Spinifex Pastures - Characteristics and Management

A summary of publications and resources for land managers, pastoralists, extension officers, and researchers

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Preface

This report was commissioned to bring knowledge on spinifex and spinifex pastures across northern Australia into a single publication for use primarily by land managers, pastoralists, extension officers and researchers.

The report forms part of a collaborative project led by the Kimberley Pilbara Cattlemen's Association. The Project is jointly funded by the Northern Hub, through funding from Australian Government's Future Drought Fund and by the Department of Primary Industries and Regional Development WA, and supported by the Northern Territory Department of Agriculture and Fisheries.

The cover page is a photo of hard spinifex plain pastures in the Kimberley, Western Australia, sourced from https://www.agric.wa.gov.au/rangelands/hard-spinifex-plain-pastures-kimberley-western-australia (Government of Western Australia).

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Spinifex Pastures – Characteristics and Management

Summary

- Climate/seasonal conditions, fire and grazing interact to affect rangeland condition and livestock production in the spinifex country.
- Different types of spinifex country can respond differently to seasons, fire and grazing.
- Recently burnt spinifex pastures are relatively productive for cattle (compared to unburnt).
- Recently burnt and long-unburnt spinifex are important habitats for biodiversity.
- Monitoring rangelands over time (including fire response) is valuable for adapting grazing and fire management at a paddock and property scale.
- Natural fire intervals vary from 2 years in high rainfall regions to 15 years in the low rainfall country.
- Management burning of spinifex is most beneficial in areas with >200 mm average annual rainfall.
- To sustain productivity, grazing and burning plans should be long term.
- Large-scale rotational burning encourages fresh growth in spinifex (more palatable and digestible).
- For soft spinifex, 5-6 years of grazing can result in a pure spinifex stand – burning at that stage can encourage re-establishment of other species and palatable spinifex regrowth.
- Deferred grazing (to allow recovery) and summer burning of spinifex encourages nutritious forage during wet season.
- It is recommended that stations develop a plan for fire management which addresses:
    - prescribed burning
    - wildfire control
    - management of spinifex hummock grass pastures
    - grazing management.

1. Introduction

This report provides descriptions and characteristics of spinifex species as well as management guidelines for spinifex in the pastoral rangelands of the Kimberley, Pilbara and Gascoyne regions of Western Australia (WA) and similar rangelands across the Northern Territory and other regions in Australia.

Spinifex grasses occur over much of Australia:

- Spinifex occurs in every mainland state (includes spinifex on sandplains and in association with other species (rocky ranges [e.g. NT MacDonnel Ranges) and mallee country in southern Australia).
- The spinifex on coastal areas is different to the arid area spinifex.
- Spinifex leaves usually have hard tips – developed partly by the uptake of silica from the soil.
- Termites are the natural grazers of spinifex – in the deserts, the mass of termites is higher than all the other animals.

(Ref. online: http://ianfrasertalkingnaturally.blogspot.com/2020/06/spinifex-prickly-heart-of-australia.html)

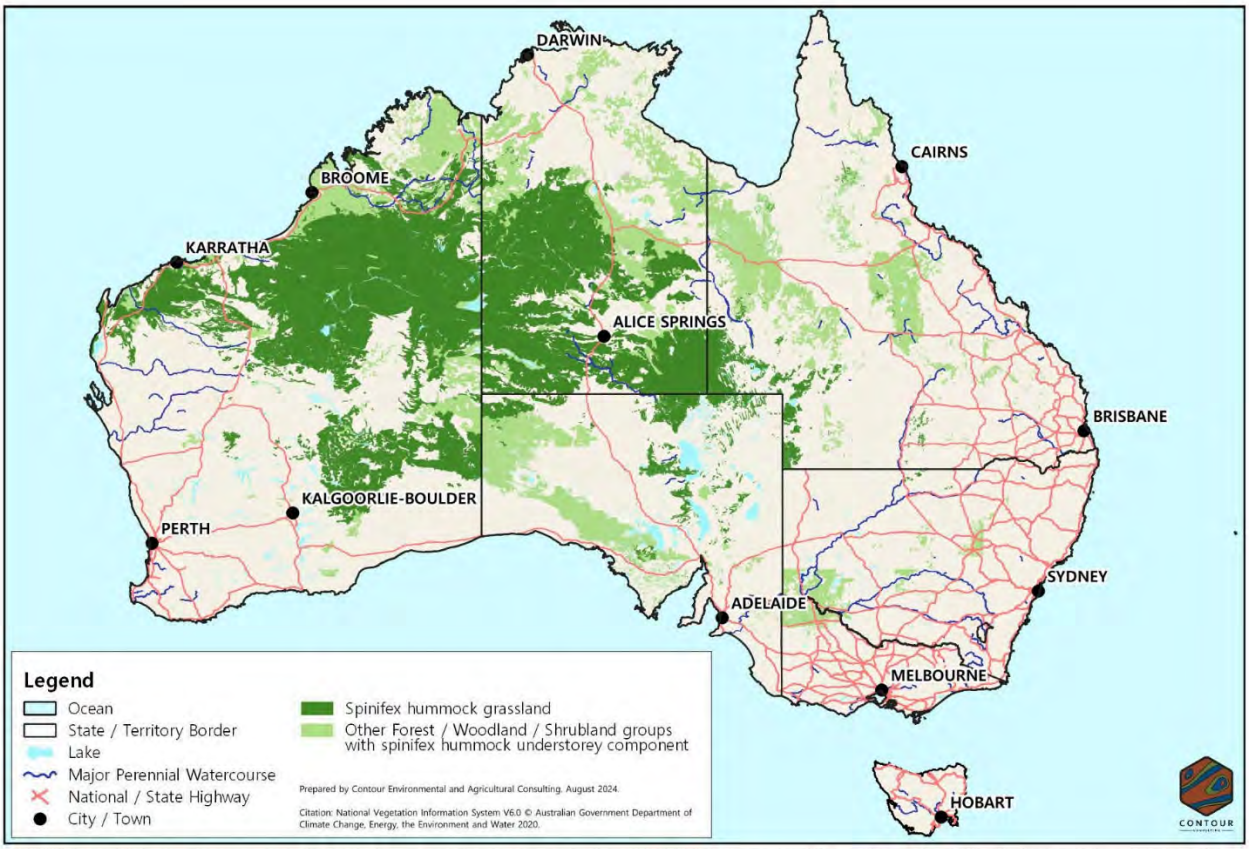
- Spinifex is a member of the grass family (*Poaceae*)
- Spinifex grasses are divided into 'hard' and 'soft' spinifexes – a distinguishing feature is that hard spinifex does not contain resin
- Spinifex provides a habitat for a wide range of wildlife (euros are one of the few species that can eat spinifex).

(Ref: Ausemade (Showcase Australia) (2001).

The pioneering pastoral industry of these regions developed from the mid-late 1800s. Since that early period, there have been profound changes in the industry and in the environment in which it works – including economic, political, societal issues and grazing land management.

While spinifex is the dominant species in the pastures covered in this report, the associated species and rangeland types are very important to overall management and productivity.

The spinifex country is referred to as "hummock grasslands". They cover more than 22% of the continent, mainly in the central and western portions of Australia. This rangeland type includes all the major deserts and occurs on sandplains and dune fields, mountain ranges and dry salt-lake systems (Griffin 1984).



DISCLAIMER: Vegetation mapping data used to prepare this map has been extracted from the collated National Vegetation Information System. As each State/Territory retains custodianship of their respective vegetation mapping data, variations in vegetation mapping may occur. Contour Consulting accept no responsibilty for any errors or omissions it may contain, or for any loss, however caused, sustained by any person who relies on it.

Fig. 1a: Detailed distribution of spinifex hummock grassland and other spinifex areas in Australia

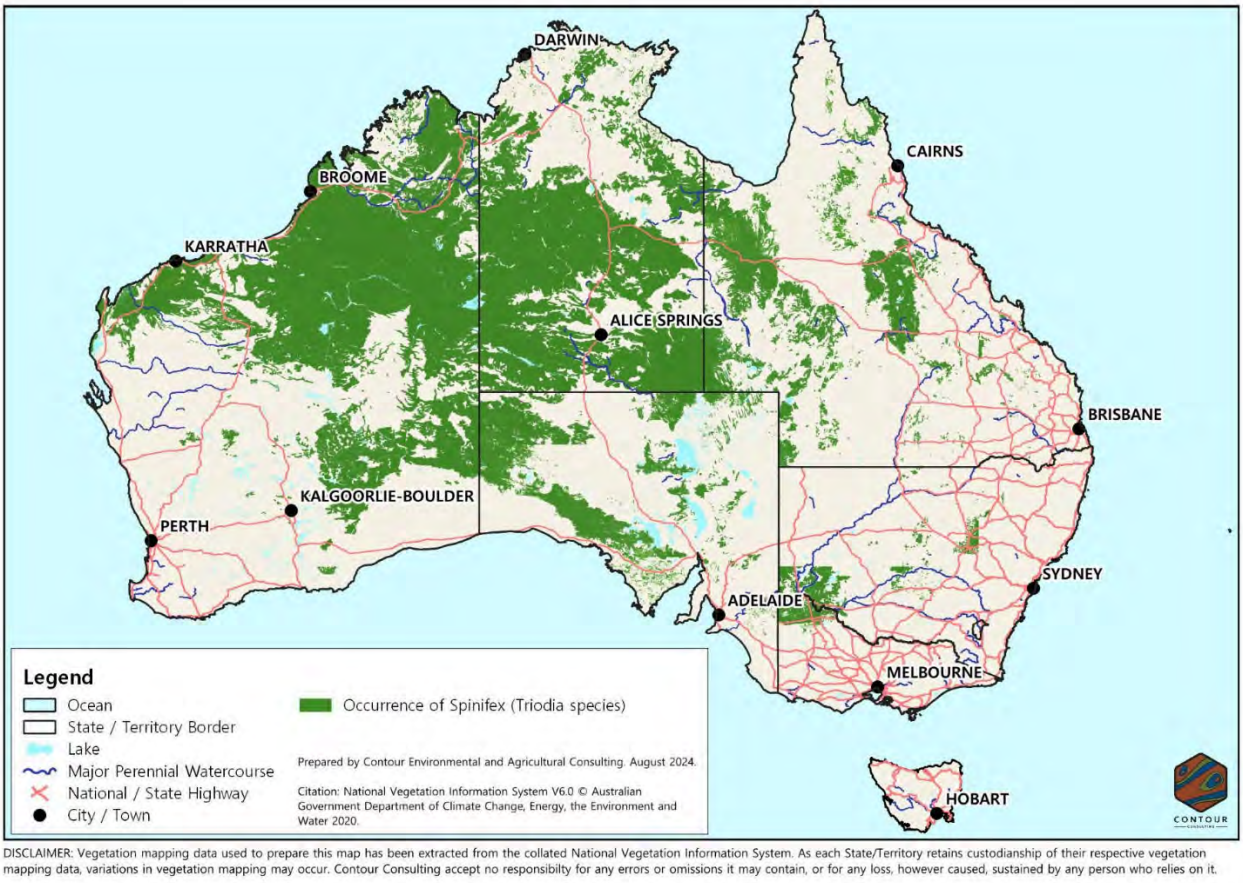


Fig. 1b: Occurrence of spinifex (*Triodia* species) in Australia

The "hummock" grasslands are named because of the physical shape of the dominant spinifex plants. The spinifex genera (*Triodia*) are perennial, 'evergreen' plants that grow as rounded hummocks. Their shrub-like form influences their role in the ecosystem, particularly in stabilising soils against erosion. The soils are primarily sandy but also include gravelly and rocky types. Fire is a natural and very important component of the spinifex ecosystem.

Only a small proportion of the hummock grasslands in Australia are used for livestock production. However, it is an important complement to other pastoral rangeland types with which it occurs, particularly in dry/drought times - for example, spinifex pastures respond to small amounts of rainfall; in contrast, Mitchell grass requires significantly more rainfall.

This report relates mainly to beef cattle production in spinifex rangelands.

2. Spinifex

2.1 Spinifex in Northern Australia

Spinifex grass is native to Australia. It is the dominant grass of arid and semi-arid grasslands, across the driest parts of Australia. There are 64 species of spinifex in Australia.

Soft spinifex (*Triodia pungens)* dominates the vegetation over a significant area in the WA pastoral region.[1]

The following map of vegetation types in the Northern Territory illustrates the dominance of spinifex grasslands across much of the southern Northern Territory[2].

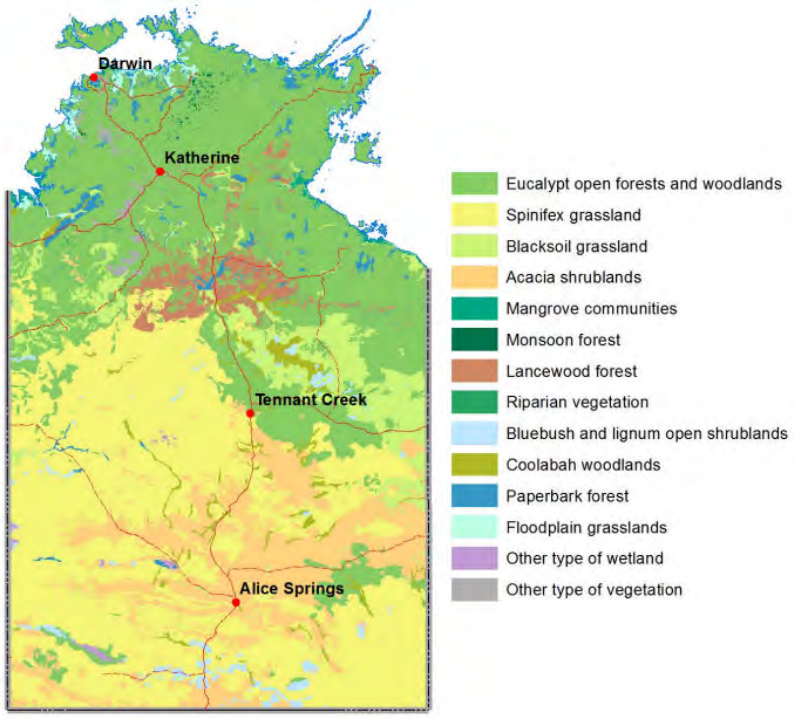


Fig. 2: Distribution of spinifex grasslands in the Northern Territory

The Australian tribe of grasses, Triodieae or 'spinifex', was well known to the early explorers of the continent's centre. The tough sharpened leaf blades of this 'porcupine grass' were a dreaded obstacle to the adventurers' vain pursuit of fertile lands and inland seas – a real Australian 'thorn in the side'. For most, the endless spinifex grasslands symbolised a harsh and monotonous, if not hostile Australian desert, a place to heroically endure rather than celebrate. The genus Triodia are a perennial Australian grass that have pointed leaves, that are often sharp.[3]

The following notes from the MLA Grazing Land Management EDGEnetwork Workshop Notes, Meat & Livestock Australia, 2015 provide a useful background to understanding spinifex:

Spinifex grass is a tough, slow-growing, tussock-forming perennial grass found in some of the most arid regions of Australia. There are 64 species of Triodia in Australia all of which are endemic (Jessop et al. 2006; Lazarides 1997). Spinifex plants have special adaptations that mean they can survive in extremely hot and dry conditions where few other plants can.

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[1] Suijdendorp, H (1969) 'Deferred grazing improves soft spinifex association', Journal of the Department of Agriculture, Western Australia, Series 4: Vol. 10: No. 11, Article 8.

[2] https://depws.nt.gov.au/__data/assets/pdf_file/0017/261062/vegetation-types-in-nt-factsheet.pdf

[3] Hansjörg Eichler Scientific Research Fund Report – Leaf blades or floral clades – A guide to spinifex phylogeny by Jim Mant, Australian National University

One such adaptation is that the roots usually grow from the same node as the stem; this ensures that each stem has its own water and nutrient supply. The root system is deep, sometimes up to 3 m and can seek out water and mine scarce nutrients. The fresh new leaf of a young spinifex plant looks flat until the plant becomes water stressed. It then 'rolls' its leaves into a cylindrical shape, and in so doing, becomes more resilient to dry times (Monroe 2008).

This 'rolling' of the leaves reduces the leaf area exposed to the sun and lessens heat absorption; it also means less moisture is lost through transpiration as the stomata are on the inside of the rolled leaf and away from the atmosphere and wind that would otherwise increase the rate of water loss. These stomata are sunken in deep narrow grooves or pits that further reduce water loss (Dickison 2000).

Spinifex grass species are broadly categorised into 'soft' spinifex and 'hard' spinifex.
The leaves of 'soft' species are more loosely arranged, and the stomatal grooves and photosynthetic tissues are on the inner surface of the leaves. They also produce a sticky resin from specialist cells in the outermost leaf layer (Gamage et al. 2012). This resin is insoluble in water and softens with heat, burns with a smoky flame and is resistant to decay (Pitman 2010).

Hard species lack leaf resin and their stomatal grooves and photosynthetic tissue are spread over both inner and outer leaf surfaces. The leaves are more closely packed and have large bundles of fibres making them rigid and often sharp to touch (Gamage et al. 2012). Their epidermal cells contain silica grains. Leaves are often greyish in colour which assists in reflecting sunlight.
Spinifex clumps create a cooler microclimate for the plants themselves and also for native animals to seek protective habitat. Hard spinifex is tough and indigestible to most animals except termites.

Termites are the main natural "grazers" of spinifex, being one of the few native animals able to digest its tough leaves. Lizards often eat termites. Further information on this is available from the following four references:

https://en.wikipedia.org/wiki/Nasutitermes_triodiae
https://australian.museum/learn/animals/insects/termites/
https://library.dbca.wa.gov.au/FullTextFiles/PAM02794.pdf
https://www.pnas.org/doi/full/10.1073/pnas.1607860113

A broad description of spinifex grasslands is available at 'Australia: The Land Where Time Began' (Monroe, 2015).

2.2 Spinifex in Pastoral Areas

Spinifex plants are noted for their ridged, hard and generally sharp pointed leaf blades; individual species vary in that characteristic. There are many species of spinifex in the pastoral areas. Two important species are *Triodia pungens* and *Triodia schinzii* – these are usually referred to as "soft spinifex" and they are useful as forage.

2.3 Spinifex Species

There is a general separation of spinifex species into hard and soft species.

Photo 1: Hard spinifex (*Triodia intermedia*)[4]

Different spinifex species can be identified by flower characteristics. However, this may be difficult at times – spinifex plants flower for only a very short period.

Individual plants of some spinifex species demonstrate a ring formation. It has been found that this natural process of death of the plant from the centre outwards is probably due to pathogenic soil microbes[5]; another view is that it is due to termites.[6]

There are a significant number of spinifex species in WA and the NT. The main species of spinifex have been described by Petheram and Kok (2003); a summary follows.

For the following spinifex plants, refer to Appendix 1 for descriptions of plant parts.

The main species described in this report are:

- **Curly spinifex** (*Triodia bitextura*) – soft spinifex
- **Feathery spinifex** (*Triodia bynoei*) – hard spinifex
- **Hard (Winged or Lobed) spinifex (***Triodia basedowii*) - hard spinifex
- **Hard Spinifex** (*Triodia intermedia*) - hard spinifex
- **Soft (gummy) spinifex (***Triodia pungens***)** – soft spinifex
- **Rock spinifex (***Triodia racemigera***)** – hard spinifex

[4] https://www.agric.wa.gov.au/rangelands/hard-spinifex-triodia-intermedia-western-australian-rangelands

[5] Ross and Moles, 2021, https://www.publish.csiro.au/bt/pdf/BT20122

[6] Walsh et al 2023, First Peoples' knowledge leads scientists to reveal 'fairy circles' and termite linyji are linked in Australia

- **Limestone (Hard) spinifex (***Triodia wiseana***)** - hard spinifex
- **Feathertop spinifex** (*Triodia schinzii*) - soft spinifex

2.3.1 Curly spinifex (*Triodia bitextura*)

Curly spinifex has the following characteristics:

- perennial; straggly tussock 80 cm high, up to 2 m wide
- stems: smooth, slender, highly branched
- leaf sheaths: elongated, smooth and shining
- leaf blades: rolled, slender, pale green, up to 30 cm long
- inflorescence: erect panicle; feathery, up to 18 cm long
- spikelets: awned
- flowers February to May

Photo 2: Curly spinifex (1 m high plant; inflorescence magnified 1.5)

Curly spinifex occurrence:

- dominant perennial on a wide range of country in the curly spinifex pastures of the Kimberley
- common on sandstone, quartzite and basalt hill country
- sandy soils and red soils
- grows with ribbon grass, annual native sorghum, woolly butt and cockatoo grass

The grazing value of curly spinifex is as follows:

- moderately palatable/low forage value
- increased forage value if there is a high density of ribbon grass
- high proportion not grazed because of its occurrence on inaccessible country
- accessible areas grazed in association with higher value pastures

- drought resistant
- valuable drought reserve.
- crude protein: seedling 6%; mature 2%
- phosphorus: 0.03 – 0.05%
- digestibility: 26-35%
- desirable species; dominance indicates good rangeland condition
- decreases under heavy grazing, frequent or poorly-timed burning

For further information and references on curly spinifex, please refer to the following:

1. 'Curly spinifex (Triodia bitextura) in the WA rangelands'
2. 'Curly spinifex plain pastures in the Kimberley, Western Australia'
3. '*Triodia bitextura*' (AusGrass Identification)

Further information on grasses associated with curly spinifex are as follows:

1. Ribbon grass
   - Ribbon grass (*Chrysopogon fallax*) is a resilient and productive species
   - Further information - 'Ribbon grass pastures in the Kimberley, Western Australia'

2. Annual native sorghum
   - Annual native sorghum (*Sorghum stipoideum*) indicates fair to poor rangeland condition when in dominance
   - Further information – 'Annual sorghum (Sorghum stipoideum) in the Western Australian rangelands'

3. Woolly butt
   - Further information – 'Woollybutt grass (Eragrostis eriopoda) in the Western Australian rangelands'
   - Woolly butt (*Eragrostis eriopoda*) has the following characteristics:
     - Pindan country (red soils of SW Kimberley)
     - dominance may indicate fair to poor rangeland condition
     - moderately palatable when green (dries off rapidly)
     - intermediate value species in Kimberley – short-lived
     - desirable species in Pilbara and arid short grass pastures in Kimberley

4. Cockatoo grass
   - Further information on cockatoo grass (*Alloteropsis semilata*) – 'Cockatoo Grass – *Alloteropsis semialata*'

2.3.2 Feathery spinifex (*Triodia bynoei*)

Feathery spinifex has the following characteristics:

- large, tufted plant
- broad leaves 15 – 40 cm long, up to 4 mm wide, shiny light green
- leaves flat (rolled when dry/old)
- inflorescence on erect stem, 1 m high
- narrow feathery panicles 25 – 35 cm long, purplish, numerous fine racemes 5 - 8 cm long

- spikelets 4 – 5 mm long, slender, long awns
- seeds in early March

Photo 3: Feathery spinifex (1.4 m high plant; inflorescence 0.5 magnification)

Feathery spinifex is common on sloping areas with shallow soils and rocky ridges (e.g. around Lake Argyle and Kununurra), often with curly spinifex.

Feathery spinifex's grazing value is limited due to poor accessibility where it occurs and its low carrying capacity.

Further information on feathery spinifex can be found at '*Triodia bynoei*' (AusGrass Identification).

2.3.3 Hard (winged or lobed) spinifex (*Triodia basedowii*)

Hard spinifex has the following characteristics:

- generally small tussock
- sheaths may have spare cover of short, soft hairs
- panicles 7 – 9 cm long, loose, few branches
- spikelets on capillary stalks, 10 mm long
- minute 3-toothed, keeled lemma

There are sometimes difficulties with identifying hard (lobed) spinifex because of the similarity to other species. For reference, please refer to the following technical papers:

- 'Triodia basedowii'
- 'A revision of the Triodia basedowii species complex and close relatives (Poaceae: Chloridoideae)'

Photo 4: Hard spinifex pasture (with northern white gum); (inflorescence magnified 0.5)

Hard spinifex occurs over large areas of the Kimberley, usually with sparse low tree cover (e.g., snappy gum) and the Pilbara.

In terms of grazing value, this hard spinifex may replace soft spinifex where there has been frequent fire and overgrazing. Management should include mosaic burning on a 3-5-year rotation and/or early summer burning followed by sowing desirable species in ash[7].

For further information and references on hard spinifex, please refer to the following:

1. '*Triodia basedowii*' (AusGrass Identification)
2. 'Hard spinifex or lobed spinifex'
3. 'Hard spinifexes (Triodia spp.) in the Pilbara, Western Australia'

2.3.4 Hard Spinifex (*Triodia intermedia*)

This "hard spinifex" is a different species to *Triodia basedowii* and has the following characteristics:

- perennial hummock grass
- grows to 1 m tall and 2 m across

[7] Suijdendorp, H. (1967). A study of the influence of management practices on "spinifex" (*Triodia pungens*) grazing. MSc.Agric. Thesis, University of Western Australia

- stems are smooth, without resin
- leaf blades green to blue-green, tightly rolled, stiff, with sharp point
- seed head single spike on short stalks.
- flowers February to May

Please refer to Photo 1 for an image of hard spinifex.

This species occurs in red and rocky soils and sandplains, limestone areas.

In terms of grazing value, it is unpalatable to livestock however it is desirable in hard spinifex country (holds soil together; other herbaceous, palatable species may grow between spinifex plants).

For further information and references on this species, please refer to the following:

1. 'Triodia intermedia' (AusGrass Identification)
2. 'Hard spinifex (Triodia intermedia) in the Western Australian rangelands'

2.3.5 Soft (gummy) spinifex (*Triodia pungens*)

Soft spinifex has the following characteristics:

- perennial
- loose tussocks up to 2 m across
- flowering stems 20 -100 cm high
- leaf blades folded, ending in sharp (relatively soft) point
- new growth covered in gummy substance
- stolons may develop new plants – vegetative regrowth after fire
- seed heads pyramid- shaped
- spikelets longer than 6 mm

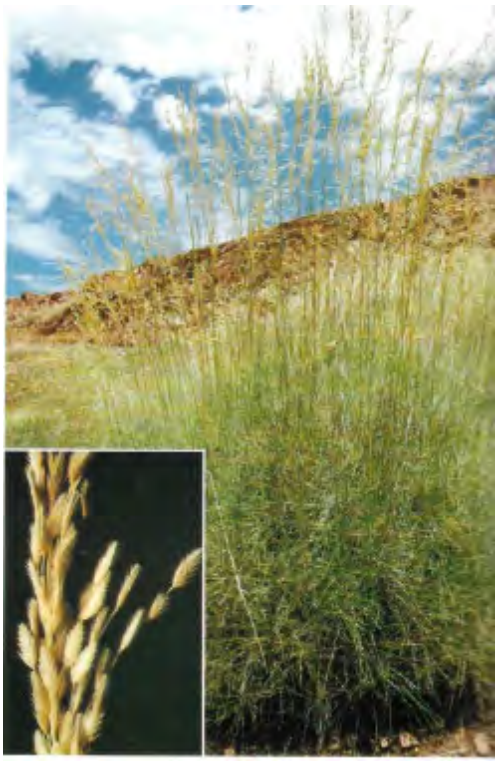


Photo 5: Soft spinifex (1.5 m high; inflorescence magnified 0.5)

Its occurrence can be described as follows:

- dominant perennial species in soft spinifex country
- northern Gascoyne, Ashburton and Pilbara
- located on extensive sandy soil plains in the Kimberley, usually with small-fruited bloodwood (*Corymbia dichromophloia*)
- "decreaser" where it is replaced by limestone spinifex (*Triodia wiseana*)

In terms of grazing value, it has the following characteristics:

- most useful of spinifex species; always palatable
- deep rooted – drought resistant and useful forage reserve
- best management: late season burning on a 4-year rotation, then spelling until spinifex seed has dropped
- hot fires kill old plants – allowing seedlings to establish
- crude protein:
    - seedling - 10%
    - 6-8 months - 5%

For further information and references on small-fruited bloodwood, refer to the following:

1. Small-Fruited Bloodwood (*Corymbia dichromophloia*): online - Small-Fruited Bloodwood Atlas of Living Australia

2.3.6 Rock spinifex (*Triodia racemigera*)

Rock spinifex has the following characteristics:

- large tussock perennial
- spike-like inflorescence; panicle narrow, up to 50 cm long with alternate lateral branches 2-3 cm long
- spikelets small with deeply lobed lemmas

This species usually occurs among rocks or in sandstone faces and is seldom affected by fire or grazing.

It holds little grazing value and is therefore seldom grazed.

For further information and references on this species, refer to the following:

1. '*Triodia racemigera*' (AusGrass identification)

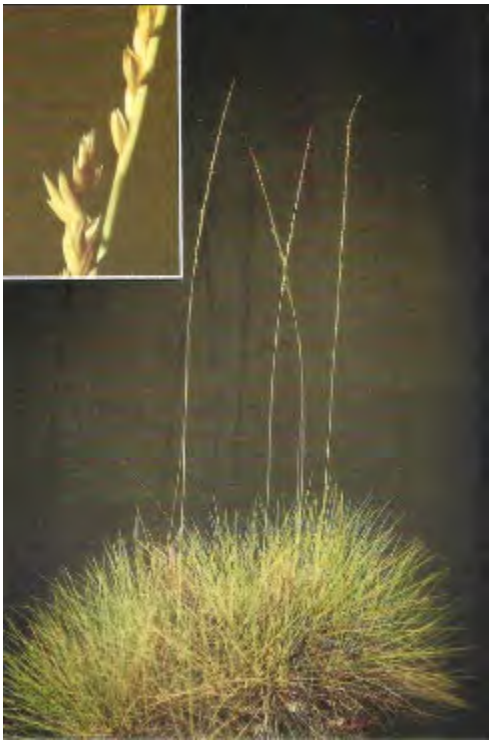


Photo 6: Rock spinifex tussock 1.2 m high (Inflorescence magnified 1.5)

2.3.7 Limestone (Hard, Stiff-haired) spinifex (*Triodia wiseana*)

Limestone spinifex has the following characteristics:

- dense, prickly perennial
- rising branched stems
- large tussocks up to 2 cm in diameter
- leaves covered in blue-green waxy bloom
- sheaths covered with dense glistening hairs

- leaf blades finely striate, sharp-pointed, 10-20 cm long, 2 mm wide
- spikelets 8-10 mm long

Reference – Journal Royal Society of Western Australia 27:166 (1942) (Online: https://keys.lucidcentral.org/keys/v3/triodia/key/pilbara_triodia_app/Media/Html/entities/triodia_wiseana.htm)

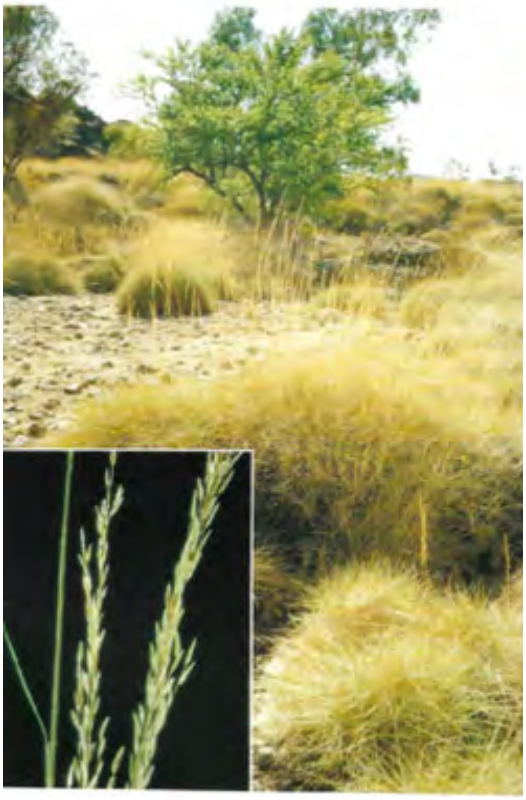


Photo 7: Limestone spinifex; 1.4 m high tussocks in limestone country (stem, hairy leaf sheath, inflorescence [magnified 0.5])

This species is very widespread on rocky ridges and gravelly slopes, and often associated with limestone.

In terms of grazing value, it has the following characteristics:

- generally low carrying capacity because of its occurrence on rough terrain
- cattle will graze new growth following burning
- best management: rotational burning on different areas, usually every 3-4 years (when tussocks have grown out to touch another)

For further information and references on this species, refer to the following: 'Triodia wiseana'

2.3.8 Feathertop spinifex (*Triodia schinzii*)

This species has the following characteristics:

- perennial; hard clumping grass
- resinous
- leaf sheath smooth

Photo 8: Feathertop spinifex plant and inflorescence (Ref.: Triodia schinzii (feathertop spinifex) – Teritory Native Plants; online: Triodia schinzii (Feathertop Spinifex) — Territory Native Plants)

Its occurrence is described as follows:

- sand-sandy loam soils, often on dunes and deeper sands
- central Australia; extensive in Great Sandy and Little Sandy deserts
- subcoastal sands – Karratha-Pardoo

In terms of grazing value, it has the following characteristics:

- moderately palatable
- good drought reserve
- when young, whole plant is edible

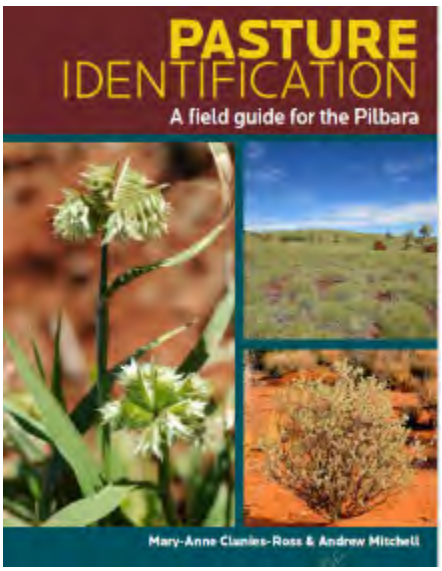
For further information and references on this Feathertop spinifex (*Triodia schinzii*), refer to the following:

1. '*Triodia schinzii (Feathertop Spinifex)*'
2. 'Soft spinifexes (Triodia spp.) in the Western Australian rangelands'

2.4 Identifying Spinifex Species

A key has been developed for identifying spinifex species in 'SpiKey: An interactive key to Triodia spinifex grasses of the Pilbara, Western Australia'. Whilst it has been developed for the Pilbara, it is useful for most species in northern Australia.

A practical and useful guide to pasture species identification is in the following book (includes soft spinifex and many of the associated species, many of which occur beyond the Pilbara):



Clunies Ross, M. and Mitchell A. Pasture Identification – a field guide for the Pilbara

- online: PastureIDGuide_Pilbara_web.pdf

For the southern rangelands of WA, a valuable reference is - Blood, *et al* (2015).

A key has been developed to determine Kimberley pasture types and can assist in identifying spinifex species:

- 'Pasture condition guide for the Kimberley, Western Australia'
- 'Download Complete Bulletin'

Information on particular spinifex species in the NT is in:

Bull spinifex (*Triodia longiceps*):
https://alicespringsdesertpark.com.au/connect-with-nature/plants/plants/bull-spinifex

Sandstone spinifex (*Triodia melvellei*):
https://alicespringsdesertpark.com.au/connect-with-nature/plants/plants/sandstone-spinifex

Weeping spinifex (Triodia brizoides):
https://alicespringsdesertpark.com.au/connect-with-nature/plants/plants/weeping-spinifex

An educational publication on spinifex has been prepared by the NT Park and Wildlife Service –https://depws.nt.gov.au/__data/assets/pdf_file/0011/249347/jrr03_issue3.pdf

Identification of pasture plants for the Barkly region in the NT is covered in - A Field Guide to Plants of the Barkly Region of the Northern Territory by Purdie et al. (2008) Jenny Purdie, Chris Materne and Andrew Bubb (Published by Barkly Landcare and Conservation Association).

Another valuable reference for grasses (including spinifex) is Grasses of the Northern Territory Savannas by Crowder and Saggers (2010).

An excellent reference on spinifex species in Qld - Milson, J. (2000). Pasture Plants of North-West Queensland. Qld Dept Primary Industries.

Note: The '*Triodia'* genus name has sometimes been referred to as '*Plectrachne'.* This has now changed and only Triodia is now used[8].

It is sometimes difficult to identify different spinifex species. It is recommended that consideration be given to developing a practical and 'user-friendly' key for all spinifex species in northern Australia.

2.5 Indigenous and Industrial Uses of Spinifex

Indigenous people have had varied uses of spinifex for millennia. Uses of spinifex and its resin include cladding for shelters, basketry, nets, bag, medicines, food, fire and resin (sealant, repair, adhesive, malleable material for craft).

This is well reported in the following two references:

1. 'The Point of Spinifex: Aboriginal uses of spinifex grasses in Australia'
2. 'Indigenous and modern biomaterials derived from Triodia ('spinifex') grasslands in Australia'

The use of fire in spinifex by indigenous people has been an important aspect of spinifex ecology. This is described in:

'Black Lightning: Aborigines and Fire in Central Australia and the Western Desert' by Richard Kimber.

- Campfires and ceremonial fires were very much part of Aboriginal culture
- Fire related to punishment, hunting, signalling, ceremonies, the hearth, clearing and improvement of country
- Large Aboriginal fires were not accidental, random or uncontrolled
- Aborigines still perceive fire as an important tool for improving country
- Some areas were not burnt for more than 10 years
- Fire was mainly in hills and ranges, river and creek banks, near claypans, rock holes and soakages

[8] 'Hummock Grasslands in Australia' – online:
https://bio.mq.edu.au/research/groups/comparative/rice/spinifex.htm

- Fire control was achieved through increasing humidity and natural firebreaks of stony areas, claypans, salt lakes, river or creek beds and previously burnt areas.

Some current aspects of indigenous burning are in the news article 'Indigenous fire management programs recognised for work to preserve vast Kimberley landscape' by ABC News.

Research from 'Renewable, versatile spinifex and the future of nanofibres' has shown that the nanofibre properties of spinifex have provided opportunity for industrial use. This has been adapted in construction, e.g.: 'Yamaha is making boats with wood 5x stronger than steel... But Aussie spinifex cellulose nanofibre is tougher, mate'

Field research into spinifex found there is potential for commercial cropping to enhance its valuable nanofibre properties for commercial use (Pennells *et al* 2018).

The following paper covers some general aspects of spinifex and includes a section on spinifex in aboriginal art - 'Spinifex'.

It is noted that there were only limited publications accessible on the use of spinifex by indigenous people; while the references included in this report are quite detailed, there appears to be a gap in published material on the topic.

2.6 Threats to spinifex

Concern has been expressed about threats to some spinifex species. However, there is no evidence that most (if not all) species of spinifex are facing any threat to their continuation in the rangelands environment. CSIRO research in the Kimberley and Pilbara did not identify any spinifex species as threatened, although there was concern about several wildlife species in the spinifex environment, noted at 'Priority threat management to protect Kimberley wildlife' and 'Priority threat management for Pilbara species of conservation significance'. Examples of animal species of concern include the Gouldian finch (*Erythrura gouldiae*), greater bilby (*Macrotis lagotis*) and the spectacled hare-wallaby (*Lagorchestes conspicillatus*).

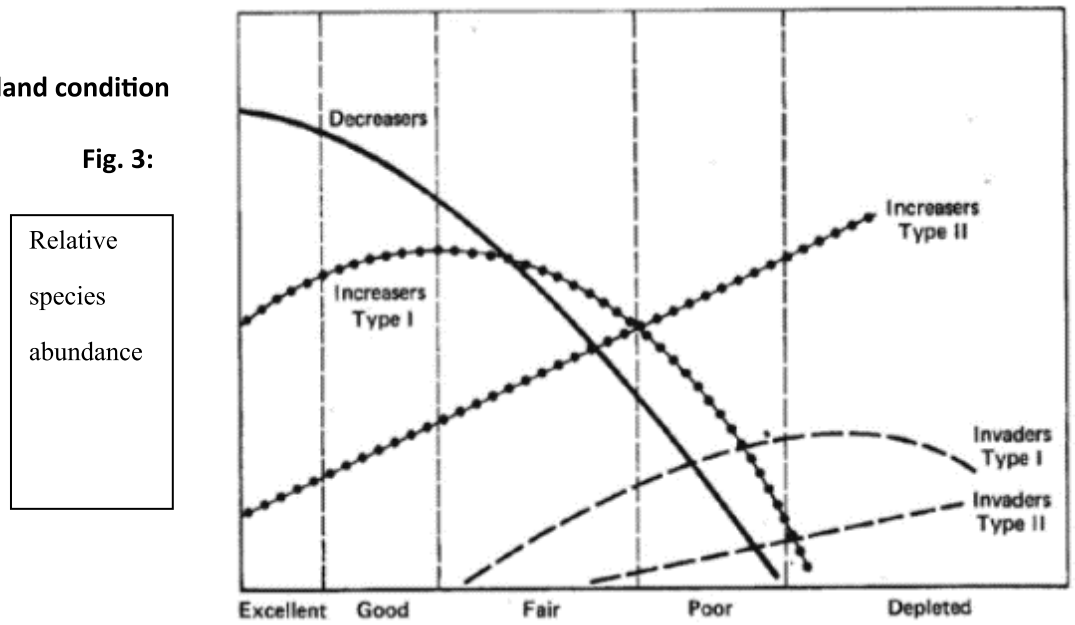
The following paper discusses the survival of spinifex after fire: 'Regeneration after fire in *Triodia* R. Br. That research indicated that the effect of fire on spinifex was variable and further research on fire threats to spinifex was needed.

3. Managing Spinifex

3.1 Dynamics of rangeland pasture species

The dynamic changes in all rangeland pasture communities can be considered with the 'increaser decreaser species' concept. This applies to spinifex pastures and the relationship to rangeland condition is illustrated in Figure 3.

Fig. 3:



Increaser/decreaser species relationship, i.e. relative abundance of species to rangeland condition (adapted from Holocheck et al. 1995)

Decreasers are relatively palatable species that decline in abundance with increasing grazing pressure above the optimum. An example of a **Decreaser** is Mitchell grass (*Astrebla* spp.). Soft spinifex could be considered a decreaser. Palatable spinifex species may decline under excessive grazing pressure.

Increasers Type I are moderately palatable species and may become an increasing component of forage intake as decreasers decline. They may increase slightly or remain stable under moderate grazing pressure, and then decrease under heavy grazing pressure as the rangeland condition declines. Increaser Type I could be less palatable spinifex species, or other associated species.

Increasers Type II are unpalatable plants that increase in abundance as rangeland condition declines. Examples are native, unpalatable woody shrubs (such as poverty wattles [*Acacia* species][9]). Hard spinifex may increase in some situations.

[9] Poverty bush (Acacia stellaticeps) in the Western Australian rangelands (online: Poverty bush (Acacia stellaticeps*) in the Western Australian rangelands | Agriculture and Food)

Invaders are not a natural component of the original plant community and encroach into degraded rangeland.

I**nvaders Type I** species may be utilised by animals if the rangeland is in very poor condition and then eventually decline under excessive grazing pressure. These may be native species from another area, but more commonly are exotic species.

Invaders Type II are unpalatable and encroach into degraded areas. They are not a natural component of the original rangeland community.

This increaser-decreaser relationship is very important in our understanding of the dynamics of spinifex pastures. Some records note decreases in soft spinifex and increases in hard spinifex as a result of continual grazing of the more palatable soft spinifex. Hard spinifex is an increaser species in a soft spinifex pasture.

3.2 Soft spinifex management – fire and grazing

3.2.1 Fire

The WA Department of Primary Industry & Regional Development has a comprehensive overview publication – 'Spinifex rangeland pastures and fire in Western Australia'.[10] This publication notes:

- Avoid late summer burns - these may:
    - predispose pastures to weedy species encroachment
    - increase risk of erosion
- Cool season burning may:
    - increase woody weed encroachment
    - require increased burning events to achieve effectiveness
- Stocking rates of 30-85 ha per cattle unit for several years after burning for soft spinifex
- Manage grazing pressure to avoid overgrazing of spinifex and desirable grass species
- Spinifex pasture grazing value highest 1-3 years after fire; gradually declines for following 4-10 years
- Caution: many post-fire plant species may be toxic to cattle
- Allow spinifex pastures to set seed before burning again
- Mosaic burning over a whole property ensures continuity of pasture productivity
- Avoid burning desirable bluebush and saltbush shrubs as they vulnerable to fire
- Avoid regular burning of hard spinifex in central or south-east Gascoyne
- Significant regrowth after burning will occur only after effective rainfall events
- Set paddock stocking rates on the assumption that cattle will concentrate on recently burnt areas
- No grazing of burnt areas in first year after a fire
- Pilbara - after burning hard spinifex, useful forage persists for only up to 2 years
    - where soft spinifex is absent, non-spinifex species may be the only forage value
- Kimberley - pastures of most value for 1-2 years after burning
    - sustainable productivity increased where spinifex sets seed after burning
- Carnarvon Basin - hard spinifex: seedlings establish after 1 favourable season, but adequate ground cover may take 1-2 years to develop
    - undesirable woody shrubs may emerge after burning

[10] online: https://www.agric.wa.gov.au/rangelands/spinifex-rangeland-pastures-and-fire-western-australia

    - burn at intervals of 4-6 years
- Soft spinifex - cool fires result in resprouting from roots
    - hot fires kill most adult plants; regeneration is from seed
- Cool fires may promote germination of undesirable acacia shrubs

Work by Stretch (1996) – 'Fire management of spinifex pastures in the coastal and west Pilbara'[11] - is a thorough coverage of fire management of spinifex pastures in the Pilbara.

The main findings were:

- October-November is the preferred burning period
- Deferred grazing after fire ensures high seedling establishment after rain
- After several fires, each followed by deferred grazing, desirable species can increase
- Cycle time between burning is generally 7-8 years
- The effect of fire on ground cover and desirable pasture species should be considered
- Cattle are attracted to recently burnt areas - caution in managing grazing pressure/stocking rates to minimise risk of overuse
- Initial stocking rate guide: 30 ha/adult equivalent
- Useful feed rarely persists for longer than 2 years after burning hard spinifex country
- The economics of burning hard spinifex country is questionable
- Trial burning may be worthwhile in some areas (i.e. burning small representative areas to check response)
- Patch or mosaic burning may be useful but may be limited by labour availability and costs.
- A wet season spell after burning will minimise loss of seedlings to grazing
- Spinifex pastures on rugged hilly country usually regrow from roots earlier than areas regenerating from seed
- Timing of burn: best practice – early in dry season and late in year under suitable conditions

A technical paper on fire spread in spinifex is in – 'A rate of spread index for fires in spinifex fuels' – online: J:/MODSIM2015/Spinifex/Sharples_etal_MODSIM2015.dvi (dbca.wa.gov.au)

3.2.2 Grazing

A publication on grazing soft spinifex – 'Deferred grazing improves soft spinifex association' shows that preventing spinifex domination can be achieved by combining deferred grazing management with summer burning on soft spinifex in the Gascoyne region - reported by Suijdendorp (1969)[12] This work showed:

- On the deeper granitic sands in much of the region, grazing soft spinifex pastures (where other species were present) for 5-6 years resulted in soft spinifex dominating – burning at that stage encourages re-establishment of other species and production of palatable spinifex regrowth.
- Winter burns near the coast do not kill mature spinifex plants - consequently, although there is spinifex regrowth, other species do not become established.
- Summer fires do kill mature spinifex plants, allowing the appearance of other species, for example:

[11] online: https://library.dpird.wa.gov.au/misc_pbns/35

[12] online: https://library.dpird.wa.gov.au/journal_agriculture4/vol10/iss11/8

    - weeping grass (*Chrysopogon latifolius*)
    - mulga grass (*Neurachne clementii*
    - woolly butt (*Eragrostis eriopoda*)
    - Northern Wanderrie grass (*Eriachne obtusa*)
- Continuous grazing of these more palatable and nutritious species during the growing season results in a decline in their vigour – with spinifex becoming dominant again.
- Early post-fire regrowth of soft spinifex provides valuable forage.
- Soft spinifex is unlikely to regain dominance when deferred grazing is linked with summer burning – this provides the opportunity for the valuable herbaceous forage species to increase during the wet season. However, these species will not support livestock in the dry season.
- The positive effect of burning will take at least several periods of burning.
- During the dry season, livestock can be grazed on the spinifex paddocks.

The results indicated that:

- Soft spinifex is unlikely to regain dominance when a deferred grazing system is associated with summer burning. (Deferred grazing is a management technique that keeps livestock off pastures for a particular period. For spinifex this refers to not grazing after burning).
- The resulting change in plant associations is towards grasses which produce a large quantity of nutritious forage during the wet season.

An experienced WA rangeland scientist, Don Burnside, observed that:

- Relatively young soft spinifex pastures could provide enough nutrition for reasonable calving percentages but will not fatten cattle - the best production system may be taking the progeny off - to be grown out somewhere else.

Work by Craig (1992b)[13] found that:

- On ungrazed soft spinifex in the Pilbara, fire destroyed adult plants
- It required 3-6 years after a fire to replenish a viable seed bank (this needs to be considered in management burning)
- Shield ants (*Meranoplus* spp.) may be important in placing spinifex seeds close to the soil surface where germination is optimal.

- **Kimberley - Hard spinifex plain pastures:**

  A useful publication – 'Hard spinifex plain pastures in the Kimberley, Western Australia'[14] – Key points:

    - Hard spinifex plain pastures are of low pastoral value
    - Hard spinifex is a desirable species in this pasture type because of its role in maintaining soil stability
    - Unpalatable at most growth stages; cattle may graze hard spinifex after plants regenerate from fire
    - Frequent burning may result in stock concentrating on regenerating pasture and a decline in rangeland condition.

[13] Craig, A.B. (1992b). Aspects of post-fire regeneration in soft spinifex (Triodia pungens) communities near Newman, Western Australia. Western Australian Department of Agriculture , Kununurra, WA.

[14] online: Hard spinifex plain pastures in the Kimberley, Western Australia | Agriculture and Food

- Grazing pressure needs to be managed to ensure sustainability of the few palatable pasture species

- **Kimberley - Hard spinifex hill pastures:**

  The hard spinifex hill pastures are covered in – 'Hard spinifex hill pastures in the Kimberley, Western Australia'[15] – Key points:

  - Pastoral value is very low
  - Grazing pressure needs to be carefully managed to ensure sustainability of associated palatable species.

'**Wet season spelling'** refers to not grazing a paddock for a period during the wet season to provide benefits for sustainability, productivity and profitability. The MLA have provided practical advice in: 'Wet season spelling - A grease and oil change for your grass' - online: https://www.youtube.com/watch?v=IoHRBg9_5O0
The video presenters are Ross Peatling (NAPCO Alexandria Station, NT) and Dr Dionne Walsh (previously NTDPI&F, now QI Consultancy) – the presentation is designed for all northern Australia beef producers, including those on spinifex rangelands. Key points:

- Wet season spelling provides opportunities for maintaining and improving rangeland condition – supporting increased productivity and profitability
- Benefits of wet season spelling are quite different to those from resting during drought
- All pasture species can benefit from wet season spelling - grasses are most sensitive to regeneration from resting early in the wet season
- General recommendation is resting for 6 months every 4 years (but important to be flexible)
- Having adequate watering points (particularly in large paddocks) is important for gaining benefits for wet season spelling
- The benefit from each resting period is closely rated to the seasonal conditions
- Developing a spelling program for a whole station can provide overall improvement
- Important that sustainable stocking rates for each rangeland type are employed pre and post season spelling.
- The resting requires removal of stock from paddock(s) – if not sold or agisted, important that they do not result in overgrazing elsewhere.

MLA also have a website providing information and support on wet season spelling - 'Northern wet season hub'[16]

Wet season spelling can be a useful management tool for spinifex pastures – improving the spinifex component as well as the associated species.

3.3 Nutritional value of spinifex pastures

Work on seasonal changes in nutritional value of spinifex in the Pilbara showed that:

[15] online: Hard spinifex hill pastures in the Kimberley, Western Australia | Agriculture and Food

[16] online: https://www.mla.com.au/extension-training-and-tools/seasonal-hubs/wet-season/

- None of the common grass species associated with spinifex were more nutritious or more palatable than soft spinifex
- There is minimal advantage from manipulating spinifex pastures through burning if the aim is to encourage alternative grass species

(Ref: Holm and Allen [1998])[17]

Phosphorus

The comprehensive FutureBeef manual 'Phosphorus management of beef cattle in northern Australia'[18] - refer *Case Study 4 (P34): Myroodah Station, West Kimberley,* WA – *includes curly spinifex pastures*. Refer Appendix 1 (P38) for **phosphorus status in spinifex country in WA, NT and western Qld.**

There is limited knowledge on the nutritional value of spinifex and associated pastures species. This requires further research in relation to seasonal changes and conditions as well as response to grazing and burning.

4. Introduced Pastures

Introduced pastures can decrease or increase the need for supplementation. By providing a higher quality diet directly to the animal there may no longer be a need for supplements, e.g. grazing legumes during the dry season reduces the need for urea supplements. ***Using stylos on low phosphorus soils may create a situation where animals will respond to phosphorus supplement when they would not on native pastures.*** On the native pastures, the nitrogen content of the diet may be too low for animals to respond to additional phosphorus and supplements would be wasted. However, the stylos provide a higher nitrogen level in the diet so phosphorus becomes the limiting nutrient and animals will respond to phosphorus supplements.

4.1 Stylos

Bob MacDonald (MacDonald Agri-Pastoral Systems – refer reference list), a very experienced soil conservationist and advisor, carried out trials with two cultivars of stylo (Seca and Verano) stylos for over 30 years (1982-2012+) in the Kimberley (mainly on "Fossil Downs" near Fitzroy Crossing). A summary of his findings:

Stylos:

- well adapted to the red soils
- soils low in phosphorus did not limit stylos
- have hard and soft seeds (hard seeds are dormant and germinate at a later time)
- sowing on the soil surface or from an aircraft produced satisfactory germination
- best results were from sowing after burning before the wet season

[17] online: Seasonal-changes-in-the-nutritive-value-of-grass-species-in-Spinifex-pastures-of-Western-Australia.pdf (researchgate.net)

[18] online: mla---phosphorus-management-of-beef-cattle-in-northern-australia---2nd-edition_v19.pdf

- cattle trampling on sown areas did not reduce establishment
- survive in cattle rumen
- ***will grow satisfactorily with spinifex***
- Seca * more suitable than Verano
  * tall woody top part eaten (Verano - cattle eat the whole plant)
  * over time (several years) increases protein of spinifex pastures
  * well-developed tap root (more drought tolerant than Verano)
- wait until plants are 15-20 cm high before grazing
- flower in autumn (Seca later than Verano)
- to encourage seeding - rest to let stylo flower and set seed
- spinifex provides some protection for stylo plants until establishment
- stylo helps protect soil surface from rain drop impact
- hot fire will kill stylos

Cattle grow faster on legume-based pastures for most of the year, but the main advantage occurs during the late wet and dry seasons – refer Figure 4.

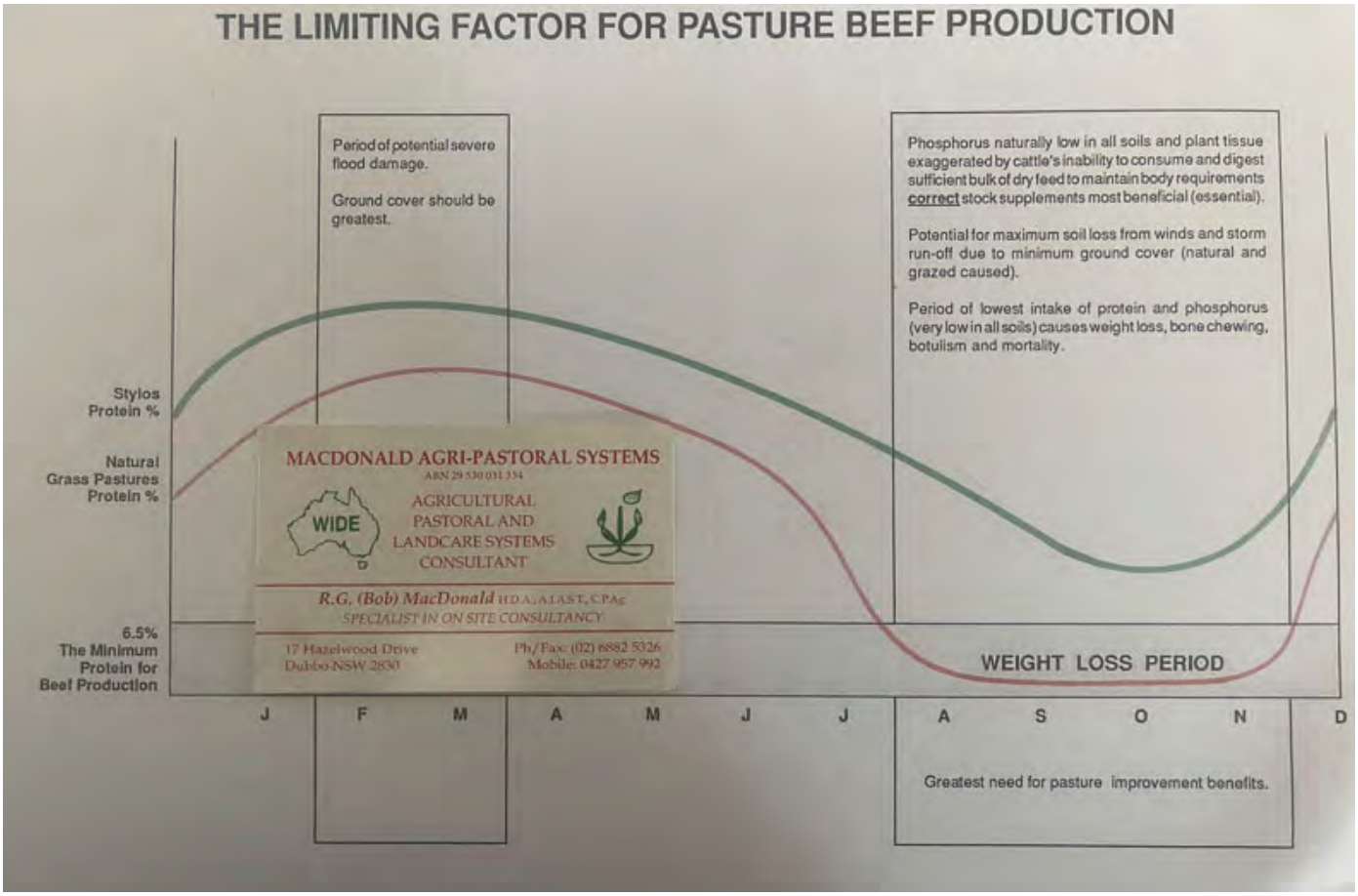


Fig. 4: Limiting factor for pasture-beef production – legumes compared to native pasture in relation to season (source: Bob MacDonald, 2024)

While legumes provide animal production benefits during the late wet-early dry season period, grass-dominant pastures can give higher animal growth rates than legume-dominant pastures during the early wet season. (This is due to the legumes being less robust than grasses by the end of the dry season - and as a result, being less responsive to rainfall).

5. Fire Management

Wildfires/bushfires are a natural occurrence in most pastoral rangelands ... and burning is a necessary component of management for most rangeland types.

Detailed information on fire is in – 'Fire in the Western Australian rangelands' – online: Fire in the Western Australian rangelands | Agriculture and Food - contains specific information on spinifex rangelands.

5.1 Natural fire regimes

Each rangeland type in a particular region has its own natural fire regime – this regime is defined by:

- **Frequency:** for example, annual, biennial or less frequent fires
- **Season:** for example, early in the dry season or early growing season
- **Intensity:** the heat of the fire

Valuable and detailed guidelines for graziers have been developed for fire management in the Kimberley, including specific reference to spinifex pastures – 'Fire management guidelines for Kimberley pastoral rangelands : best management practice guidelines' (dpird.wa.gov.au)[19]

Key points:

- Management of fire risk through fuel reduction balanced with forage requirements
- Adequate firebreaks and tracks for backburning
- Avoid concentration of cattle on small regenerating areas
- Loss of ground cover can predispose areas to soil erosion

5.2 Management burning

5.2.1 Fuel dynamics

Fire behaviour relates strongly to fuel dynamics. Fire generally requires continuity of fuel for it to move across an area. 'Spot fires' may result from windy conditions transporting burning embers ahead of the main fire.

There are minimum quantities of fuel for each rangeland type; the minimum quantity depends on distribution, structure and dryness of the fuel. For most grass fuels the minimum is 800 -1200 kg/ha.

[19] online: Fire management guidelines for Kimberley pastoral rangelands : best management practice guidelines (dpird.wa.gov.au)

Fuel loads can be up to 12 000 kg/ha where litter accumulates under trees and in spinifex grass.

Most grasses require curing before they will burn (spinifex grasses do not cure at any stage and will ignite and burn rapidly when green because of their volatile resin content).

5.2.2 Burning spinifex

It is important for those involved in managing the burning of spinifex to have an understanding of the fire dynamics involved. Technical information on fuel dynamics and fire spread in spinifex are in – 'Fuel Dynamics and Fire Spread in Spinifex grasslands of the Western Desert'[20]

5.2.3 Intensity and distribution of fire

In the rangelands, the intensity of the fire is largely dependent on the fuel load in the ground layers of grass and litter. In most spinifex pastures, it is this layer that dominates the fuel load. Where woody plants are present in spinifex pastures, high intensity fires can kill a large proportion of the woody plant population. Low intensity fires are effective in killing some woody plant seeds on the soil surface and in breaking dormancy in others, e.g. acacias. For a uniform burn, fuel needs to be continuous with more than 50% ground cover. *Where the wind is sufficiently strong, spinifex grasses can bend over to ignite adjacent plants.*

5.2.4 Pattern of burning

Burning in rangelands can be carried out on a whole paddock or on a mosaic pattern. In some situations, the whole paddock must be destocked for a significant period before the burn to build up the fuel load – this may not be necessary with spinifex because of its high level of flammability. It may also be necessary to rest the whole paddock for a significant period after the burn – this will depend partly on follow-up rains.

The mosaic pattern allows for focus areas to be burned where required (e.g. clumps of undesirable shrubs or weeds). In open country in north-eastern Australia, mosaic burning has been achieved using equipment such as the Brompton Fire Rat (manufactured by Hughenden Welding Works). It is usually pulled by a tractor and cuts a small break with a blade and has a drip-torch on a swinging arm). This *could be considered for open spinifex country.*

A particular advantage of mosaic burning is that destocking may not be required. The burned areas may support a 'green pick' and be overgrazed for a short period (by livestock and wildlife). There is a need to ensure that the individual areas burnt in a mosaic pattern are large enough to prevent long-term overgrazing when stock are in the paddocks. Mosaic burning can be used to attract stock to less preferred areas.

Rotational-within-paddock burning of large paddocks has been tested in the Victoria River District. It was found that fire acts similarly to watering points in focussing animal activity – *this could be applicable to spinifex country.*

[20] online: (PDF) Fuel Dynamics and Fire Spread in Spinifex Grasslands of the Western Desert (researchgate.net)

The following video – 'Grassland Dry Firefighting' demonstrates the use of the Brompton Fire Rat (and other dry firefighting equipment and vehicles): online: https://www.youtube.com/watch?v=spGb4706P9I

5.2.5 Post-burn management

Following a spinifex fire, the rate of revegetation depends on the interaction of grazing pressure with:

• Soil moisture

• Temperature

• Density of grasses

• Seed bank of desirable species (*including palatable spinifex and associated species*)

Burnt areas may be susceptible to erosion until revegetation has occurred. Post-fire grazing management (including grazing wildlife) which allows regeneration must be employed.

5.2.6 Burning and grazing

Increased grazing pressure may lead to decreased fire frequency, which may promote woody plants and further decrease both fuel for fire and forage for stock. This increases the probability of further overgrazing and decreases the opportunity for burning - in an ongoing cycle.

Fire can be used to influence grazing distribution and to reduce patch grazing in monsoon tallgrass pasture (Andrew, 1986). It is particularly useful in influencing grazing distribution in large paddocks. Fire can also increase the quality and quantity of pasture for grazing. Specific results from Andrew (1986) work showed:

- Continuous grazing of preferred patches in set-stocked, unburnt pastures of native monsoon tallgrass results in the death of the perennial grass plants within several years.
- Cattle strongly preferred to graze areas which had been most recently burnt
- Resting appeared to enable previously grazed patches of pasture to recover, arresting pasture degradation
- Grazing early in the wet season, but not after, depressed final dry matter yield of individual grass plants by about 60% (mean pasture yield was depressed by only 10% because many plants were not grazed at all)

A comprehensive guide on fire management prepared by Russell-Smith (2020)[21] *contains specific reference to the low rainfall zone where spinifex pastures dominate.* (It is focused on Indigenous Ranger Groups).

There are some gaps in the knowledge on the interaction of burning and grazing in spinifex pastures required to achieve maximum benefit – further research into this is recommended for the different rangeland types and varying seasonal conditions experienced.

5.2.7 Burning in the Kimberley

[21] online: nb04-russell-smith-ar-2020.pdf (bnhcrc.com.au)

Guidelines for graziers on management burning in the Kimberley have been prepared by the WA DPIRD – 'Fire management guidelines for Kimberley pastoral rangelands: best management practice guidelines (dpird.wa.gov.au)'.[22]

A comprehensive paper – 'Fire Management of Rangelands in the Kimberley Low-Rainfall Zone: a Review'[23] - noted that:

- Satellite imagery assists in interpretation of current fire regimes
- Irregular, extensive fires appear to be the main fire regime
- Management burning on stations is essential for controlling fire risk
- For spinifex pastures – recommendations: periodic burning of mature spinifex just before/shortly after first rains with deferment of grazing
- Burning early dry season for creating firebreaks

A report on the high rainfall Kimberley fires from 1990-1999 – 'Patterns of landscape fire and predicted vegetation response in the North Kimberley region of Western Australia'[24] - reported that:

- Substantial (31%) areas of the North Kimberley were burnt each year
- Most burning occurred late in the dry season under relatively severe fire weather conditions
- Most burning was on pastoral stations, particularly on fertile basalt soil country
- Woody plant regeneration increased followed burning, but some may be removed in later burns

5.2.8 Burning spinifex

Detailed guidelines for burning spinifex are in – 'National Burning Project 2014 – National Guidelines for Prescribed Burning Operations. Case Study 8 – Burning of spinifex grasslands in the arid interior of WA'[25]. Important points raised in this publication are:

- The lowest risk period for fire control and safety is May-August
- From a rangeland condition perspective, the preferable period for burning is September-December
- Mosaic burning of 30-35% of an area is recommended – with patches being <250 ha to 1000 ha.

Further burning management principles for WA rangelands are in – 'Guiding principles for fire management in the Western Australian rangelands'[26]. This contains practical information with specific reference to spinifex country.

Future Beef have compiled comprehensive information on burning (including grazing management in the spinifex country) – 'Using fire'[27].

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[22] online: Fire management guidelines for Kimberley pastoral rangelands : best management practice guidelines

[23] online: Online: https://www.publish.csiro.au/RJ/RJ9990039

[24] online: CSIRO PUBLISHING | International Journal of Wildland Fire

[25] online: afac_ops-guide_case_study_8.pdf (aidr.org.au)

[26] online: Guiding-Principles2.pdf (rangelandswa.com.au)

[27] online: Using fire Archives - FutureBeef

Northern Territory: A review of fire as a pastoral management tool in central Australia (including spinifex) is in - 'A review of fire as a pastoral management tool in central Australia'[28]. This includes useful references to spinifex pastures.

5.2.9 Indigenous group burning

Information has been compiled to assist indigenous groups in fire management – 'Information Tools to Support Indigenous Groups to make the Best Decisions in Their Fire Management Projects'[29].

6. Bushfires

Bushfires are a seasonal threat in northern Australia. MLA have a comprehensive and useful hub of information for graziers for all vegetation types, including spinifex – 'Bushfire hub'[30]. While this contains some general information, it is focussed towards all livestock producers and can be adapted to spinifex rangelands.

6.1 North Australia and Rangelands Fire Information (NAFI)

The NAFI website: https://firenorth.org.au/nafi3/ - provides satellite-based fire detection and mapping for northern Australia. ***This is a very important tool for graziers tracking and managing bushfires. It identifies all regions in northern Australia which include spinifex. It also provides a fires history, which can be useful for land management decisions.***

6.2 Bushfires in spinifex

Detailed Information on bushfires in spinifex and shrublands is in – 'Fire regimes in arid hummock grasslands and Acacia shrublands'[31].

6.3 Bushfire ignition

While many bushfires are started by 'dry lightning', accidental or deliberate fire ignition is also a serious problem. With a significant portion of the spinifex country being traversed by tourist routes, there is an increased risk of campfires, etc causing ignition. Reports on examples of issues:

Kimberley Pilbara Cattlemen's Association calls for arson squad to be sent to WA's north (msn.com)

Lake Argyle blazes thought to be sparked by campfires scorch Gouldian finch habitat - ABC News

[28] online: Burning for Profit February 2001 (nt.gov.au)

[29] online: https://bushfiresresearch.files.wordpress.com/2019/03/theme3.4.pdf

[30] online: Bushfire Hub | Meat & Livestock Australia (mla.com.au)

[31] online: Fire-regimes-in-arid-hummock-grasslands-and-Acacia-shrublands.pdf (researchgate.net)

NT Landholders exhausted with bushfires burning for two months - Beef Central

6.4 Bushfires and livestock

Bushfires can be prevalent in spinifex country and graziers need to be aware of their possible impact on livestock. In addition to mortality and serious injury, there are productivity issues. A recent paper has compiled information on this – 'Impact of bushfires on Australian livestock health, welfare and carcase quality'[32]. The main findings in this report:

- There is limited knowledge on bushfire/smoke exposure on livestock health, welfare and carcase quality
- Proximity to fire reduces the hot carcase weight and subcutaneous rib fat.
- The longer a fire persists, the higher the occurrence of pneumonia.

6.5 Northern Territory

Bushfires NT have a useful website which covers all types of country, including spinifex – online: *https://nt.gov.au/emergency/bushfire/managing/bushfires-nt*

FutureBeef have compiled grazier experience in Central Australia into 'Before it all goes up in smoke – proactive fire planning for Central Australia'[33].

[32] online: Impact of bushfires on Australian livestock health, welfare and carcase quality - ScienceDirect

[33] online: https://futurebeef.com.au/before-it-all-goes-up-in-smoke-proactive-fire-planning-for-central-australia/

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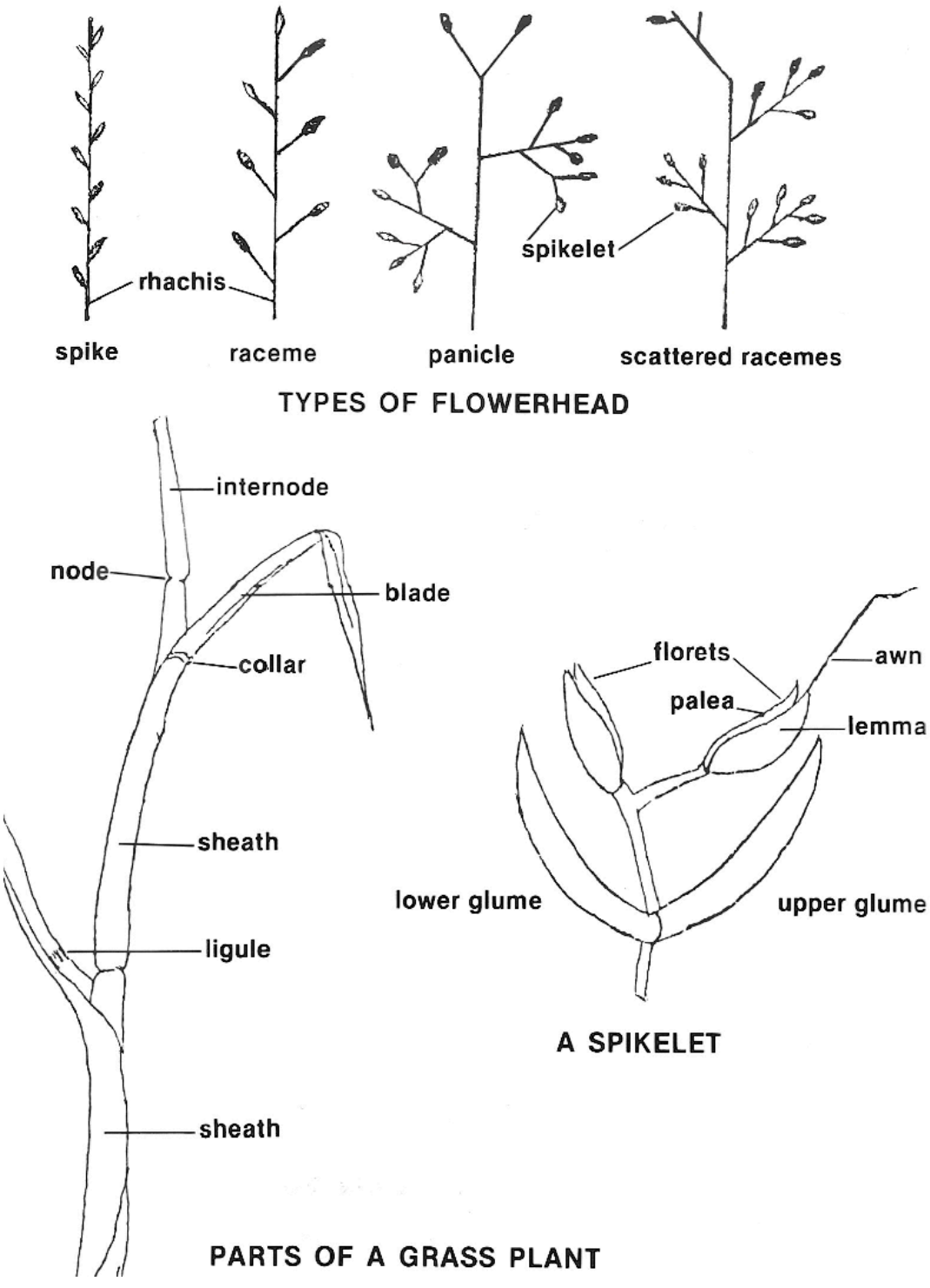
9. Appendix 1 – Parts of grass plants



Parts of Grass Plants (Ref.: Petheram and Kok, 2003, pp 550)

10. Appendix 2 – Additional Notes and References on Spinifex Rangeland Management

Spinifex Rangeland Management

A detailed guide to pasture condition and management of spinifex country in the Gascoyne is included in: https://library.dpird.wa.gov.au/bulletins/288/

A very useful pasture condition and management guide for graziers in the Pilbara is online: https://www.agric.wa.gov.au/rangelands/pasture-condition-and-management-guide-pilbara-rangelands-western-australia - this *includes the main spinifex pasture types and livestock carrying capacity.*

A useful outline of Pilbara pastures is – 'Introduction to rangeland pastures in the Pilbara, Western Australia' – online: Introduction to rangeland pastures in the Pilbara, Western Australia | Agriculture and Food This includes reference to spinifex pasture types.

Holm and Allen (1988) noted that The rainfall in the Exmouth Gulf region is bimodal, with a peak in winter and summer - with usually more rain falling in summer than winter, online: Seasonal-changes-in-the-nutritive-value-of-grass-species-in-Spinifex-pastures-of-Western-Australia.pdf (researchgate.net) This rainfall distribution is important for opportunistic management decisions on spinifex pasture management.

A comprehensive guide for assessing pasture condition in the Pilbara – 'Pasture condition guides for the Pilbara' - online: https://library.dpird.wa.gov.au/misc_pbns/7. This reference includes details on the main spinifex pasture types.

A very useful publication for the Pilbara is: 'Pastoral Resources and Their Management in the Pilbara Region of Western Australia'. (2004) (online: https://library.dpird.wa.gov.au/misc_pbns/15/). It *includes significant detail on spinifex pastures and grazing land management at an individual station level.*

A general guide to rangeland grazing management (including the Gascoyne) is – 'Grazing the rangeland: towards an understanding' - online: https://library.dpird.wa.gov.au/journal_agriculture4/vol29/iss4/9/ . It *includes specific reference to spinifex pastures.*

Spinifex pastures occur across many rangeland types in the NT. An example of the NT govt. general advice on the management of pastures (with reference to spinifex) is online:

https://industry.nt.gov.au/__data/assets/pdf_file/0011/233498/345.pdf

Land Resource Reports

Land systems were developed by CSIRO to describe the occurrence of patterns of geology-landforms-soils-vegetation in rangelands. CSIRO published this information in reports (including detailed maps) under the 'Land Use' series. Some states have complemented the CSIRO series, resulting in all of Australia's rangelands being covered. These reports are very valuable for grazing land management and can be used at a property/paddock level. They include maps at an appropriate scale and describe the individual land units which comprise each land system. For example: Land Systems of the Kimberley region, Western Australia (2011); available at: https://library.dpird.wa.gov.au/tech_bull/11/

A series of comprehensive reports on the Kimberley have been prepared over recent decades. The following two references contain detailed descriptions of the natural resources in The Kimberley, *including spinifex pastures*:

Payne, A. L., Kubicki, A., Wilcox, D. G., and Short, L. C. (1979). 'A Report on the Erosion and Range Condition in the West Kimberley area of Western Australia.' Technical Bulletin No. 42. (Department of Agriculture of Western Australia: Perth.) – online:

https://library.dpird.wa.gov.au/tech_bull/54/

'No. 4 The Lands and Pastoral Resources of the North Kimberley Area, WA'. – online: https://www.publish.csiro.au/CR/LRS04

DPIRD staff developed *Pastoral land condition standards for the West Kimberley* – the 5 monitoring and assessment units, 10 key pastures and their indicator species for the West Kimberley region are in Table 1. *Note the reference to spinifex in Table 1.*

Table 1: Indicator pasture species for West Kimberley

MAU	Key pasture	Indicator species*
Alluvial Plain	Mitchell grass alluvial plain pastures	*Astrebla elymoides, A. pectinata, Dichanthium fecundum*
Alluvial Plain	Blue grass alluvial plain pastures	*Chrysopogon fallax, Dichanthium fecundum*
Coastal	Buffel grass pastures	*Cenchrus ciliaris, C. setiger*
Frontage	Frontage grass pastures	*Chrysopogon fallax, Dichanthium fecundum*
Frontage	Buffel grass pastures	*Cenchrus ciliaris, C. setiger*
Plains Hummock	Pindan pastures	*Chrysopogon fallax, Triodia bitextura*
Plains Hummock	Curly spinifex pastures	*Chrysopogon fallax, Triodia bitextura*
Plains Hummock	Soft spinifex pastures	*Chrysopogon fallax, Triodia pungens*
Plains Tussock	Ribbon grass pastures	*Chrysopogon fallax, Dichanthium fecundum*
Plains Tussock	Arid short grass pastures	*Chrysopogon fallax, Enneapogon polyphyllus*

MAU = monitoring and assessment unit (= rangeland type)

* Although other productive species might be present in these pastures, the indicator species are those whose relative presence or absence best define the condition status.

Ref: Pastoral land condition standards: Conceptual basis and West Kimberley region case study – (Online:

https://www.agric.wa.gov.au/sites/gateway/files/Pastoral%20land%20condition%20standards%20-%20Conceptual%20basis%20and%20West%20Kimberley%20region%20case%20study%20-%20Draft%20October%202022.pdf)

Forage Management

Useful information on pasture plants in WA is in –_'Common pasture plants in the rangelands of Western Australia' – online: Common pasture plants in the rangelands of Western Australia | Agriculture and Food – this reference contains information on the spinifex species and their management in the Pilbara and Kimberley regions.

Buffel Grass

Buffel grass has been introduced to northern Australian rangelands over the past decades. It is well established and, in many situations, naturalised and recognised as a rangeland type. Information on buffel grass is in: 'Buffel grass pastures in the Kimberley, WA' - online: Buffel grass pastures in the Kimberley, Western Australia | Agriculture and Food . *Note the association of soft spinifex and buffel grass in Table 2 in that publication.*

Chris Materne (rangeland ecologist at the Arid Zone Research Institute, Alice Springs, NT) provided the following information on spinifex and buffel grass:

- The government has recently declared buffel grass a weed over much of the NT
- Buffel grass has been observed growing out of spinifex stands
- There has been no observations of buffel invading and depleting spinifex stands
- Buffel grass, along with other grasses, is severely set back by drought – but buffel and all grasses respond strongly to drought breaking rains.

Reclamation of Degraded Spinifex Country

Severe degradation and soil erosion have occurred on the Ord River catchment. Remedial treatment projects have been carried out in that area since the 1990s; large parts of the project area supported hard spinifex (*Triodia wiseana*). Payne *et al* (2004) reported on 'Spectacular Recovery in the Ord River Catchment' in 2004 (online: https://library.dbca.wa.gov.au/static/Journals/081862/081862-2004.17.pdf).

Fire Management

A technical paper has been developed on fire behaviour – 'Fuel, fire weather and fire behaviour in Australian ecosystems' - online:

Fuel-fire-weather-and-fire-behaviour-in-Australian-ecosystems.pdf (researchgate.net) . This publication *includes specific reference to spinifex*.

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