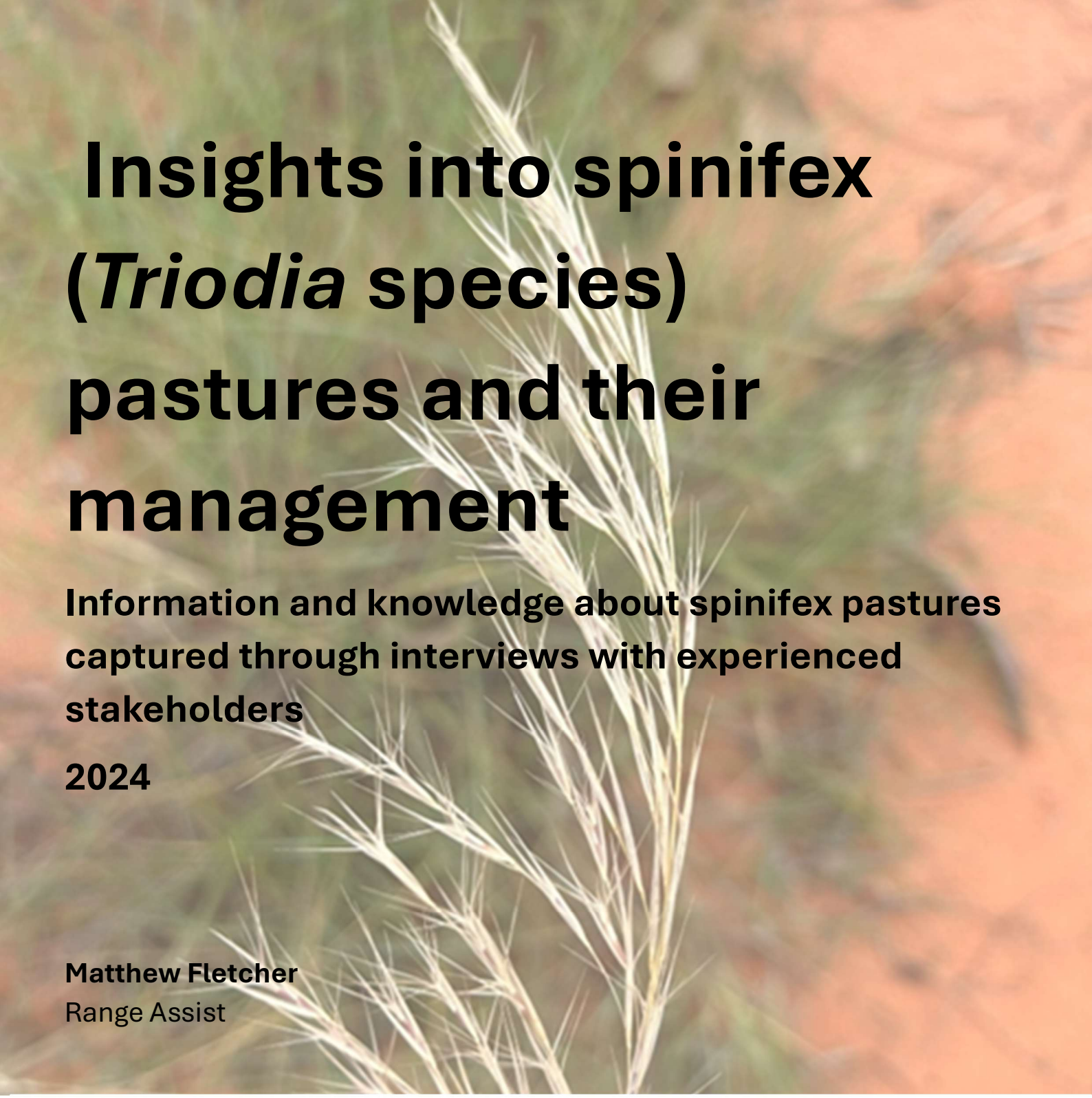

Insights into spinifex (*Triodia* species) pastures and their management

Information and knowledge about spinifex pastures captured through interviews with experienced stakeholders

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Matthew Fletcher
Range Assist

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Author

Matthew Fletcher, Kununurra, Western Australia; matt@rangeassist.com.au

Disclaimer

The views and opinions in this report are the interpretations the author has made from interviews with stakeholders. The content is derived from sources with extensive individual experiences with spinifex and is believed to be reliable. Despite careful preparation, the author cannot guarantee the accuracy or currency of all information presented. The author accepts no liability whatsoever arising from the use or release of this report or any part of it.

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Interview planning

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Interviewees

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Reviewers

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Abstract

Interviews about various aspects of spinifex pastures were conducted with 21 pastoralists, five Traditional Owners, and seven rangeland scientists from the Pilbara, Kimberley, and central Australia regions. These interviews were completed during April and May 2024. Interviews sought to provide insights into spinifex pastures and covered topics such as plant identification, mosaic burning, grazing systems, tree/grass balance and Indigenous uses of spinifex and burning practices; knowledge gaps were also identified.

The interviews made it clear that fire plays a significant role in spinifex pastures and is frequently used to enhance grazing productivity by removing old or moribund spinifex and allowing palatable new growth to replace it. Additionally, fire is used as a tool for wildfire mitigation by creating different-aged fire scars and subsequent variations in fuel levels across the landscape. The amount of non-spinifex material in the diet of grazing animals was commonly discussed. Interviewees reported stock preferences for available annual and perennial grasses and forbs as well as browse species, predominantly wattles.

This report is not intended for use as a comprehensive guide for managing spinifex pastures. Rather, it aims to provide a foundation for further work by documenting current knowledge and management practices. The report also provides industry, industry bodies, and government agencies with information to guide future research, extension, and development activities to benefit those working with and managing spinifex pastures.

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Background and objectives

Although spinifex covers a significant proportion of northern Australia, there is limited readily available information on spinifex plants or the management of spinifex pastures in a pastoral context. In 2023 the Kimberley Pilbara Cattlemen's Association commissioned two reports on spinifex pastures.

The first report, 'Situational Analysis on Spinifex Pastures', reviews scientific papers, other publications and the media. This second report captures knowledge about spinifex pastures gathered during interviews with pastoralists, Traditional Owners and rangeland scientists.

Together, the purpose of these reports is to consolidate our collective knowledge on spinifex pastures and make this information available to land managers, pastoralists, Traditional Owners, extension officers, researchers and other interested stakeholders. Additionally, the reports identify knowledge gaps of where more information is needed to improve our understanding and management of spinifex pastures.

This report is not intended for use as a comprehensive guide for managing spinifex pastures. Rather, it aims to provide a foundation for further work by documenting current knowledge and management practices. Over the next 3–4 years, the Kimberley Pilbara Cattlemen's Association proposes to address key knowledge gaps and produce a more complete and in-depth document outlining spinifex ecology and best practices for managing spinifex pastures.

Introduction

Spinifex is the common name for a group of native perennial grasses (*Triodia* species) that are found in all Australian mainland states (Australian Virtual Herbarium 2024) and cover more than 25% of the Australian continent (Allan *et al.* 2002). Spinifex plants grow predominantly on soils with low nutrient levels and low water-holding capacity, such as on sand-plains, gravelly slopes, hillsides, and large ranges. The genus *Triodia* is endemic to Australia and consists of 86 species (Barrett *et al*. 2023). This number continues to evolve as taxonomic research progresses.

A notable feature of many *Triodia* species is their ability to form a ring. A hummock is formed as the plant expands outwards via above-ground stolons. At some point the central growth may die and disappear leaving a distinctive ring surrounding a bare area.

Another important feature of spinifex is that the hummocks are highly flammable due to a dense accumulation of dry, often-resinous biomass which builds up following periods of significant rainfall.

Hard spinifex foliage is generally unattractive to livestock at all stages of growth. In contrast, soft spinifex foliage is grazed by livestock and remains palatable for 3–4 years after fire, after which the feed quality deteriorates.

The regions covered in this report are the Pilbara, Kimberley, and central Australia, where spinifex is generally widespread. Although spinifex also grows in the southern rangelands of WA and other areas of the Northern Territory, these areas were outside the project scope.

Methods

Interviews were conducted with pastoralists, Traditional Owners and rangeland scientists who were either living in the Pilbara, Kimberley or central Australia or had previously lived in these regions. A total of 33 interviews were completed; 21 with pastoralists, five with Traditional Owners, and seven with rangeland scientists (Table 1). Due to the large distances and time constraints, all central Australian and rangeland scientist interviews were conducted by phone.

Table 1. Interviews completed with pastoralists, Traditional Owners and rangeland scientists

	In-person	Phone	Total
Pastoralist	16	5	21
Traditional Owner*	3	2	5
Rangeland Scientist	0	7	7

*Content from two Traditional Owner interviews was also used in the pastoral section.

There was a comparatively even distribution of interviewees from the Pilbara, Kimberley, and central Australia regions. However, no Traditional Owners from central Australia were interviewed; any further interviews should aim to include representatives from this region (Table 2).

Table 2. Representation of regions in interviews

	Pilbara	Kimberley	Central Australia
Pastoralist	9	7	5
Traditional Owner	2	3	0
Rangeland scientist	1	2	4
Total	**12**	**12**	**9**

Pastoral and rangeland scientist interviewees were asked a standard list of questions (see Appendix A). In a small number of cases, interviewees chose not to respond to certain sections because of time constraints or their perceived lack of qualification. For example, few rangeland scientists commented on the topics of fence maintenance and the feeding of supplements.

Of the five Traditional Owners interviewed, two were asked all interview questions, while the other three focused only on the aspects of spinifex and fire as relevant to Traditional Owners.

Notes were transcribed from the recordings that were made of each interview. As several interviewees requested that their names not be mentioned in the report, all interviewees remain anonymous. The content of this report is based on the 33 completed interviews.

Limitations

Owing to time and logistical constraints, it was not possible to interview all pastoralists, Traditional Owners, and rangeland scientists with significant knowledge of spinifex pastures.

Some interviewees had a lifetime of experience living and working with spinifex pastures, and it was obviously not possible to capture all relevant knowledge in the scheduled two-hour interview.

This document is a compilation of observations on spinifex pastures from a wide area encompassing various soil types, broad temperature ranges, and a large variation in annual rainfall; for example, it includes Halls Creek in the Kimberley, where the average rainfall is 571 mm, Newman in the Pilbara (321 mm), and Alice Springs in central Australia (283 mm) (Bureau of Meteorology 2024 a–c). Most interviewees referred to the 'wet season' or 'summer' as the period when most of their region's rainfall usually occurs. However, some coming from areas as far south as the Tropic of Capricorn also receive winter rain and do not typically experience a regular wet season like those from further north, such as the Kimberley. Any generalisations drawn from this report should be considered in the context of the reader’s local area.

Several interesting topics were briefly raised during interviews but are not further discussed in this report. They included:

- the positive influence of smoke on spinifex germination rates
- masting, which is the synchronized release of spinifex seed, flooding the environment with seed, and
- spinifex resin/wax production from excess carbohydrates.

Results and discussion

Spinifex species and identification

Verifying the type of species being discussed during interviews was not practical. Therefore, any conclusions drawn regarding species must be approached with caution. Having said that, most interviewees referred to the following spinifex types (relevant *Triodia* species are listed after each group name):

- Curly spinifex: *Triodia bitextura*
- Soft spinifex: *T. epactia, T. pungens*, and *T. schinzii* (referred to by some as a hard spinifex)
- Hard spinifex: *Triodia basedowii*, *T. intermedia*, *T. irritans, T. secunda, and T. wiseana*
- Buck spinifex: *Triodia longiceps* (a hard spinifex)

There are several key plant anatomy differences between hard and soft spinifex. Hard spinifex is non-sticky, whereas soft spinifex always has a sticky resin on the new growth (Latz 2007). Hard spinifex has stomata on both sides of its leaves, while soft spinifex only has stomata on the inner side (Barrett *et al*. 2017). Stomata regulate gas exchange (oxygen and carbon dioxide) and water loss in plants. Pronounced differences in leaf anatomy distinguish hard species, characterized by stronger fibres, from soft species with weaker fibres (Memmott 2013).

Interviewees were asked how they identify different spinifex species in the paddock. The most common methods used were:

- From seed head and reproductive parts (seed); this was the most common response.
- By feel: soft spinifex usually has a waxy (sticky) texture; you can step on soft spinifex with little resistance whereas hard spinifex is much firmer.
- By smell: the wax on soft spinifex has a distinctive smell.
- By shape: a tight sharp ball indicates hard spinifex.
- By colour
- Through observing location: soft spinifex in sandy desert country and hard/buck spinifex on rocky ridges.

Throughout this document, spinifex will be referred to using the groups mentioned above unless otherwise indicated. Help in accurately identifying the different species of spinifex was the most common request from interviewees when asked about the need for more information. It should be noted, however, that there were some interviewees with an excellent grasp of species identification and botanical names.

Common and botanical names of plants referred to in this report are provided in Appendix B.

Figure 1 Feathertop spinifex (*Triodia schinzii*) seed head.

Spinifex plant

Spinifex rings

Most interviewees were aware that spinifex plants grow outwards via stolons (runners), which are above-ground stems that anchor in the soil by establishing roots at the stem nodes. A ring can form when the older plant material at the centre of a hummock dies and decays.

A number of spinifex species are known to form rings as they age. Porcupine grass (*Triodia irritans*) and lobed spinifex (*Triodia basedowii*), both regarded as 'hard' spinifexes, can form large rings that are in the order of 40–50 years old. Soft spinifex (*Triodia pungens*) and feathertop spinifex (*Triodia schinzii*) are both 'soft' spinifexes and if left long enough will also form a ring. This is uncommon in high rainfall/high ignition areas as both spinifex types burn too frequently. Spinifex rings are more commonly found in central than northern Australia due to lower rainfall and reduced fire frequency.

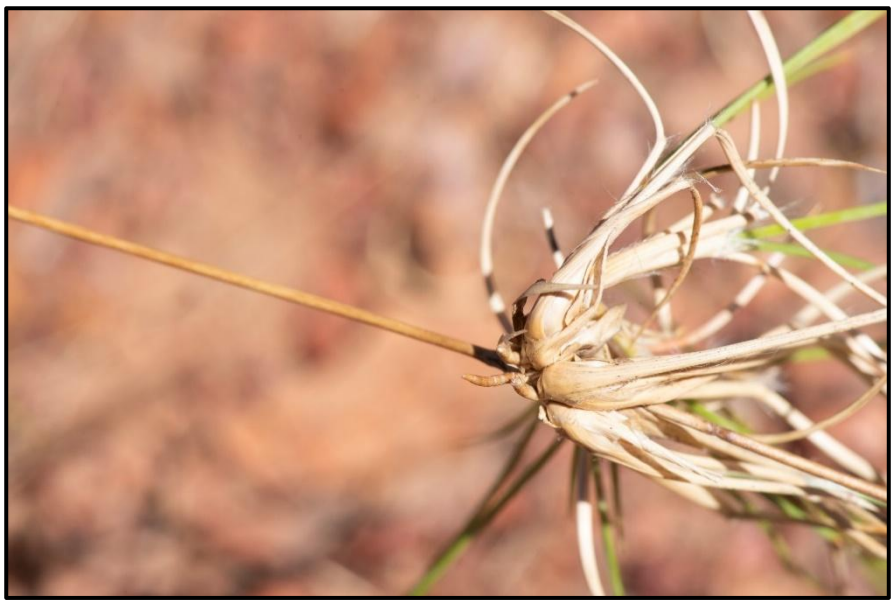

Figure 2 On the left is a stolon (runner) from a mature curly spinifex (*Triodia bitextura*). On the right, a ramet (clone of the mature plant) with new shoots. At the base of the ramet, you can see the beginning of a root that will anchor the ramet to the ground. (Photo courtesy of Peter Maloney, DPIRD WA).

Grazing of seed heads

There was consensus that spinifex seed heads are potentially the most nutritious part of the plant and are consumed by both cattle and horses. Several interviewees suggested that stock may prefer hard spinifex seed heads over soft ones. Livestock eat the seed heads by pulling them, along with part of the stem, out of the plant, the lower part of the stem being sweet to the taste. Other observations include cattle stripping the seeds from the seed head. The seed heads remain nutritious for a few weeks and are grazed while green, then left until later in the year. Cattle typically return to the seed heads (even though the seeds have dropped) when other more palatable grasses become scarce and by which time supplements are often being fed concurrently.

One interviewee recalled that grain poisoning or acidosis had occurred on extremely rare occasions in the Pilbara when cattle had eaten fresh spinifex seed heads, after a long period of consuming low-quality spinifex. When rain immediately produced fresh spinifex growth and seed heads, their rumens, having been on low-quality spinifex for so long, were not adapted for the highly digestible seed heads and a number of cattle deaths were the result.

Several references were made to the desirability of having some spinifex in horse paddocks so that the horses had access to seed heads. Before grains like barley and oats were readily available, horse trainers used to harvest the hard spinifex seed heads for their racehorses.

There were, however, a few interviewees who questioned the benefit of seed heads. They believed that when there are fresh spinifex seed heads, there are other much more palatable grasses such as buffel (*Cenchrus ciliaris*) also available for grazing. These interviewees had not often observed cattle eating seed heads and noted that generally, at the time seed heads are available there are also better things to eat on offer.

Of the native fauna, only birds were noted as eating the seed while it was still on the plant. However, once the seeds dropped to the ground, they were eaten by ants and rodents or collected and taken back to their nests.

A few interviewees pointed out that the presence of a seed head does not always indicate that it is filled with seeds. One interviewee noted, “The untrained eye would think the florets [part of the seed head] were full of seeds; however, they are often empty.”

Red seed heads

The presence of red seed heads in spinifex was not originally covered in the standard questions. However, during an interview in the Pilbara it was mentioned that, after winter rain, spinifex seed heads seemed to be red in colour rather than the expected green or yellow. Although it was noted that seed heads are uncommon in winter, a few other interviewees from the Pilbara had also observed red-coloured seed heads that were often associated with winter rain.

Time between fire and seed head production

The interviews made clear that seed head production is rainfall-driven, with summer rain being generally more important for significant production. One manager from central Australia observed that “Spinifex will green up after a storm but a couple of inches of rain are needed to produce a seed head.” A high rainfall year will result in a good seed set; however, seed set significantly declines in average and poor years. With so much depending on rainfall, its high variability in the Pilbara, central Australia and southern Kimberley means there is no simple relationship between seed head production and time since fire.

Other factors also affect how long it takes after fire for spinifex plants to produce seed heads. Plants resprouting from the base are able to produce a seed head more quickly than plants regenerating from seed. Estimates from the interviews conducted are that soft spinifex in the Kimberley takes 2–3 years after fire to produce seed heads (based on two responses, n=2) while hard spinifex will take 4–5 years (n=1). In the Pilbara, soft spinifex will produce seed heads 2–4 years after fire (n=3).

There were several outliers in estimates given. Two interviewees, one from central Australia and one from the Pilbara, had observed plants as young as 12 months producing seed heads. Another noted that in central Australia it can take up to eight years after a fire for “seeding spinifex to resemble a wheat field.” All these answers are valid; they illustrate the difficulty in making 'apples with apples' comparisons when so many variables are at play.

The interviewees agreed that older plants produce more seed heads. After good rain, there is limited fresh growth on older plants; however, they produce more seed heads. It seems that older plants put more energy into seed production, whereas younger plants focus on growth. It was also reported that during an average to below-average wet season, spinifex seed heads develop more quickly (survival mode) compared to a big wet season when the plant grows leaves first and then produces seed heads.

Other influences on seed production that were briefly mentioned during the interviews were cumulative rainfall, evaporation, masting and the availability of soil nutrients, particularly phosphorus.

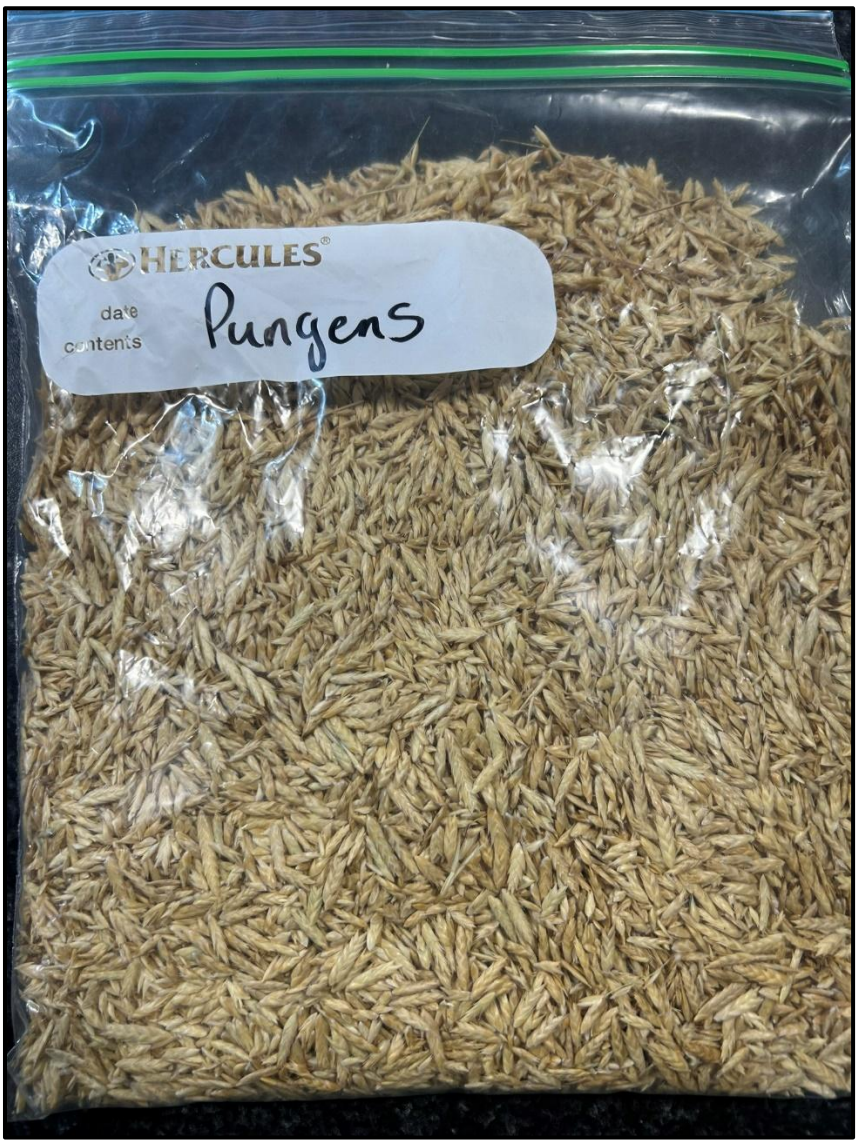

Figure 3 Soft spinifex (*Triodia pungens*) seed destined for mine-site rehabilitation.

Traditional Owners and spinifex

Five Traditional Owners were interviewed regarding how they have used spinifex themselves in more recent times and how their ancestors had used it in the past.

The comments in this section are based on interviews with three Traditional Owners from the Kimberley and two from the Pilbara. There were no central Australian Traditional Owners interviewed at this time. Any future interviews would aim to include Traditional Owners from central Australia.

Four main uses were described by those who were interviewed. Actual quotes are used where indicated.

Making wax from spinifex

"Pick a patch of spinifex, usually on or near a hill where a flat rock can be found. Gather the spinifex onto the rock and light it. Once the fire has burnt down, brush the ash away, and the wax will be left on the rock. Scrape the wax off the rock and form it into a big ball. This wax was then taken with them and was a bit like saddler's wax. When heated and softened, it was used to affix the spearhead to the main shaft and would set very hard."

"*Another method was to collect resinous spinifex onto a rock slab and thresh it until the resin was detached from the foliage. The gathered resin was then collected into a concentrated mass, semi-melted and pressed to form a coherent ball* (non-traditional owner interviewee)."

Food

"People used to collect spinifex and other seeds and put them in their bags. When they had gathered enough, they would grind them up and make a Johnny cake, which was flat because they had no baking powder."

Signalling

"Fire was often used for signalling (someone saying hello over there). They would light fires as they walked to let the other groups know that they were coming."

"This could be for lore or other purposes."

"When mustering in the early days we had no radio, so fire was used to signal where everybody was."

Freshening country, attracting game and other 'burning for purpose'

"The old spinifex was no good for kangaroos. If you burnt a section the kangaroos would come in and eat. (The Aborigines) would then use the old spinifex for cover and sneak onto the kangaroos by forming a circle. It didn't matter which way the kangaroos went, they ran into a hail of spears."

"They used to burn spinifex before the wet season so it would rejuvenate and get the animals back; this was done just before the rain would come. They knew when it was going to rain and would burn just beforehand to get a green shoot. Burning after the wet season (cool burns) is a recent thing; (the east Kimberley) is different to the Kakadu area where cool burns are preferred."

"Wherever Aboriginal people walked they would burn. They did not go walking to deliberately burn; they were more likely to burn enroute to – or while – conducting other activities."

"(There) used to be big fires started from lightning."

"Fires were used to clear the country up and patch burns were also done."

"Kangaroo, goanna, black headed snake and emu were all hunted on spinifex country."

"Most pastoralists burn spinifex early in the year when other grasses are too green to burn. However, because of the wax in the spinifex, it will burn. Towards the end of the year when good grasses are too dry or are grazed out, the spinifex will have come up to about riding boot height and at this stage is very good for cattle."

"Burning for wax, hunting and signalling would have stopped masses of fuel building up and reduced the incidence of wildfire. This is burning for a purpose/reason."

Pastoralists and scientists comment on the Traditional Owners' use of spinifex pastures

This section is about burning of spinifex pastures and outlines what pastoralists and rangeland scientists have gleaned from their experiences talking to and working with Traditional Owners.

There were a number of comments about how spinifex was burned to attract game and how it also provided wax for tool making. These topics have been sufficiently covered by the interviews with Traditional Owners themselves so this section will focus on other practices.

One Pilbara pastoralist employed Aboriginal stockmen for mustering and said he would give them each a box of matches to light the spinifex when they needed to show others where they were. It was thought that the Traditional Owners would have used fire in a similar manner to create smoke signals when they were walking around the bush.

Two other interviewees who worked with Aboriginal stockmen in mustering crews also remembered being given boxes of matches for burning spinifex. This was to show your location so

the person working beside you knew whether to slow down or hurry up (to keep in line) and to indicate the location of the main mob. This burning was effectively a form of patch burning. Mustering was mainly done in winter, so these were cool small fires that would only spread 10 to 20 metres. Burning targeted the larger, rank patches of spinifex and generally avoided recently burnt plants and any areas where the fire could get out of control and be difficult to manage. Aboriginal stockmen were somewhat selective about which spinifex species to burn.

It was thought that Traditional Owners avoided burning large areas, as this would have made it more difficult to ambush prey and would have necessitated extensive walking to find food. Burning large areas could therefore have led to food shortages. Additionally, the smaller areas would have provided areas of retreat when lightning started wildfires.

Burning without roads to act as firebreaks would have been challenging, so they must have been highly skilled at burning small patches without allowing fires to get out of control.

Lightning was thought to be responsible for most of the fires occurring in the spinifex-dominated arid zones. Aboriginal people didn't have prolonged access to much of the spinifex country; it was too dry, and there weren't enough water sources for them to stay for long. They moved around and burnt between water sources; however, they were generally unable to access much of the surrounding country. Aboriginal people burned areas they could access, while fires started by lightning burned the areas in between.

Fire, spinifex and grazing

In the technical literature, the term fire (or 'fireline') intensity has a specific meaning and is commonly defined as the rate of energy release by a fire per unit length of the fire front.

In layman's terms, fire intensity is often referred to as 'hot' or 'cool' and interviewees generally regarded landscape fires as falling into one of these two broad categories. These distinctions encompass the differences encountered around the difficulty of fire control and effects of the fire on vegetation and soils.

Cool fires

Most of the interviewees preferred cool fires and emphasised the need for adequate soil moisture prior to burning. Burning after rain, when the soil and spinifex are well hydrated, is desirable because fire intensity is reduced. Importantly, pre-existing soil moisture also enables rapid regrowth of spinifex and any other perennial grasses that have not been killed by fire, typically within a week or two. This rapid growth response was frequently mentioned as a key reason for burning when soil moisture was readily available. Ideally, rainfall would follow the fire, allowing annual grasses and forbs to germinate, filling in the vegetation gaps left behind after fire and providing nutritious pick for cattle.

Another commonly observed characteristic of a cool fire was its self-extinguishment at night. Interviewees favoured short sharp burns and could usually achieve these by lighting a fire in the evening and having it out by the following morning. Some interviewees liked a strong wind to push the fire along quickly, as they did not have the resources to monitor fires constantly. Others preferred a slow, creeping fire that would be less likely to get out of control but would still self-extinguish at night. Typically, the wind must be sufficient to bend the flame over and allow fire to spread from one spinifex clump to another. When there are plentiful cured annual grasses and forbs growing between the spinifex hummocks, the requirement for a strong wind is reduced.

Humidity was another key requirement for a cool fire. With high humidity, the fuel (particularly of cured pasture plants) absorbs moisture from the air. This increased moisture content renders them more difficult to ignite and slows down the rate at which they burn. Consequently, fire intensity and its rate of spread is reduced.

In the Kimberley and Tennant Creek areas, cool burns were typically undertaken at the end of the wet season or early in the dry season, most commonly between March and May. In the Pilbara and

central Australia, the timing of burning had a much greater spread, starting as early as December after summer storms and extending into winter. This wide variation is due to the high rainfall variability and the potential for winter rainfall.

Burning while it's cool in winter (Pilbara and central Australia) was also noted to be convenient because it could be done while mustering. Also, extinguishing fires in the middle of winter with the cooler temperatures makes it a lot easier logistically compared with doing so in the middle of summer.

Several interviewees discussed the importance of burning spinifex before any nearby buffel and Mitchell grass pastures had dried off enough to carry fire. Preserving these valuable grasses is of high priority to them.

Burning without soil moisture

Some Pilbara interviewees burn with little soil moisture, prior to rain. This allows for immediate regeneration of annual and perennial grasses and forbs after rain. If burning is delayed until after rainfall and there is no follow-up rain, only perennial grasses and spinifex not killed by the fire will grow. Although burning between rainfall events with soil moisture is ideal, it is challenging to achieve in low-rainfall regions due to the infrequency and unpredictability of rain.

To reduce the potential of these fires to burn too hot and get out of control, burning is conducted when humidity is high and the wind is blowing toward a natural fire break. These fires creep along and go out at night. With proper spinifex management, there won't be a large buildup of spinifex, and the fire will still require some heat and wind to carry the flames. These controlled burns tend not to leave the land scalded.

Hot fires

In general, interviewees emphasised that they do not deliberately ignite hot fires; however, they often encountered them as a result of lightning strikes or unauthorised fires. At a property level, interviewees had observed that a large area was affected by hot fires in some years, while cool fires predominated in other years. Hot fires were typically associated with strong easterly winds, low humidity, dry fuel, and high temperatures from September to December and throughout the summer until sufficient rainfall occurred.

Many interviewees made efforts to avoid hot fires because burning with insufficient soil moisture would leave the land barren until the next rain, reducing available feed and increasing erosion risk. Additionally, it was noted that areas affected by hot fires often take years to recover. This prolonged recovery was attributed to several factors:

- subsequent high plant and seed mortality
- absence of soil moisture necessary for the resprouting of surviving plants, and
- the sometimes lengthy period before rainfall sufficiently replenishes the soil moisture reserves needed for sustained growth.

The effectiveness of hot fires in killing spinifex, shrubs, and trees was frequently discussed. Having said that, few of the interviewed pastoralists deliberately light hot fires to manage the tree/grass balance. This is because these fires entail significant risks, particularly concerning their safe control. Legally, it has become more challenging because the consequences can be severe if something goes awry, especially if a permit has not been obtained. It is currently increasingly difficult to safely organise and contain a hot fire; it demands substantial preparation and human and machinery resources, especially when burning a large area and such fires are inherently tricky to manage. While unplanned fires are generally of great concern to pastoralists, some conceded that they may, on some occasions, derive land management benefits from lightning fires or fires ignited by others, provided the extent of the fire can be limited and their infrastructure is protected by earlier preparation.

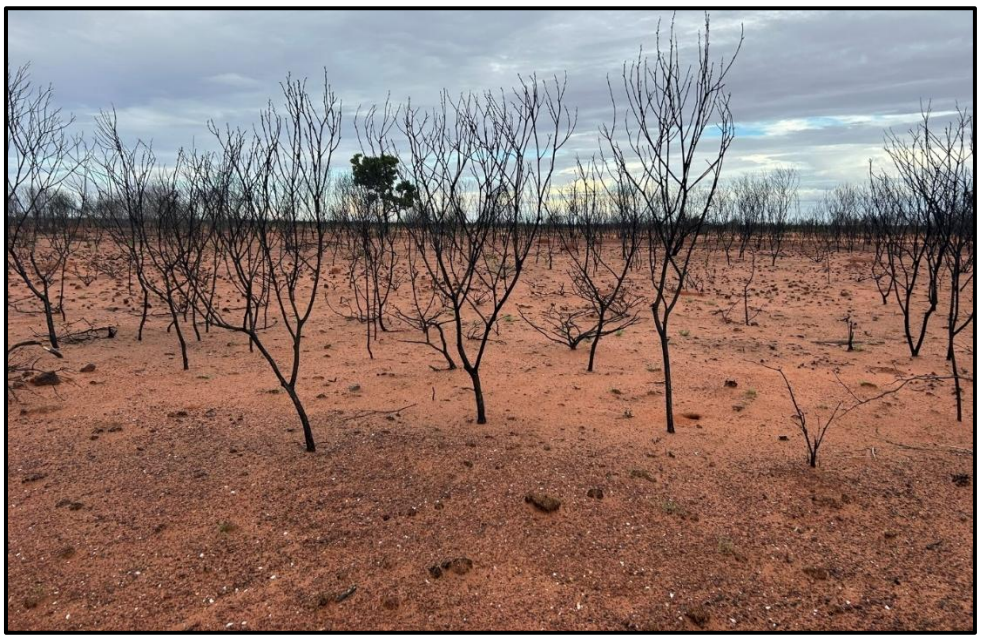

Figure 4 Photo taken March 2024 between Broome and Port Hedland; this area of spinifex was burnt (unplanned) in October 2023. The 2023/24 wet season (October to April) rainfall for this area was 50–100 mm (very much below average in the terminology of the BOM).

Wildfire mitigation

In the interviews recorded, the term ‘wildfire’ was generally interpretated as fires not lit by the land manager and usually started from lightning or unauthorised ignition.

From the interviews, it was determined that the primary tool utilised for wildfire mitigation in spinifex is mosaic/patch burning. Creating variation in fuel levels through different-aged fire scars is considered the most effective method for mitigating wildfires. Not only does this practice minimise the risk of wildfires, it also rejuvenates the spinifex pastures by replacing old, dense spinifex with new growth.

Essentially, to prevent wildfires, one must ‘combat fire with fire’. It is considered essential to use fire to control fuel loads; however, this doesn't mean waiting for a big season or recognising a potential fire problem and then burning everything. That approach only leads to the same problem recurring in a few years. The key is to consistently engage in controlled burning.

One interviewee gave the following advice:

“When doing a bore run through spinifex country, light it up and let it burn to create a patch. Next time, light another section to create another patch. Continue this process around the patches you've already burned. The following year, repeat the process, burning around the sections you have already burned. Gradually build up a patchwork where fuel is reduced, but spinifex is also recovering. This way, when a big fire comes, it will hit your burnt patches and won't have enough fuel to get through. A wildfire might penetrate the 4 to 5-year-old patches, but only in bits and pieces, as the fire will be broken up. You won't get the large, destructive fires caused by a lack of prior burning activity. While this method involves some risk, it is essentially the only tool for mitigating wildfires and keeping spinifex pastures actively growing and grazeable.”

When wildfires occur, interviewees relied mostly on barriers such as roads, rivers, and old fire scars, allowing the fire to burn into these areas and self-extinguish. Back-burning was also discussed as a tool for stopping the progression of wildfires. This involves controlled burning ahead of the fire, typically along a road or fence line, to remove the combustible fuel that would otherwise feed the wildfire. Well-maintained station tracks and graded fence lines are important to enable back-burning as well as to protect fences from fire.

Burning permits

Some interviewees, particularly those from the Pilbara, discussed concerns and challenges with obtaining burning permits. Since the Australian Fire Danger Rating system was updated in 2022, the ratings relative to conditions are now much higher. As a result, accessing permits to burn has become more difficult, making it hard to get a permit when conditions are optimal for burning. One interviewee stated, "Sometimes when we want to burn, it is considered out-of-season by the Shire and the Department of Fire and Emergency Services; this is a headache."

Providing a date, time, and place in advance of burning is challenging because variables such as wind direction and speed, humidity, and temperature cannot be predicted with confidence far in advance. Instead, these factors are best determined on the day or just prior to burning to ensure safety and a successful burn. One interviewee commented, "You are meant to pinpoint exactly where you are going to burn; however, the wind may change, and you will then need to burn elsewhere. The current fire permit system is not flexible enough for this."

Additionally, the need to keep fires small and limited to a couple of hectares is impractical on a pastoral lease. If fires are too small, not enough area will be burned, reducing the effectiveness of wildfire mitigation and encouraging overgrazing of burnt patches.

Time between fires

The time between fires in a spinifex pasture is strongly influenced by the amount of rainfall received since the last fire (cumulative antecedent rainfall). After fire, spinifex plants regenerate from the base or from seeds, accumulating biomass after major rainfall events and retaining it during dry periods. This biomass accumulation process happens much more quickly in higher rainfall areas than in lower rainfall areas.

In the Pilbara and central Australia, where the average rainfall is 200–300 mm (see Table 3), interviewees observed that it takes spinifex seven to nine years to accumulate sufficient biomass to support another fire.

Spinifex may not always be the primary fuel source, especially when annual grasses such as kerosene grass (*Aristida contorta*) and bottle washers (*Enneapogon* sp.) quickly occupy bare areas after a fire. As a result, and particularly in high rainfall areas, fire can be carried before the spinifex hummocks are mature.

Table 3 Time between fire in spinifex pastures

Region	Annual rainfall (mm)	Fire frequency (year)	Comment
Pilbara/central Australia	200–300	7–9 years	Hard and soft spinifex, based on two interviews.
Pilbara/central Australia	300–400	5–11 years	Hard and soft spinifex, based on four interviews.
Kimberley/Tennant Creek area	400–500	4–5 years	All soft spinifex pasture, based on four interviews.

Wind and fire

Wind plays a critical role in fire behaviour and is crucial for driving fire, especially when there is not a continuous cover of grass. During the dry season or winter, wind typically picks up in the morning, peaks in the mid-afternoon, and dies down by evening. Many spinifex fires extinguish at night due to the lack of wind needed to push the flames between hummocks. Understanding the relationship between fire and wind is essential as fire movement is primarily driven by wind.

One interviewee commented that, *"A good wind can drive a fire 30 km in one direction while keeping it only half a kilometre wide, breaking up the country."* Another interviewee said, *"Looking at satellite images you will see long fire scars, like someone has taken a brush and painted a stroke of a fire out across the spinifex country."*

Regeneration after fire

No definite rule applied for determining how spinifex species regenerate after fire. Regeneration seems to depend on multiple factors including fire intensity, pre- and post-fire rainfall, seed availability and how well the base of the plant is protected by sand.

In soft spinifex, there was consensus among interviewees that the plant can regenerate from both seed and plant bases. Several of those interviewed said that regeneration from seed often occurs after a hot fire, whereas regeneration from the base is more common after a cool fire. The behaviour of curly spinifex in the Kimberley region was observed to be similar.

There was also consensus that hard spinifex on rocky country in the Kimberley mostly resprouts from the base after fire.

One interviewed researcher described how spinifex regeneration can be influenced by the amount of sand that has built up around the plant. If 20–30 cm of sand has accumulated in the middle of the hummock any fire that comes through will burn the leaves but not the growing stems that are buried in the sand. These parts are subsequently unaffected by the fire and will resprout immediately, provided there is sufficient moisture.

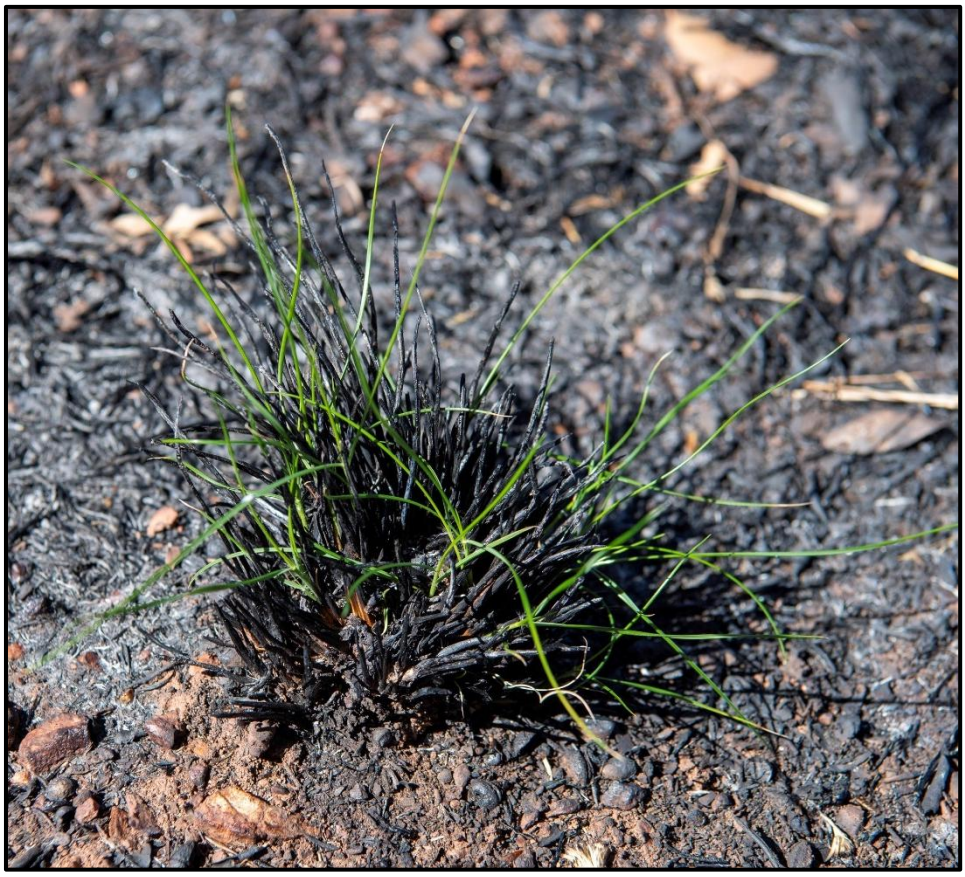

Figure 5 Curly spinifex (*Triodia bitextura*) regenerating from the base following a May 2024 fire, photo taken June 2024 near Kununurra (Photo courtesy of Peter Maloney, DPIRD WA).

Grazing after fire

Cattle congregate on burnt areas so, once an area is burned, it takes a while for the volume of feed to build up again. The early growth is nutritious, however is not abundant so that cattle also need access to other bulk feed. Getting the proportions right around how much to burn or not burn is crucial; burning areas that are too small can lead to excessive localised grazing, while burning too much can deplete feed reserves and affect areas that should be reserved for burning in following years.

Most interviewees reported that their properties had limited internal fencing, aside from holding, weaner, and bullock paddocks. With few fences to control their movement, stock preferentially graze on burnt areas and the more productive and palatable pastures. On leases with areas of buffel or Mitchell grass (*Astrebla* spp.), stock numbers are set based on these pastures since stock do not generally utilise spinifex pastures unless conditions are dry, and they are being fed supplement. Paddocks or areas dominated by spinifex that contain smaller sections of the more productive pastures are more likely to be spelled than those paddocks with only spinifex. This ensures protection of the more heavily grazed areas and allows pasture condition to be maintained or improved.

Interviewees from properties with limited internal fencing still appreciate the benefits of spelling spinifex pastures. By constantly burning and keeping spinifex pastures fresh, managers can encourage stock to move around and target the fresher regrowth of recently burned areas. Although these paddocks are set-stocked and stock can move around freely, some areas are rested when cattle preferentially graze the other recently burnt areas.

Comments in favour of wet season spelling included:

- Palatable annuals and forbs that emerge between spinifex hummocks after a fire must be able to set adequate levels of seed or they will not reappear in subsequent years.
- References to the uprooting of young soft and curly spinifex plants by cattle grazing or trampling. There is a need to give plants (especially new ones) time to develop their root systems.
- Desirable perennial grasses and spinifex are vulnerable when young and growing. A mouthful of leaf or stem taken from a seedling can have a negative impact on growth, whereas one from a well-established plant will have much less impact.

There were few examples where paddocks or areas are spelled for six months or more after fire. Instead, paddocks are typically partially burned and destocked or they carry reduced numbers for three to four months before full cattle numbers are reintroduced. Some managers had the capacity to burn whole paddocks and would remove cattle until the second mustering round later in the year; however, this was uncommon.

Grazing value after fire

This section looks at the palatability of spinifex pastures after fire. There are more annual grasses and forbs present 1–3 years after fire compared with longer time frames of 4 or more years, and it seems the presence or absence of these species significantly influences productivity. Similarly, young spinifex plants, aged 1–3 years, contain a higher concentration of nutrients compared to older plants, aged 4 or more years. Additionally, the leaves are more digestible when actively growing than when dormant. Interviewees were aware of the benefits to animal performance provided by increased amounts of annual and perennial grasses and forbs and appreciated the importance of varying nutrient concentration and digestibility of spinifex.

Soft spinifex pastures in the Pilbara and central Australia

The dynamics and palatability of annual and perennial grasses, forbs and spinifex in the Pilbara and central Australia are similar to those in the Kimberley. The main difference is the longer fire interval due to the lower annual rainfall received (Table 4).

Table 4 Palatability of spinifex pastures after fire (all rainfall dependent) in Pilbara and central Australia

Years after fire	Palatability	Comment
1	High (depending on rainfall)	If rainfall is insufficient, there will be minimal growth and little grazing material. Sufficient rainfall means the grazing quality will be high and stock will graze annual and perennial grasses, forbs, and spinifex.
2	High (most palatable)	The second year after fire is commonly described as the most productive year, with stock preferentially grazing the annual and perennial grasses, forbs, and spinifex.
3	High to moderate	Spinifex is still palatable although now starting to become less so. However, there are now benefits from grazing the seed head.
4	Moderate or low	Spinifex is crowding out the annual and perennial grasses and forbs, and stock are grazing the seed head only.
5	Low	Pasture consists mostly of rank spinifex, and it is probably time to consider burning again in the 300-–400 mm rainfall areas. There is still some value in grazing the seed head.
6	Low	Spinifex pastures are unpalatable. There is still some value in grazing the seed head.
7	Low	In the low rainfall areas (200–300 mm), there will generally now be enough biomass for another fire.

Soft spinifex pastures in the Kimberley

In the soft spinifex pastures of the Kimberley, feed quality (including non-spinifex species) is assessed as 'good' one year after a fire. In the second year, the feed quality is fair; however, by the third year, it becomes marginal. By the fourth year, the feed quality is poor. When spinifex hummocks reach four years of age, they contain more black (dead material) than green and feed quality is low, indicating it is likely time to consider burning again. Plants generally won't be grazed once they are more than two years old although stock will sometimes eat the seeds.

Hard spinifex pastures in the Kimberley

In the Kimberley, stock graze on hard spinifex from the time it emerges until it reaches about 5 inches (12.5 cm) in height. However, about six weeks after germination, the spinifex becomes too hard to eat, so it was considered important to get the cattle grazing it as soon as it shoots. As one interviewee said, "If you can touch and rub it, cattle will generally eat it."

Interviewees were not concerned about cattle pulling out hard spinifex either when it is growing from a seedling or regenerating from the base during the first few weeks of regrowth after a fire.

For about three years after a fire, cattle will graze the annuals and forbs that grow amongst the spinifex until the spinifex starts crowding them out. At that point, it's usually time to consider burning again. Cattle will eat everything growing along the creeks and in between the spinifex plants. If there is nothing else left, they will then eat the hard spinifex.

Stock were reported to graze the seed heads of hard spinifex, with some managers refraining from burning until the seed has dropped to ensure cattle have had a chance to eat them. Visual observations indicate that during the 3–5 weeks when the seed is ripe and available, the cattle appear to do well. It was also noted that stock would be doing well on the annual grasses and forbs that also grow during this period.

Non-use of fire

Some interviewees choose not to burn spinifex. Instead, they prefer to maintain ground cover and relied on soft spinifex, buffel, native panic (*Panicum decompositum*), perennial sorghum (*Sorghum plumosum*), and ribbon grass (*Chrysopogon fallax*) to provide the bulk of feed. Even though soft spinifex tussocks become old and rank, they still grow a veneer of green shoots that are grazed.

Stock are also supplemented with phosphorus over the wet season and urea and phosphorus over the dry season, to increase intake.

It was agreed by these interviewees that plant species diversity generally increases after fire. However, in one interview in March 2024, it was pointed out that there had been an instance in late 2023 where a hot fire had passed through and without soil moisture or follow up rainfall, the ground remained bare.

Maintaining ground cover is paramount for several reasons. It protects the soil from erosion and plays a crucial role in reducing evaporation, which in turn preserves moisture in the soil for plant growth.

In the event of a fire starting from a lightning strike or unauthorised ignition, interviewees who preferred not to burn usually let the fire burn to a fire break and self-extinguish.

Influence of fire on species composition

Before a fire, nutrients accumulate or are tied up in the above-ground spinifex biomass. Few other annual grasses and forbs are able to survive because they are unable to compete with spinifex for nutrients, moisture, and sunlight. However, after a fire, the above-ground spinifex biomass is reduced to ash and nutrients leached from this become available for spinifex seedlings and other plants. There is also increased moisture, sunlight, and space for growth.

Common annual grasses that take advantage of the increased availability of nutrients, moisture and room to grow are kerosene grass, bottle washers, and button grass (*Dactyloctenium radulans*).

Perennial grasses, already present pre-fire, no longer need to compete with spinifex for nutrients and moisture, nor are they required to grow up through the spinifex hummock to access sunlight. The main perennial grasses discussed during the interviews included buffel, Birdwood grass (*Cenchrus setiger*), ribbon grass, native panic, perennial sorghum, silky brown-top (*Eulalia aurea*), hop-a-long grass (*Paraneurachne muelleri*), buck wanderrie (*Eriachne helmsii*), woolly butt (*Eragrostis eriopoda*), and unequal three-awn (*Aristida inaequiglumis*).

Forbs discussed during interviews and also observed to take advantage of after fire conditions include mulla mulla (*Ptilotus* spp.), tick weed (*Cleome viscosa*), cockroach bush (*Senna notabilis*) and narrow-leaf indigo (*Indigofera linifolia*). Winter burns in the Pilbara seem to favour the growth of woolly corchorus (*Corchorus walcottii*).

During one Pilbara interview, previous research was cited. This research showed that, in a soft spinifex pasture 17 months after fire, there were 24 ephemeral (short-lived) species recorded. However, at 70 months after the fire, these ephemerals had been crowded out and only seven were recorded. It was assumed this change would have also been reflected in the grazing animal's diet as the ephemeral species were shown to be more digestible than spinifex.

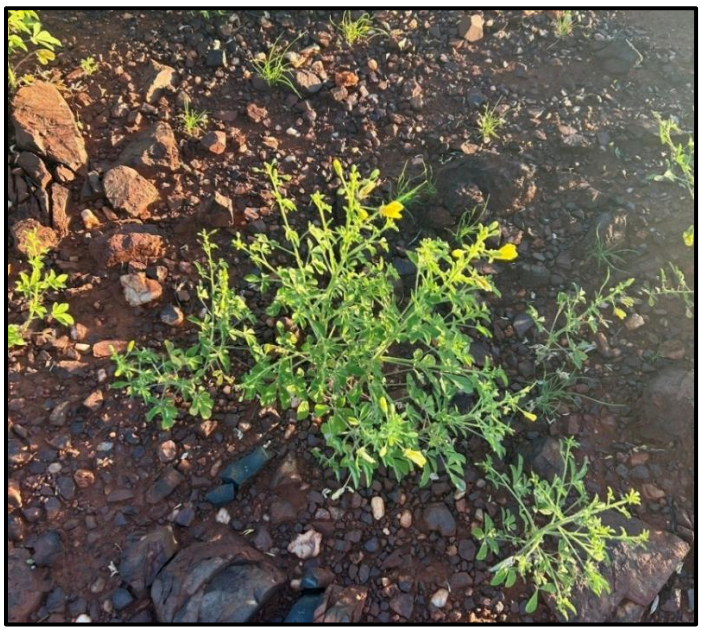

Figure 6 Photo taken in March 2024 (east Pilbara); this area was burnt from a lightning strike in January 2024. Main plant with a yellow flower is tick weed (*Cleome viscosa*); spinifex seedlings are shown in top half of the photo.

Grazing land management

Trees and shrubs

There was no consensus amongst those interviewed on whether trees or shrubs are increasing or decreasing in spinifex pastures.

Some concerns were raised about the observed increase in wattle, although the exact cause—be it fire, climate, or grazing—remains unclear.

Photographs provide evidence that suggests an increase in trees and shrubs. In addition, the shift to using helicopters instead of bikes for mustering has been attributed an increase in bardi bush (*Acacia* spp.).

However, some interviewees believe wattle is not increasing and may actually be decreasing due to recent dry periods and/or the prevalence of hot fires across the Kimberley. Several interviewees expressed greater concern about woody thickening in their more productive pasture types, such as flood-out country, rather than in spinifex pastures.

Regardless of their beliefs about whether tree or shrub populations are increasing or decreasing, most interviewees appreciate the roles these plants play. They recognise that trees and shrubs provide browse for stock, recycle nutrients through their deep root systems, and create habitat for the forbs and grasses underneath. They also enhance infiltration rates beneath the canopy and any fallen branches protect desirable grasses from being grazed.

Comments from several pastoralists indicated that the heat from fires causes wattle seeds to crack, allowing oxygen and water to enter and trigger germination. It is believed that hot fires crack wattle seeds more effectively than cool fires, meaning hot fires leading to increased germination. So, although hot fires are effective at killing wattle, they also promote its germination. As one interviewee noted, *"If you kill one wattle in a hot fire, ten will come to its funeral!"*

Another interviewee pointed out that the best time to burn and kill wattle is in September and October. At this time of year, the seeds are still green on the trees. It is assumed that the fire would ‘cook the seeds’ before they fall to the ground, preventing their germination. It was still acknowledged that these fires would also crack any surviving wattle seeds or those already on the ground and potentially lead to a high germination rate.

Managing woody growth in spinifex pastures does not follow a one-size-fits-all rule. Factors such as variations in rainfall, the species and height of trees and shrubs, soil type, grazing practices, and fire all play significant roles in this dynamic.

Non-spinifex in diet

Following after fire rain in a soft spinifex pasture, cattle primarily feed on a non-spinifex diet by selecting soft fresh growth of annual and perennial grasses and forbs.

However, every area is different.

For instance, if buffel grass is abundant in creek lines or on a floodplain, the diet may exclude spinifex altogether because there is sufficient biomass of buffel.

However, in paddocks dominated by spinifex there will generally be some spinifex in the diet even when there is a flush of annual and perennial grasses and forbs. This is likely for two main reasons: firstly because of its abundance and, secondly, like the grasses and forbs, it is more palatable since its fresh growth is higher in nutrients, and more digestible.

Three years after fire, there is a decrease in annual grasses and forbs, and the spinifex leaves are no longer as nutrient-rich or digestible. At this stage, the most valuable part of the pasture is found in the palatable perennial grasses. If these preferred perennial grasses are not abundant, livestock will need to utilise the spinifex.

While spinifex may not be the first choice for grazing animals, it will often make up the bulk of the diet. Feeding a nitrogen and or a phosphorus supplement will increase utilisation.

The practice of patch burning enables cattle to have access to spinifex at various stages of regeneration. This way, cattle may never need to graze pastures that are considered rank (4–6 years old), as there are always some available areas that have been burnt more recently (in the last 1–3 years). As a result, cattle may only graze areas of rank spinifex for a short time; grazing the seed heads for a couple of weeks each wet season.

The few forbs mentioned as being grazed by cattle included parakeelya (*Calandrinia* sp.), rhynchosia (*Rhynchosia minima*), mulla mulla, and zornia vine (*Zornia prostrata*). Despite forbs being a significant component of the animals' diet, only the names of a few specific plants are known. It is recommended that DNA analysis be conducted on cattle faecal samples to identify which forbs are being grazed.

Stock also browse the trees and shrubs in spinifex pastures.

Interviewees reported that cattle graze specific woody plants, including bauhinia (*Bauhinia cunninghamii*), holly-leaf grevillea (*Grevillea wickhamii*), lemonwood (*Dolichandrone heterophylla*), curara (*Acacia tetragonophylla*), bardi bush (*Acacia* spp.), mulga (*Acacia aneura*), snake wood (*Acacia xiphophylla*), miniritchie (*Acacia* spp.) and saltbushes (*Atriplex* spp.). It is unknown if these trees and shrubs are grazed more frequently 1–3 years after fire, 4–6 years after fire, or seasonally.

Wattles (*Acacia* spp.) are an important browse species in the Pindan areas of the Kimberley. When the season changes in October, the trees produce green leaf and seed pods thus providing a visible nutritional boost for cattle. Similarly, in the Tennant Creek area, the trees produce new growth in spring. During this time, cattle are often seen walking around with their heads up and browsing on fresh wattle leaves.

Likewise, in the Pilbara and central Australia, interviewees mentioned that cattle eat, “and in some cases have been bred to eat,” mulga and other trees/shrubs. A central Australia interviewee has observed wattle leaves in the stomachs of slaughtered animals, but only when the cattle were on dry spinifex pastures. It is likely cattle prefer wattles towards the end of the year when spinifex pastures are at their lowest in terms of nutritional value and digestibility. When cattle are grazing more productive country, such as areas with buffel and Mitchell grass, wattle leaves are not found in their stomachs.

Indicators of pasture condition

Interviewees were asked what makes them think they are managing their spinifex pastures well, or how they can tell that the pastures are in good condition.

The three most common answers were:

- the presence of a high density of spinifex in the pasture
- the occurrence of desirable perennial grasses growing between the spinifex clumps, and
- having a mix of different-aged spinifex.

Interviewees also looked for the following:

- a mix of trees and shrubs (but not overgrown)
- having more feed than just spinifex (including annual grasses and forbs), and
- having few bare areas.

Some land managers also used the condition of cattle and their dung, as well as growth and conception rates, to provide an indication of the quality of the feed on offer.

Interviewees were also asked how they determine if their spinifex pastures are not being well-managed or are in poor condition.

The most common answers were:

- a loss of palatable spinifexes in the pasture. For example, a decrease in soft spinifex (*Triodia pungens*) and an increase in unpalatable hard spinifex (*Triodia intermedia*)
- when buck spinifex (*Triodia longiceps*) is growing where it doesn't normally grow
- a shift in species composition from palatable annuals such as bottle washer to unpalatable forbs and undesirable grasses such as three-awn grasses (*Aristida* spp.)
- bare areas
- excessive woody growth (mainly *Acacia* spp.)
- one interviewee in the Pilbara noted that when cattle start pawing at and eating buck spinifex (*Triodia secunda*), this is a warning that you have had them in that country too long.

Soil erosion

When spinifex burns, the soil becomes loose and mobile. This was observed in central Australia following the wet years of 2011 and 2012, when significant biomass growth led to fires. During the subsequent dry period, sand dunes up to one metre deep formed on roads because the spinifex, which normally held the soil in place, had been burned away.

Some interviewees believe that the movement or redistribution of sand is a natural process that occurred even before European settlement. They do not consider it a significant issue when sands shift locally.

In areas where spinifex grows on deep sands, most rainfall soaks into the soil. However, during heavy rainfall from cyclones or significant rain depressions, the soil can become saturated. When this happens, the excess water runs off, causing erosion in places with little ground cover, including areas where water collects, such as roads and fence lines. Ground cover is crucial to slow the water flow and prevent soil erosion. Interviewees discussed using 'whoa-boys' to slow water flow and divert it away from roads and fence lines.

Although large areas of spinifex grow on deep sands, it also thrives in rocky and hilly terrain. While these areas are somewhat protected by their rock armour, the smaller areas of topsoil in between are not, and are susceptible to erosion when soil cover is reduced and especially on slopes.

High density/short duration/long rest grazing

High density/short duration/long rest grazing of spinifex pastures was not originally the subject of an interview question. However, after the topic was mentioned a few times, a question on this topic was included in subsequent interviews.

Only one of the interviewees practises high density/short duration/long rest grazing principles and this was on a tussock grass plain, not a spinifex pasture. This manager thought it possible that the benefits currently received from burning spinifex, such as removal of rank growth and an after-fire flush of annual and perennial grasses and ephemerals, could alternatively be achieved with high density/short duration/long rest grazing.

Were this to prove a successful management practice, long term benefits would be an increase in the density of perennial grasses and decrease in—but not altogether removal of—spinifex. The goal would not be to eliminate spinifex but to enhance the biodiversity of the pasture. The interviewee considered that patience would be needed to effect these changes owing to the low soil fertility.

Buffel grass

Besides spinifex, buffel grass was the next most discussed grass, as it is common across the different regions and recognised as a reliable and nutritious cattle feed. Interviewees indicated that buffel grass is already well established along creek lines and in areas with better quality soil. If not already present, it is slowly spreading into these areas.

Buffel grass is generally absent from broad expanses of spinifex pastures such as the soft spinifex pastures on the Singleton land system of central Australia. In this region, as well as in the soft and hard spinifex pastures of the Pilbara and Kimberley, buffel grass was only found growing in disturbed areas, such as around water points or roadsides. It was also commonly reported growing under bloodwood trees (*Corymbia* spp.) in spinifex pastures. This is likely due to the increased nutrients found beneath these trees compared with areas outside their drip line.

Not all interviewees were enthusiastic about buffel grass. Some commented that it takes over and outcompetes native grasses. When it fully takes over, nothing else grows, and once the buffel is gone due to overgrazing or drought, the land is essentially bare. This does not occur with spinifex. Additionally, it was mentioned that fires are more intense when burning in areas with buffel grass.

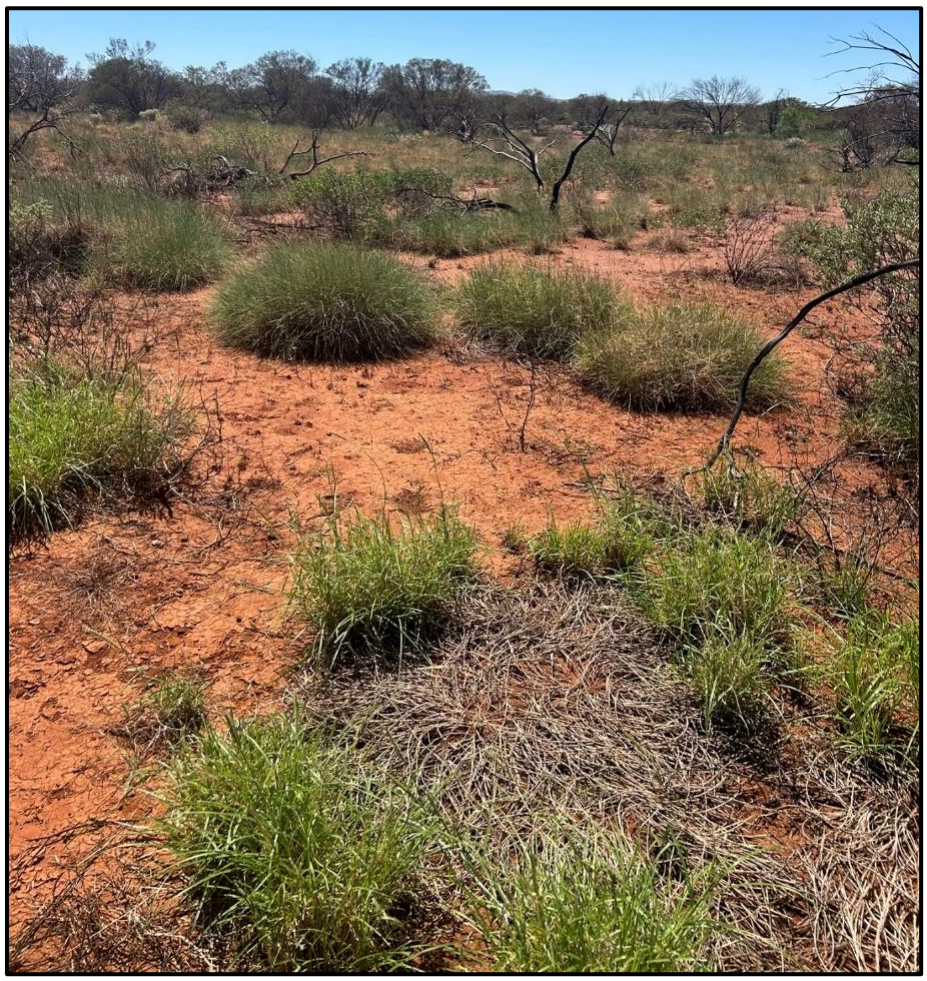

Figure 7 Photo taken in March 2024 near Newman, showing spinifex hummocks and buffel growing around a dead spinifex clump at bottom of photo.

Introduced legumes

Most interviewees in the Pilbara and central Australia were not aware of any introduced legumes growing on their properties. Some did report stylo growing along roadsides but not in spinifex pastures. Stylos, such as seca/shrubby stylo (*Stylosanthes scabra*) and verano (*Stylosanthes hamata*) are well-known in the Kimberley; however, they predominantly grow around water points, roadsides, and under bloodwood trees in spinifex pastures.

One Kimberley interviewee reported that stylo is 'everywhere' (in the Pindan country) and they are trying to exclude fire to promote more stylo growth. They observed that their cattle do not seem to eat it much but will graze on it when there is little else to eat.

General comments regarding stylo indicated that it does not handle dry spells well and is often killed by fire, then needs to regenerate from seed. Observations were that stylo appears to be generally unattractive to stock and is grazed only if kept short.

Biodiversity

The list of native animals/insects mentioned during interviews included: kangaroos, lizards, emus, snakes, hopping mice, insects, bilbies, turkeys, quails, dunnarts, spinifex lizards, quolls, echidnas, thorny devils, and termites. Non-native animals discussed were cats and foxes.

The following is based on comments from several interviewees relevant to the actual time of fire through to old-growth spinifex. When a fire passes through spinifex, lizards and mice take refuge in holes in the ground. Once the spinifex is removed, these animals lose their protection from cats and

other predators and become vulnerable until the spinifex sufficiently regenerates. Freshly burnt areas attract bustards and kangaroos, while tracks from mammals like hopping mice, bilbies, and dunnarts are more common in recovering burnt areas. This could either be because they are grazing on the new plant growth, or their tracks are more easily seen with less spinifex cover.

As the spinifex plants mature, the number and diversity of animal and insect species also increase. Dunnart and lizard populations grow, and some mammal populations can increase rapidly, particularly after periods of well-above-average wet season rainfall. Old spinifex provides an important habitat for many of these animals.

Fire plays a crucial role. Burning in summer benefits birds and small animals that are not nesting at the time. It is essential to burn smaller areas at a time within spinifex pastures to allow animals to shelter from predators in mature spinifex and graze in recently burnt areas. A mosaic of different-aged spinifex is beneficial for biodiversity, while wildfires that burn large swaths of land negatively impact fauna.

Termites were described as 'herbivores of the desert country'. When dry grass is available, they collect it in large amounts and store it in their galleries. During periods of grass burning or droughts, they rely on their stored reserves, waiting for better conditions to return. They continue to graze on the stored material while awaiting the maturation of above-ground spinifex, on which they can feed once again. In this manner, the stored grass acts as a buffer, enabling termites to sustain their grazing activities during dry times.

Carbon

Interviewees appreciated that there is significant fluctuation of carbon levels in spinifex pastures.

This is particularly evident with above-ground material where significant biomass and associated carbon accumulates as the spinifex plant matures, then, when a fire occurs, most is lost in the smoke.

They also assumed there is minimal potential for increasing soil carbon levels due to low soil fertility and rainfall. However, interviewees were interested in learning more about the soil carbon cycle in spinifex pastures and about the above and below-ground carbon levels and how these might be influenced.

There were several comments indicating that spinifex is lacking in a strong root system, especially as the plant is easily dislodged. However, other interviewees were convinced that spinifex has a considerable root system as they have observed this while digging soil pits and because the plant survives drought so well.

Beef production

Responses from the pastoralists interviewed indicated that Droughtmaster and Brahman cattle are the most common breeds that are run in the Kimberley. These breeds are also common in the Pilbara and central Australia where Santa Gertrudis, Angus and Herefords are also found.

What class of stock do you run in spinifex country?

All pastoralists keep breeders in their spinifex country; mainly older cows that have had at least two calves. Where possible, weaners, steers, and heifers are moved onto the more productive buffel and Mitchell grass pastures.

Some interviewees can grow their cattle out on the more productive pastures of their lease, while others have farms in the agricultural areas of WA, where all growing and sale cattle are transferred for finishing.

Can you fatten cattle on spinifex?

The consensus from interviewees was that some cattle can be fattened on spinifex. A common response from those interviewed was that dry or spayed cows will fatten, however wet cows or growing cattle will not.

Weight gain/herd fertility on spinifex vs grass pastures?

While the interview didn't probe for data on weight gain figures, some comments that were offered included:

"*Male weaners off spinifex will average around 240 kg (live weight), whereas weaners off buffel grass will average around 280 kg in an average season,*" and

"*You can load about two weaners less per pen when comparing between buffel grass and spinifex country.*"

One comment regarding fertility was that "*There is not much difference in fertility between spinifex and grass country, you just run fewer cattle on spinifex.*" This indicates that pregnancy and weaning rates achieved on more productive pastures can also be achieved on spinifex pastures by adjusting stock numbers accordingly.

Another comment, that "*You can breed more kilos than you can grow,*" supports the general view that, while spinifex is not suitable for growing or fattening, it is well suited for breeding, and high pregnancy and weaning rates can still be achieved.

Feeding supplements in spinifex country?

Spinifex grows on soils that are inherently low in nitrogen and phosphorus; hence supplementary feeding of stock on spinifex pastures is an important consideration. Most interviewed pastoralists feed either nitrogen or phosphorus-based supplements, or both. Timing of supplementary feeding varies between season (wet, dry or both). While there were different combinations of timing and supplement type, it is evident that most animals have access to supplements at some point during each year.

There were two interviewed pastoralists who do not normally feed supplements. One has more crab-hole/floodout country than spinifex, so supplements were not deemed necessary. The other pastoralist's lease is dominated by spinifex that is growing on a paleo-drainage channel and cattle do not take supplements, "as there are sufficient minerals and nutrients already in the soil."

Some pastoralists had, either independently or in cooperation with the Department of Primary Industries and Regional Development WA or the Department of Industry, Tourism and Trade NT, tested cattle to ascertain nutrient levels. Blood samples were tested for phosphorus levels and faecal Near Infrared Reflectance Spectroscopy (NIRS) samples (dung samples) were analysed for nitrogen and phosphorus levels.

The importance of feeding phosphorus in the Kimberley and Tennant Creek area was evident with most interviewees indicating that they feed over the wet and/or dry season. One comment regarding feeding phosphorus was, *"(We) have cut back on P before but will never do it again as it took three years for cattle to recover."* This highlights the importance of feeding phosphorus where it is the primary limiting nutrient.

What type of supplement do you use during the dry season?

Twelve of the 18 pastoralist interviewees feed nitrogen and phosphorus-based supplements over the dry season. This is, however, influenced by:

- Seasonal conditions; for example, one central Australian interviewee commented that they were *"not feeding much supplement as feed quality and quantity has been good."*
- Cost of supplement; there was good discussion regarding the cost benefit of feeding nitrogen supplements over the dry season. One pastoralist said, "*Feeding nitrogen supplements was costing too much money so now we only feed phosphorus over the dry season."*
- The practice that nitrogen and phosphorus-based supplements are only fed to growing cattle over the dry season.

Three interviewees from the Pilbara and central Australia feed solely nitrogen-based supplements over the dry season. One Pilbara interviewee commented that *"There is a little bit of phosphorus in the iron ore, therefore it is not really lacking in pasture; although cattle respond well to phosphorus when dry, in a normal year they're not so deficient."*

One interviewee, from the central Australia region, fed solely phosphorus over the dry season. They have also tried feeding phosphorus over the wet season, however they found that, in those months, stock would leave the bore, disperse across the paddock and not access the phosphorus supplement.

What type of supplement do you use during the growing season?

No interviewees fed a nitrogen-based supplement over the wet season. Eight of the interviewees fed a phosphorus-based supplement during the wet season; five of these were from the Kimberley. Some interviewees who do not feed phosphorus during the wet season have tested their herd's phosphorus levels and found them to be sufficient.

Figure 8 Soft spinifex (*Triodia pungens*) regenerating after fire from the base and likely from seed in the bottom right corner.

Infrastructure

The most common water points on interviewed pastoralists' holdings are solar bores, tanks and troughs. Trap yards are also commonly located at water points. Minimal surface water means that the ability to turn bores off further afield can provide the means to bring stock in closer to the intended yards or laneway.

Dams

Many pastoralists have constructed dams in undeveloped areas due to salty groundwater, less productive pastures or distance from stock handling facilities. These dams hold water for 3–4 months over the wet season. Cattle take themselves out to the dams, rock holes and springs over the wet season, then as these water sources dry up, the cattle work their way back to the bores. This also gives pastures growing around bores a wet season spell from grazing.

Fences or no fences

Some of the interviewees manage whole properties that are dominated by spinifex. In this situation extensive internal fencing is not considered necessary. Some of them might have a bullock paddock and they might have fenced off rivers or creeks by fencing to land type. However, in general, stock 'had the run of the place'.

Without fencing:

- Movement of animals can be managed by turning water points on or off to move cattle around; for example, to assist with spelling from grazing or bringing cattle in close to yards.
- Stock can walk to the next working water point, when a water point stops working; this would not be possible if waters were separated by a fence.
- Cattle can walk to where the rain has fallen and graze the fresh pick, when storm rainfall occurs; this would not be possible if separated by a fence.

Even though many of the interviewees had minimal internal fencing, the benefits of segregating stock, spelling country, and ease of mustering were also acknowledged.

Interviewees with well-fenced leases or those in the process of subdividing paddocks were mainly (but not all) from the Kimberley. Advantages of internal fencing that they discussed included the:

- need to fence to land type, otherwise cattle will overgraze the more productive pastures
- ability to segregate breeders according to pregnancy status so you can look after cows calving out of season, thus reducing mortality rates
- ability to spell pastures over the wet season
- ease of mustering, and
- grading of fence lines to assist with burning off.

Two interviewed pastoralists have used electric fencing, both one and two strand, to good effect. To ensure the fence remains effective, one regularly graded fence lines and the other ensured there was enough power going through the fence to burn any contacting plant and cause it to grow a scab (dead wood), which would then ensure the fence remained insulated.

Costs/maintenance

Due to the low carrying capacity of spinifex pastures, interviewees are cautious about over-capitalising on improvements. A simple budget (excluding labour) provided by a manager from central Australia for a new water point for 65 breeders (90 AE) can be split into the following estimated costs (assuming it can be plumbed into an existing line).

- $3,500 for a tank
- $1,500 for a trough, and
- $10,000 for polythene pipe.

The cost of materials and fence line construction is high (estimates range between $3,300 and $6,000 per kilometre).

One interviewee commented that *"We have not gone much into fencing as we don't want to be grading hundreds of miles of fence lines each year as turpentine will grow up through them—and this is costly."*

Other comments regarding infrastructure included:

- Keep solar panels away from cattle areas to minimise dust gathering on panels.
- Keep water points away from fences to reduce damage.
- Before putting in a permanent tank and trough, dig a hole in the ground and have cattle water out of that so they learn to water at that point.
- Put water points in the centre of a paddock; observations are that stock 'do' better than when a water point is positioned along a fence line.
- Grade fence lines (even outside the boundary fence), so cattle are more likely to see them; when a fence is covered with grass and shrubs such as turpentine, the animals are less likely to see the fence and *"will be through it before they realise it"*.

Grazing distance to water

From the interview results, there appears to be little regional difference in the distance between water points in spinifex-dominant paddocks. On average, water points are spaced 8 km apart, meaning the grazing radius is about 4 km. In calculating the average, estimates from producers whose property water points were surrounded by a mix of pasture types were excluded.

Several interviewees indicated that if they were to start again, they would put water points closer together.

Some interviewees commented that there was a lot of potential to be realised by putting new water points in undeveloped country or between existing water points. They suggested that this has become more feasible in recent times as it is cheaper to establish and maintain a water point than it was previously.

Conversely, comments were made about the observation that when water points are too close together, the country can be overused, since the tendency is to run more cattle when there are more water points. Then, when it does turn dry, the problems associated with overstocking become more severe. This can certainly happen in the absence of feed budgeting. In these circumstances, distance buffers between water points are seen as a benefit.

Stock numbers around a water point

Stock numbers around water points in paddocks that were dominated by soft spinifex showed variation between regions.

Numbers provided for three properties in the Kimberley, and one from Tennant Creek indicated that stock numbers were around 120 breeders (171 AE) per water point, with a range of 90 to 150 breeders.

Interviews conducted on four properties in the Pilbara showed lower numbers per water point with the average being around 70 breeders (98 AE), with a range of 40 to 100.

The figures above were based on eight interviewees all having soft spinifex pastures around their water points. Estimated numbers from some other properties were not included as figures were confounded by the presence of other pasture types around water points. Some interviewees did not provide specific numbers since they prefer to monitor their spinifex and other useful grasses and vary stock numbers accordingly.

When is it good to have spinifex?

For most interviewees, the value of spinifex was greatest during extended dry periods. This is particularly important in the Pilbara, central Australia, and southern Kimberley because of their high rainfall variability. During dry periods, spinifex (with supplements) can provide the bulk of the feed when more palatable grasses like buffel and Mitchell have been grazed down. It is not just this bulk that helps pastoralists tide over until the next general rain; it is also the capacity of spinifex to produce green pick from small amounts of rain such as 5–10 mm. In contrast, Mitchell grass can require around 50 mm of rainfall before there is noticeable above-ground growth.

One interviewee commented that, "*With productive country like Mitchell grass, people often run lots of cattle and when it turns dry a lot of these places have to destock; whereas with spinifex you cannot pile the cattle up, otherwise they start losing condition. With a little bit of rain spinifex will keep going unlike Mitchell grass which does not respond to small falls of rain and generally by this time (year-end) there is no nutritional value in Mitchell grass.*"

An example from the Pilbara during the 2018 to 2020 dry period illustrates this point. At that time, a property dominated by buffel grass was running at 20% of the normal stocking rate while another property, dominated by soft spinifex, had only reduced its numbers to 80% of the normal stocking rate.

Thankfully, the dry times do not last forever and it seemed generally agreed that, where established, there is no better feed than buffel or Mitchell grass. While many interviewees appreciated their spinifex pastures, there was no doubt they valued the superior production benefits of buffel and Mitchell grass and, given the choice, would usually prefer less spinifex and more of these grasses.

Additional information needs

At the conclusion of each session, interviewees were asked what further information they would like on spinifex. Some were not looking for additional information, whereas others had many unanswered questions, most commonly around spinifex identification and nutritional characteristics.

Spinifex identification

Spinifex types were discussed within the broad categories of curly, soft, hard and buck spinifex. Interviewees appreciated, however, that there were several species within each of these groups and nine different species of spinifex were mentioned during the interviews. For example, within the soft spinifex group, species names were soft spinifex (*Triodia pungens*), feathertop spinifex (*Triodia schinzii*) and grey soft spinifex (*Triodia epactia*).

Pastoralists and researchers can recognise differences between spinifex species in the field by looking at, for example, the seed head, hummock shape and presence or absence of wax. However, they still often struggle to accurately identify the spinifex species being observed and there was a desire for improved identification.

Plant nutrients

Interviewees wanted more information on the nutritional value of spinifex seed heads and leaves, especially focusing on the changes in nutrient content and digestibility throughout the year and between fire intervals. There is a specific interest in determining whether spinifex follows a nutritional path similar to that of buffel and Mitchell grass, where nutrients are held mainly above ground prior to seed set and some are then transferred into the seedheads and below ground after seed set.

Tracking nutrient content and digestibility between rainfall and fire events would also potentially help managers make more informed grazing land management decisions. For example, it would assist with planning around wet season spelling and would also help with management of nutritional requirements (including supplements) of livestock grazing on spinifex pastures.

In addition, the knowledge of spinifex biology would be significantly enhanced.

'101' of spinifex

Following closely behind the topics of spinifex identification and plant nutrients was a keenness for more information on 'all things spinifex'. It was suggested that information exchange could take many forms, including but not limited to:

- stand-alone workshops and field days on spinifex
- incorporation of more spinifex content into workshops and presentations
- booklets (similar to FutureBeef's '*Keeping your spear grass pastures productive – don't overgraze'*)
- information notes
- articles in newsletters
- webinars, and
- webpages.

A '101' of spinifex implies a basic introduction to the key principles around understanding and managing spinifex. This might include topics such as spinifex biology, ring formation, fire in spinifex pastures, annual grasses and forbs found in spinifex pastures, and the nutritional value of associated species.

Topics of general interest

Plant DNA sampling

During interviews, it was frequently stated that in a spinifex pasture, cattle graze on the co-existing annual and perennial grasses, forbs, and browse as well as on spinifex. Some interviewees even suggested that the bulk of an animal's diet consists of non-spinifex species; however, few specific examples were provided apart from buffel grass. It was suggested that by taking dung samples and testing the DNA of plants present in the samples against what is growing in the paddock, we could increase our understanding of which plants stock are grazing.

Tracking cattle movements

When discussing cattle movements throughout the year, observations were shared of how cattle preferentially graze fresh pick from recently burnt areas for a few weeks, then move into areas that were burned 2–3 years prior.

It was noted that, just before the wet season, cattle will graze on the areas where the wattle has produced seed. Then, when it rains, they move into areas where there is older spinifex that has not burnt for four years and where seed heads are abundant. They graze on these for about two weeks before returning to old haunts along creek lines to graze any new buffel or other grass growth.

One of the pastoralists interviewed from central Australia already tracks movements of animals via their ear tags; this has enabled significant learnings about grazing habits that were previously unknown. Monitoring grazing habits in spinifex pastures would be an important step forward in these areas where animals graze large, unfenced territories. It would also increase our understanding of grazing radiuses in spinifex pastures.

Grazing strategies

Some interviewees found the idea of using high-density, short-duration, long-rest grazing principles interesting and worthy of further exploration. It was suggested that this approach could achieve the benefits currently obtained from burning, such as removal of rank growth and enabling of a after fire flush of annual and perennial grasses and ephemerals.

Soil carbon

Interviewees were interested to learn more about above- and below-ground soil carbon, as well as the soil carbon cycle in spinifex pastures.

Other

Other topics mentioned by individuals during the interviews were as follows:

- More information on the cost/benefit of developing spinifex pastures.
- Use of a stick rake to thin turpentine (*Acacia lysiphloia*) and seed useful pasture species behind.
- Blade-ploughing of soft spinifex to increase buffel grass density, while leaving the trees.
- Additional information on weight gain of dry cattle vs. wet cattle in spinifex pastures.
- Investigation of legume options other than stylo (*Stylosanthes* sp.).
- Potential for using spinifex in feed trial as a roughage with lupins/corn.
- Examine the idea of woody species compositional changes in response to fire history; for example, fires at 3, 5, and 10- year intervals. This would also need to account for the significant variation in spinifex pastures that is likely due to fire and rainfall history.

Conclusion

This report provides insights into spinifex pastures and their management and is based on 33 interviews with experienced practitioners from the Pilbara, Kimberley and central Australia.

Notably, fire plays a significant role in spinifex pastures and is frequently used to enhance grazing productivity by removing old or moribund spinifex and allowing palatable new growth to replace it. Additionally, fire is used as a tool for wildfire mitigation by creating different-aged fire scars and subsequent variations in fuel levels across the landscape.

The amount of non-spinifex material in the diet of grazing animals was a commonly discussed topic. Interviewees reported stock preferences for available annual and perennial grasses and forbs as well as browse species, predominantly wattles.

Many of the interviewees would like more information on spinifex identification, and nutrient levels relative to time of year as well as time since fire. There was support for developing a '101' of spinifex dealing with spinifex biology, wildfire mitigation, and other plants found in spinifex pastures, to name a few. Over the next 3–4 years, the Kimberley Pilbara Cattlemen's Association proposes to address identified knowledge gaps and produce a more comprehensive and in-depth document outlining spinifex ecology and best practices for managing spinifex pastures.

It is envisaged that this current report will provide industry, industry bodies, and government agencies with information to guide future research, extension, and development activities to benefit all those working with spinifex pastures.

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Appendices

Appendix A – Interview questions

Management of spinifex pastures - questions

Disclaimer: Participants who took part in interviews did not claim to be subject experts; however, they agreed to participate to further the collective knowledge of spinifex pastures. The notes taken are those of the interviewer and have not been reviewed by the interviewee.

Name:

Date:

Place:

District:

Rainfall:

How long have you been working with spinifex?:

Mix of pastures on lease:

Spinifex species on lease/plant ID:

Fire

How do you use fire in spinifex country (when and why): wildfire mitigation, control grazing distribution, improve diet quality, manage pasture species composition, control exotic weeds, manage tree-grass balance and maintaining biodiversity?

Grazing distribution.

Grazing after fire.

Manage pasture species composition.

Nutrition in different phases of growth.

Traditional owner use of fire.

Grazing land management

Grazing strategies on spinifex country.

What trees/shrubs do you have growing in your spinifex country; are they increasing?

Amount of non-spinifex in diet (browse, forbs, grasses).

Do you have any indicators for when you know that you have your management of spinifex pasture about right or wrong?

Soil erosion.

High density/short duration/long rest.

Introduced legumes.

Spinifex plant/other

Spinifex rings.

Spinifex regenerating after fire.

How hummock grasses grow compared to tussock grasses.

Eating seed head.

Red seed heads.

Seeding.

Infrastructure

Highest priorities/best advice in spinifex country for infrastructure development.

How many head do you generally run around a water point?

What type of water points work best in spinifex country?

Grazing distance to water.

Fencing/fence maintenance.

Beef production

What class of stock do you run in spinifex country?

Can you fatten cattle on spinifex?

Reproduction/weight gain on spinifex vs other pastures?

Do you feed supplements in spinifex country?

- What type of supplement do you use during the dry season?
- What type of supplement do you use during the growing season?

Other

Carbon sequestration:

Biodiversity:

General/closing

Main issues affecting the profitability of your enterprise in relation to spinifex?

When is it good to have spinifex?

What would you like more information on regarding to spinifex?

Appendix B – Plant names

Spinifex

buck spinifex	*Triodia longiceps*
curly spinifex	*Triodia bitextura*
feathertop spinifex	*Triodia schinzii*
grey soft spinifex	*Triodia epactia*
hard spinifex	*Triodia intermedia*
porcupine grass	*Triodia irritans*
limestone spinifex	*Triodia wiseana*
lobed or hard spinifex	*Triodia basedowii*
porcupine spinifex	*Triodia secunda*
soft spinifex	*Triodia pungens*
spinifex	*Triodia* spp.

Grasses

Birdwood grass	*Cenchrus setiger*
bottle washers	*Enneapogon* spp.
buck wanderrie	*Eriachne helmsii*
buffel grass	*Cenchrus ciliaris*
button grass	*Dactyloctenium radulans*
hop-a-long grass	*Paraneurachne muelleri*
kerosene grass	*Aristida contorta*
Mitchell grass	*Astrebla* spp.
native panic	*Panicum decompositum*
perennial sorghum	*Sorghum plumosum*
ribbon grass	*Chrysopogon fallax*
silky brown-top	*Eulalia aurea*
three-awn grasses	*Aristida* spp.
unequal three-awn	*Aristida inaequiglumis*
woolly butt	*Eragrostis eriopoda*

Forbs

mulla mulla	*Ptilotus* spp.
tick weed	*Cleome viscosa*
cockroach bush	*Senna notabilis*
narrow-leaf indigo	*Indigofera linifolia*
woolly Corchorus	*Corchorus walcottii*
parakeelya	*Calandrinia* spp.
rhynchosia	*Rhynchosia minima*
zornia vine	*Zornia prostrata*
saltbushes	*Atriplex* spp.

Trees and Shrubs

bardi bush	*Acacia* spp.
bauhinia	*Bauhinia cunninghamii*
bloodwood trees	*Corymbia* spp.
curara	*Acacia tetragonophylla*
holly-leaf grevillea	*Grevillea wickhamii*
lemonwood	*Dolichandrone heterophylla*
miniritchie	*Acacia* spp.
mulga	*Acacia aneura*
seca/shrubby stylo	*Stylosanthes scabra*
snake wood	*Acacia xiphophylla*
turpentine	*Acacia lysiphloia*
verano stylo	*Stylosanthes hamata*