024 National – 26.0 2018 National - 26.0% First Nations - 31%	$2.9 billion

BOWEL CANCER			
National – 3.4 NT - 4.2 First Nations – 4.4 Major cities – 3.4 Remote and very remote – 3.3 Most Advantaged – 2.6 Most Disadvantaged – 4.0	5.8%	2024 National – 26.1% National - 26.3% First Nations - 31.8%	$210.4 million

* These estimates reflect the amount of burden that could have been avoided if all people in Australia ate a healthy diet

TABLE 4 – OVERWEIGHT (INCLUDING OBESITY)		
BURDEN OF DISEASE – VULNERABLE PRE-EXISTING CONDITIONS (DALY PER 1,000) [644] [645]	BURDEN OF DISEASE ATTRIBUTABLE TO OVERWEIGHT (TOTAL DALY %)[646] [647]	HEALTH SYSTEM SPENDING ATTRIBUTABLE TO OVERWEIGHT 2018-19[648]
ALL DISEASES		
See Table 1	2024 National – 8.3% 2018 National – 9.7% Non-Indigenous – 8.8% Indigenous – 9.7% DALY rates per 1000[649] Non-indigenous – 13.92 Indigenous – 46.99 Most advantaged 9.6 Most disadvantaged 21.3 (DALY per 1000)	$4.27 billion[650]
CORONARY HEART DISEASE		
National – 10.5 NT - 21.8 First Nations – 28.9 Major cities – 9.5 Remote and very remote – 21.3 Most Advantaged – 7.2 Most Disadvantaged – 14.7	2024 National – 28% 2018 National – 28.2% First Nations – 43.0%	$172.6 million
TYPE 2 DIABETES MELLITUS		
National – 4.8 NT - 9.1 First Nations – 14.5 Major cities – 3.7 Remote and very remote – 7.4 Most Advantaged – 2.4 Most Disadvantaged – 5.8	2024 National – 54.5% 2018 National – 54.7% First Nations – 67.9%	$568.4 million
CHRONIC KIDNEY DISEASE		
National - 1.7 NT – 8.4 First Nations – 13.2	2024 National – 42.6%	$564.2 million

Major cities –1.6 Remote and very remote – 5.0 Most Advantaged – 1.1 Most Disadvantaged – 2.4	2018 National – 42% First Nations – 54.5%	
GALLBLADDER AND BILE DUCT DISEASE		
National - NT – 0.2 First Nations – 0.5 Major cities – 0.2 Remote and very remote – 0.3 Most Advantaged – 0.1 Most Disadvantaged – 0.3	2024 National - 41.4% 2018 National – 41.2% First Nations – 55%	$350.1 million

TABLE 5 – AIR POLLUTION

BURDEN OF DISEASE – VULNERABLE PRE-EXISTING CONDITIONS (DALY PER 1,000) **2018** [651] [652]	AIR POLLUTION ($PM_{2.5}$) CONTRIBUTION TO TOTAL BURDEN OF DISEASE (DALY) 2024[653] AND 2018[654] [655]	HEALTH SYSTEM SPENDING ATTRIBUTABLE TO AIR POLLUTION **2018-19**[656]
ALL DISEASES		
See Table 1	2024 National – 1.6% 2018[657] National – 1.8% Indigenous - 1.3% Non-Indigenous – 1.4% DALY rates per 1000[658] Non-indigenous – 2.1 Indigenous – 6.96 Most advantaged - 1.5 Most Disadvantaged – 3.2 (DALY per 1000)	$352 million
ASTHMA		
2024 National – 5.3 National – 5.19 NT - 3.3 First Nations – 11.4 Major cities – 5.0 Remote and very remote – 7.3 Most Advantaged – 3.7 Most Disadvantaged – 6.9	Not available	Not available
CHRONIC OBSTRUCTIVE PULMONARY DISEASE		
2024 National – 5.74 2018 National – 5.84 NT - 10.5	2024 National – 7.5% 2018 National – 6.7% First Nations – 6.8%	$57.4 million

First Nations – 19.3 Major cities – 5.2 Remote and very remote – 8.5 Most Advantaged – 4.3 Most Disadvantaged – 7.5		
LOWER RESPIRATORY TRACT INFECTIONS		
2024 National – 1.36 2018 National – 1.4 NT – 2.0 First Nations – 4.7 Major cities – unavailable Remote and very remote – unavailable Most Advantaged – unavailable Most Disadvantaged –unavailable	2024 National - 6.2% 2018 National – 5.7% First Nations – 5.8%	$80.0 million
LUNG CANCER		
2024 National – 4.59 2018 National – 5.46 NT – 9.8 First Nations – 12.5 Major cities – 4.9 Remote and very remote – 7.4 Most Advantaged – unavailable Most Disadvantaged – unavailable	2024 National - 9.5% 2018 National – 9.6% First Nations – 3.4%	$17.9 million
CORONARY HEART DISEASE		
2024 National – 8.91 2018 National – 10.5 NT - 21.8 First Nations – 28.9 Major cities – 9.5 Remote and very remote – 21.3 Most Advantaged – 7.2 Most Disadvantaged – 14.7	2024 National – 9.0% 2018 National – 8.6% First Nations – 11.9%	$94 million
STROKE		
2024 Australia – 3.45 2018 National – 4.17 NT - 4.5 Aboriginal population – 7.9 Major cities – 4.0 Remote and very remote – 4.9 Most Advantaged – 3.3 Most Disadvantaged -5.2	2024 National – 8.8% 2018 National – 9.2% First Nations – 12.1%	$34.6 million

TYPE 2 DIABETES MELLITUS		
2024 Australia – 3.7 2018 National 3.8 NT - 9.1 First Nations– 14.5 Major cities – 3.7 Remote and very remote – 7.4 Most Advantaged – 2.4 Most Disadvantaged – 5.8	2024 National – 15.9% 2018 National – 16.1% First Nations – 6.7%	2018 $68.1 million

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