GOVERNMENT OF WESTERN AUSTRALIA

Department of **Planning, Lands and Heritage**

Good Pastoral Land Management Guidelines

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The Department of Planning, Lands and Heritage acknowledges the traditional owners and custodians of this land. We pay our respect to Elders past and present, their descendants who are with us today, and those who will follow in their footsteps.

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Gordon Stephenson House
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Perth WA 6000

Locked Bag 2506
Perth WA 6001

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website: www.dplh.wa.gov.au
email: info@dplh.wa.gov.au

tel: 08 6551 8002
fax: 08 6551 9001
National Relay Service: 13 36 77

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Foreword

I am pleased to introduce the Pastoral Lands Board's *Good Pastoral Land Management Guidelines*.

The Guidelines are designed to assist you to enhance the productivity and financial viability of your lease, whilst simultaneously achieving improved land management outcomes. The wider community increasingly expects a greater balance between economic development and ecological management of the pastoral lands, and the Pastoral Lands Board (PLB) is convinced this is not only possible, but necessary for the industry's long-term prosperity and survival. The Guidelines are a foundational document for the achievement of this vision.

The Guidelines provide a detailed how-to guide for land managers, whether new entrants to the industry, or more experienced operators looking for a different way to tackle a particular problem. Further, they provide clarity about the PLB's expectations of pastoralists in relation to land management.

The role of the PLB is to advise the Minister for Lands on policy relating to the pastoral industry and to ensure pastoral leases are managed on an ecologically sustainable basis. The Guidelines were developed through broad consultation - to ensure they are useful as a practical tool for pastoralists and to provide clarity around environmental management in a way that is consistent with environmental conservation legislation. Drawing from conversations with pastoralists across Western Australia, a wide range of information has been incorporated into the Guidelines. Government departments, including the Departments of Primary Industries and Regional Development; Water and Environmental Regulation; Biodiversity, Conservation and Attractions; and Fire and Emergency Services have provided invaluable input and expertise.

I wish to acknowledge the invaluable contributions of the Departments of Planning, Lands and Heritage, and the Department of Primary Industries and Regional Development. I also extend my thanks to the Pastoralists and Graziers Association of WA and the Kimberley Pilbara Cattlemen's Association for their assistance in developing this document and to the individual pastoralists who contributed their time, hospitality and forbearance to ensure the Guidelines would be of practical use.

The Board and I are pleased to commend the Good Pastoral Land Management Guidelines to the pastoral industry and to other interested readers.

Tim Shackleton
Chair
Pastoral Lands Board of Western Australia

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Purpose of the Guidelines

The Good Pastoral Land Management Guidelines (Guidelines) have been developed by the Pastoral Lands Board (PLB), whose remit under Part 7 of the *Land Administration Act 1997* (LAA) is, *inter alia*, to ensure pastoral leases are managed on an ecologically sustainable basis. In addition, pastoralists are required to manage and work the land under the lease to its best advantage as a pastoral property, use methods of best pastoral and environmental management practice, and maintain the indigenous pasture and other vegetation on the land to the satisfaction of the PLB.

While the practical interpretation of both the PLB's and the pastoralists' requirements under the LAA is a matter of policy, to date this work has been done on an ad hoc basis. The exception is the PLB's *Pastoral Purposes Framework* (Framework), which is an important reference document for these Guidelines. The Framework provides a clear articulation of what the PLB considers pastoral purposes, within the definition provided at section 93 of the LAA. The Framework explains what is permissible without a permit or alternative tenure.[1] However, even where an activity falls within the Framework, approvals may be required under other legislation, such as a clearing permit, or a water licence. A more detailed discussion of the specifics of section 93 and the Framework's role is articulated in the legislative context section below, as are the requirements of other legislation in respect of pastoral activities.

These Guidelines will assist pastoral land managers to plan and implement good practice land management techniques, which will further the PLB's aim to see pastoral leases managed on an ecologically sustainable basis. In the context of this document, and the PLB's broader approach, ecologically sustainable pastoralism means:

> The management, development and use of natural resources relevant to pastoral operations being undertaken on the land, with an aim to meet the needs of today while conserving ecosystems for the benefit of future generations.[2]

The Guidelines are also designed to reflect the need for pastoral businesses to turn a profit. Well-managed land leads to better profits, as this document makes clear. First, the cost of rehabilitation is greater than the cost of prevention, and as much emphasis is placed on the latter as the former. Second, the Guidelines provide different options for action across many of the areas of land management, some of which involve high costs, and some that are cheaper. Lessees can then determine the most appropriate land management approach, with the goals of ecological and economic sustainability in mind.

This is not designed to be the last word on land management practice, but rather a living document that changes as best practice evolves. Further, the Guidelines are not a comprehensive guide; rather, they will be a first port of call for those seeking information about land management issues and techniques. Within this document is a list of best-practice techniques with

[1] Pastoral Lands Board of Western Australia, *Pastoral Purposes Framework 2018: A guide to activities that can be undertaken on a pastoral lease*, Perth: Department of Planning, Lands and Heritage 2018

[2] Pastoral Lands Board of Western Australia, *Policy Statement: Ecological Sustainability*, Perth: Department of Planning, Lands and Heritage, 2017: 2

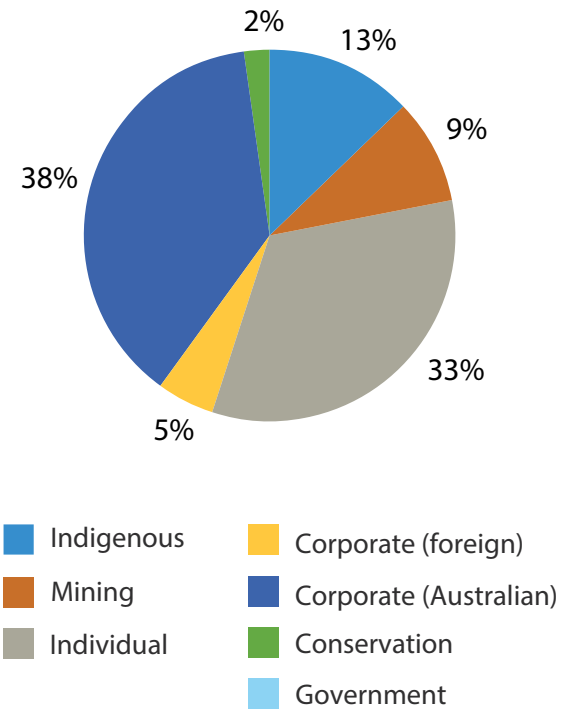
basic descriptions. However, each chapter contains a list of resources providing detailed technical advice on how to implement a specific land management or land rehabilitation task. The PLB is also developing field guides on the Guidelines' key land management themes, which are user-friendly and detailed.

Additionally, the Guidelines will not provide detailed information on animal husbandry. Federal Standards and Guidelines for animal welfare, published in 2016,[3] are in the process of being implemented by the Department of Primary Industries Regional Development (DPIRD). Amendments to the *Animal Welfare Act 2002* were passed in November 2018 to allow regulations to be made to give effect to the Australian Animal Welfare Standards and Guidelines for livestock.[4] Once these are in force, the Guidelines will make mention of them, but animal welfare issues fall outside the remit of the Guidelines.

The pastoral estate

The pastoral estate in Western Australia represents 34.4 per cent of the State (or around 865,000 square kilometres) being used for grazing livestock on native vegetation. As at 1 July 2015, there were 435 pastoral stations consisting of 493 leases (some stations contain more than one lease). Of the 435 pastoral stations, around nine per cent are held by mining companies; 13 per cent by Indigenous corporations; and two per cent by conservation groups. The balance of leases is held by individuals or families (33 per cent) and other corporate businesses (43 per cent) principally engaged in livestock production. Figure 1 illustrates that individual or family owned leases and those held by corporate entities are the predominant forms of lease ownership across the pastoral estate.

Figure 1: Pastoral lease ownership in Western Australia



Source: Department of Planning, Lands and Heritage

[3] For a copy of the Australian Animal Welfare Standards for Cattle, see: http://www.animalwelfarestandards.net.au/files/2011/01/Cattle-Standards-and-Guidelines-Endorsed-Jan-2016-061017_.pdf

[3] DPIRD, 'Animal Welfare Act Amendments', DPIRD Website https://www.agric.wa.gov.au/animalwelfare/animal-welfare-act-amendments Accessed 18 February 2020

This vast estate resides in the Rangelands. Rangelands include all those environments where natural ecological processes predominate and where values and benefits are based primarily on natural resources. They are areas that have not been intensively developed for primary production. The rangelands of the semi-arid and arid zones cover approximately 75 per cent of the Australian continent and equate broadly with the Outback. However, rangelands also occur in higher rainfall areas where limitations other than rainfall, such as remoteness and tropical wet/dry seasons, restrict use to management of the natural landscape.[5] They extend across low rainfall and variable climates, including arid and semi-arid regions in the south and east, as well as some seasonally high rainfall areas north of the Tropic of Capricorn. They include a diverse group of relatively undisturbed ecosystems such as tropical savannahs, woodlands, shrublands and grasslands.[6] However, the Western Australian (WA) Rangelands are sparsely populated, with the 2016 census indicating that less than 150,000 people live in the Rangelands, which represents just over five per cent of the State's population.[7]

The WA Rangelands occupy 87 per cent of the State's landmass (approximately 2.3 million square kilometres), with rangelands present in all regions excluding the South West agricultural area. The Rangelands are divided into two separate areas, the Northern and Southern Rangelands, which are comprised of the following regions: the Kimberley and Pilbara (Northern Rangelands); and the Gascoyne, Mid West, Goldfields, Nullarbor and Interior (Southern Rangelands).[8]

Pastoral stations across these regions differ as much as the climate – in the Southern Rangelands, there are 286 stations, whose average size is 182,232 ha. In the Northern Rangelands, there are 149 stations, whose average size is 230,083 ha. Further, in the south, pastoral leases can be as small as 31,000 ha, with the largest lease being 593,322 ha, while the smallest station in the Kimberley is just over 81,000 ha and the largest 480,800 ha.

Unallocated Crown land (UCL) is the largest category of land tenure in the Rangelands outside the pastoral estate, amounting to almost 37 per cent of the State's land mass (around 935,000 square kilometres), much of which abuts the pastoral estate (mostly labelled Arid Interior in Figure 2). Such a large amount of UCL, which is mostly unmanaged, can create challenges for pastoral lessees, particularly those whose stations are adjacent to UCL, in the form of bushfires and incursions of feral and native animals from the UCL. These animals can be herbivores, such as kangaroos and feral horses, camels, and donkeys, as well as predators, such as wild dogs (including dingoes). The Department of Biodiversity, Conservation and Attractions (DBCA) is responsible for managing fire, weeds, and feral animals on UCL outside of town sites,

[5] Australian Rangeland Society, www.austrangesoc.com.au

[6] Department of the Environment, *Outback Australia – the rangelands*, www.environment.gov.au/land/rangelands

[7] Australian Bureau of Statistics, Total Population for Outback North 2016, https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/510?opendocument; Australian Bureau of Statistics, Total Population for Outback South, 2016, https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/511?opendocument

[8] Department of Lands, Land Administration Amendment Bill: Consultation Paper, Perth: Department of Lands, 2016: 11-12

Figure 2: The Western Australian Rangelands

Source: Department of Primary Industries and Regional Development (DPIRD), 'Arid Zone Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

albeit on a limited budget. In general, DBCA control efforts are focussed on the pastoral/UCL interface. Significant effort is required to control these animals and minimise the damage they can do to pastures and livestock.

These variables, ranging from climate to lease size, ownership to location of the lease in respect of UCL, demonstrate that there can be no one-size-fits-all approach to land management across the pastoral estate. These guidelines acknowledge this diversity and provide general and regional-specific information where possible and appropriate.

Legislative context

The Land Administration Act 1997

Pastoral leases are governed by the terms of the lease and Part 7 of the *Land Administration Act 1997* (LAA). Part 7 of the LAA sets out administrative arrangements for Government, establishes the Pastoral Lands Board, and outlines pastoral lessees' responsibilities in respect of the land under lease. The PLB is a statutory authority, established under section 94 of the LAA and, together with the Minister for Lands, administers pastoral leases in accordance with Part 7 of the LAA.

The Department of Planning, Lands and Heritage (DPLH) and DPIRD provide administrative assistance and technical advice, respectively, to both the Minister and the PLB in relation to the pastoral estate. Additionally, DPIRD assists the Commissioner for Soil and Land Conservation under the *Soil and Land Conservation Act 1945* (SLC Act) (see discussion below).

The LAA requires that pastoral lessees undertake activities that fit within the definition of pastoral purposes, as defined in section 93 of the Act. That definition states:

> ***Pastoral purposes*** means the purposes of –
>
> (a) The commercial grazing of authorised stock; and
>
> (b) Agricultural, horticultural or other supplementary uses of land inseparable from, essential to, or normally carried out in conjunction with the grazing of authorised stock, including the production of stock feed; and
>
> (c) Activities ancillary to the activities mentioned in paragraphs (a) and (b).

While pastoral purposes is defined by the above, what that means in practice is not always clear. However, the terms of the lease provide additional guidance at Clause 5.1, Permitted Use:

> (a) This lease confers on the Lessee a right to occupy and use the Land for the Permitted Use in accordance with the LAA and the provisions of this Lease.
>
> (b) The lessee must not use the Land for any other purpose unless such use is authorised by a Permit or any other Law.
>
> (c) For the avoidance of doubt, the Permitted Use includes the right to place, effect, construct, erect, undertake, alter and add Improvements on the Land as are reasonably required or necessary for or ancillary to the Permitted Use and replace, renew, restore or remove all such Improvements.[9]

Improvements, as listed at (c) above, are defined as follows:

> Improvements means buildings, sheds, yards, fences, windmills, bores, wells, dams, water apparatuses, drains and pipes and other facilities, structures fixtures and fittings on the Land at the Commencement Date or thereafter placed, effected, constructed, erected or

[9] Pastoral Lands Board of Western Australia, *Pastoral Lease (Long Form)*, Perth: PLB, 2015: 5

undertaken on the Land during the Term and includes any alterations, additions, replacements, renewal or restorations made to those improvements during the Term.[10]

Therefore, the permitted use works hand in hand with the definition of pastoral purposes provided at section 93, and reproduced above. The list of improvements complements the Framework, developed by the PLB in providing further guidance in respect of activities that are classed as pastoral purposes.

The Framework guides pastoralists and the PLB in respect of what pastoral purposes means in practice. The relevance of the Framework for the Guidelines is that the vast majority of the land management activities and techniques discussed in the Guidelines are permissible under the Framework. For example, control of weeds, the building of fences and yards, earthworks for land rehabilitation, such as ripping and bund building, and the building of tracks and roads on a pastoral lease do not require any kind of permit, and this is reflected in the Framework.

However, some activities may require permits and/or licences under other Acts for them to be legally permissible (for example, shooting permits for culling kangaroos or establishing bores for stock watering points). These activities are discussed in the relevant sections of the Guidelines.

The role of the PLB is defined in section 95 the LAA, including:

The functions of the Board are —

(a) to advise the Minister on policy relating to the pastoral industry and the administration of pastoral leases; and

(b) to administer pastoral leases in accordance with this Part; and

(c) to ensure that pastoral leases are managed on an ecologically sustainable basis; and

(d) to develop policies to prevent the degradation of rangelands; and

(e) to develop policies to rehabilitate degraded or eroded rangelands and to restore their pastoral potential; and

(f) to consider applications for the subdivision of pastoral land and make recommendations to the Minister in relation to them; and

(g) to establish and evaluate a system of pastoral land monitoring sites; and

(h) to monitor the numbers and the effect of stock and feral animals on pastoral land; and

(i) to conduct or commission research into any matters that it considers are relevant to the pastoral industry; and

(j) to provide such other assistance or advice as the Minister may require in relation to the administration of this Part; and

[10] Pastoral Lands Board of Western Australia, *Pastoral Lease (Long Form)*, Perth: PLB, 2015: 2

(k) to exercise or perform such other functions as it may be given under this or any other Act.

As noted above, one of the roles of the PLB is to develop policies relating to the pastoral industry, the prevention and rehabilitation of degradation or erosion in the Rangelands; development of these policies has been *ad hoc* in the past. These Guidelines are a move towards a more comprehensive series of policies across these and other areas of the PLB's functions. They also signal the intent of the PLB and Government more broadly to work with pastoral lessees in a collaborative manner to the benefit of all parties.

Pastoral lessees are on-ground land managers and have certain obligations under their leases and the LAA to manage the land. Under both the Long Form and Short Form leases, pastoral lessees must manage the land according to the provisions of the LAA and related legislation, including the *Biosecurity and Agricultural Management Act 2007* (BAM Act) and the SLC Act. The terms of the Short Form pastoral lease state:

(3) That the Lessee will to the satisfaction of the Minister for Agriculture comply effectively with the provisions of the *Soil and Land Conservation Act 1945*, and with the provisions of the *Agriculture and Related Resources Protection Act 1976* [now replaced by the BAM Act].

(4) That the Lessee will maintain on the area leased good and improving soil and plant conditions.

(5) That the Commissioner of Soil [and Land] Conservation may, in any case where the construction of a large dam is contemplated, implement in respect of the area leased special provisions for full control of water catchment areas.

(6) That the Lessee will not permit or suffer any grazing on all or part of the area leased where grazing is prohibited under the powers contained in the *Soil and Land Conservation Act 1945*.[11]

Whereas the Short Form Lease refers to specific laws wherever possible, the Long Form Lease provides broader terms. Clause 7.2 notes that the Lessee must comply with the LAA and the lease, as well as 'all laws and requirements, notices, orders or lawful direction of any Governmental Agency' applicable to:

(a) The exercise of the Lessee's rights or the performance of the Lessee's obligations under this Lease;

(b) The use and occupation of the Land by the Lessee or the Lessee's Agents;

(c) Any Improvements; and

(d) The Stock.

[11] Department of Planning, Lands and Heritage, '20170223 Information to the OAG – Example lease to be read with Lease Option 1 old terms and conditions'. Perth: Department of Planning, Lands and Heritage, 2017. Lands File no: 00049-2017 CROWN LAND ADMINISTRATION – AUDIT – Office of Auditor General – Performance Audit Management of Pastoral Lands in Western Australia, Document no.: A6514932

Under the LAA, there are several specific requirements with which lessees must comply. Of key importance is section 108, which requires pastoral lessees:

(1) To manage and work the land under the lease to its best advantage as a pastoral property, to the satisfaction of the PLB;

(2) To use methods of best pastoral and environmental management practice, appropriate to the area where the land is situated, for the management of stock and for the management, conservation and regeneration of pasture for grazing; and

(3) To maintain the indigenous pasture and other vegetation on the land to the satisfaction of the PLB.

In addition, section 111 of the LAA requires pastoral lessees to control declared animals and declared plants in compliance with the BAM Act and to the satisfaction of the PLB.

The Biosecurity and Agricultural Management Act 2007

The BAM Act regulates the introduction of plants and animals into the State, the control of declared plants and animals, and is concerned with providing effective biosecurity and agricultural management for WA. It does this by controlling the entry, establishment, spread and impact of organisms that may have an adverse impact on other organisms, humans, the environment or agricultural, fishing or pearling activities carried out in WA. Plants that are declared under this Act are controlled through regulation of movement and the requirement of landholders to control these plants, including the eradication of certain species and to prevent them from spreading to uninfected areas. Part 2, Division 3 of the BAM Act, administered by DPIRD, requires land managers to control declared pests on pastoral leases. For more detailed discussion of the BAM Act, and the roles and responsibilities of pastoral lessees and land managers in respect of declared pests see the Fire, Weeds, and Feral Animals chapter below.

The Soil and Land Conservation Act 1945

In addition to references to the BAM Act, the LAA also includes references to the SLC Act. Part 7 of the LAA and the role of the PLB is complementary to the SLC Act and the role of Commissioner for Soil and Land Conservation (Commissioner), established under the SLC Act. The SLC Act provides for the prevention and mitigation of land degradation and establishes the role of Commissioner for Soil and Land Conservation (Commissioner). The Commissioner is responsible for ensuring land use and land management across Western Australia is undertaken in such a way as to preserve the land in good condition. To do so, the Commissioner manages the land conservation district system and supports Land Conservation District Committees (LCDCs), which report to the Commissioner on the effects of land use or land management on the condition of the land within its land conservation district. Additionally, the LCDCs may, 'in accordance with any direction, approval or authorisation given by the Commissioner, manage projects or carry out or cause

to be carried out works or practices, for preventing, remedying or mitigating land degradation and for promoting soil conservation and reclamation'.[12]

In addition, where the Commissioner determines that an action, or failure to act, on any land has resulted in land degradation occurring, or such degradation is likely to occur, the Commissioner may issue a Soil Conservation Notice. Section 32(2) of the SLC Act states that a Soil Conservation Notice may:

(a) direct each or any one or more of the persons bound by the soil conservation notice to do all or any of the following things —

(i) adopt or refrain from adopting any agricultural or pastoral methods specified in the notice;

(ii) refrain from clearing any land specified in the notice;

(iii) refrain from destroying, cutting down or injuring any tree, shrub, grass or other plant on any land specified in the notice;

(iv) take such action as is specified in the notice for preventing the erosion, drift or movement of sand, soil, dust or water on or from any land specified in the notice;

(v) any other matter incidental to the foregoing; and

(b) specify a period within which or for the duration of which such things shall be done.

Pastoral lessees must act upon a Soil Conservation Notice as part of the terms of their lease, as noted above, in relation to clause 7.2 of the Long Form Lease, and Clause (3) of the Short Form Lease.

The Commissioner and the PLB are required to share information relevant to their respective roles, under section 137 of the LAA. This information sharing element is particularly relevant in respect of a Soil Conservation Notice, because Board determinations and diversification permits may be suspended as a result of the Notice. Section 112(1) states:

(1) If a soil conservation notice is issued as to the numbers or distribution of stock on land under a pastoral lease, the notice has the effect, while it is in force, of suspending any determination under section 111 and the operation of any permit issued under Division 5 to the extent of any inconsistency.

Should stock numbers be reduced by a Soil Conservation Notice, the Minister, on the advice of the PLB, may reduce the rent in proportion to the reduction in stock.[13]

Further, the Commissioner is required under section 112 to provide 'a report on the current condition of land under pastoral leases in the State, by reference to regions of the State as defined by the Board for this purpose'. Additionally, where the Commissioner has issued a soil conservation notice, 'that relates to the

[12] Department of Primary Industries and Regional Development, 'Land Conservation District Committees', https://www.agric.wa.gov.au/land-use-planning/land-conservation-district-committees accessed on 3 October 2018

[13] *Land Administration Act 1997*, Section 112(3)

stocking of land under a pastoral lease', the Commissioner must notify the PLB in writing of the terms of the proposed notice. [14]

Diversification permits

The BAM Act and SLC Act are both also significant in respect of proposals to grow non-indigenous plant species on a pastoral lease under a permit, which is provided for in sections 119, 120, and 122 of the LAA. Indeed, section 117 of the LAA states:

> The Board must not issue a permit under this Division unless it is satisfied that any requirements in relation to the proposal arising from the operation of —
>
> (a) the Biosecurity and Agriculture Management Act 2007; or
>
> (b) the Environmental Protection Act 1986; or
>
> (c) the Soil and Land Conservation Act 1945; or
>
> (d) the Biodiversity Conservation Act 2016; or
>
> (e) any other written law relating to environmental conservation which is applicable to the land under the lease,
>
> have been complied with.

While the BAM Act has already been discussed, analysis of the other legislation listed above and its relevance to the pastoral estate follows.

DPIRD provides technical assistance to the PLB in relation to land management, through its various work areas in the realm of agriculture and biosecurity. Experts from DPIRD provide advice on many of the areas covered in these Guidelines, including land system and pasture identification and classification, infrastructure development and management, grazing management, and the prevention of land degradation and rehabilitation of areas that have become degraded. Further, DPIRD provides expert advice on

- feral animal management
- control and eradication of weeds
- identification and assessment of species of plant that may be appropriate to be grown on pastoral leases for the benefit of pastoral enterprises.

The Environmental Protection Act 1986

The SLC Act complements the *Environmental Protection Act 1986* (EP Act), which is administered by the Department of Water and Environmental Regulation (DWER). The EP Act provides permits to clear native vegetation, which is required, from time to time, by pastoral lessees in the management of their leased land. While certain exemptions are provided for, such as fire breaks, should a lessee wish to clear land, that clearing must be accompanied by a permit, issued by DWER pursuant to Part V, Division 2 of the EP Act and the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (Clearing

[14] *Land Administration Act 1997*, Section 138

Regulations). The box below provides some examples of what types of activities on a pastoral lease may require a clearing permit and/or other permits or licences, under environmental legislation.

Part IV of the EP Act makes provisions for the Environmental Protection Authority (EPA) to undertake environmental impact assessment (EIA) of significant proposals, strategic proposals and land use planning schemes. Anyone may refer a proposal to the EPA (e.g. proponent, government agency or third party), however the EPA decides whether a referral requires assessment. Proponents are encouraged to contact DWER to discuss the proposal prior to making a referral (*Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual*, April 2018). Further guidance on environmental impact assessment is available on the EPA's website www.epa.wa.gov.au.

Environmental permits for pastoral lease activities

Pastoral activities, including fencing, road building, and diversification activities may require permits under environmental laws, even if the LAA and the Pastoral Purposes Framework does not require additional permission from the PLB or Minister for Lands. For example:

- A pastoral lessee may wish to sow Lucerne under a diversification permit pursuant to Part 7, Division 5 of the LAA. However, in order to do so, the lessee will likely have to clear native vegetation from the land, unless the land has been cleared previously in accordance with the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (Clearing Regulations). A lessee will then have to apply to DWER for a permit pursuant to Part V, Division 2 of the EP Act and the Clearing Regulations in order to clear the land.

The application may also require a permit to extract water, most likely from an aquifer, unless the activity does not propose irrigation (dryland agriculture). Applications for a water licence to draw groundwater from a bore for non-pastoral purposes (such as irrigation under a permit issued by the PLB) are made pursuant to the *Rights in Water and Irrigation Act 1914* (RIWI Act), administered by DWER. For a more detailed discussion of RIWI Act permits, see the Water Points section of the Infrastructure chapter. The section also discusses the *Country Areas Water Supply Act 1947*, which provides for Water Source Protection Areas in regional areas, including the Rangelands.

- Constructing vehicle tracks on a pastoral lease. While the Framework allows a pastoral lessee to clear for the establishment of tracks and roads on a pastoral lease, the Clearing Regulations provide that clearing for a track on a property must not exceed 5ha per financial year, except under a clearing permit.

Environment Protection and Biodiversity Conservation Act 1999

Activities that may have a significant impact on a matter of national environmental significance (MNES) are considered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Matters of national environmental significance include:

- world heritage properties;
- national heritage places;
- wetlands of international importance (Ramsar wetlands);
- nationally threatened species and ecological communities;
- migratory species;
- Commonwealth marine areas;
- the Great Barrier Reef Marine Park;
- nuclear actions (including uranium mining);
- a water resource, in relation to coal seam gas development and large coal mining development.

After a public comment period, the Minister (or the delegate) decides whether the project should be assessed under the EPBC Act. At this stage, a decision may also be made to accredit the state assessment process under a bilateral agreement. This means that the relevant State agency will undertake the assessment of both State environment matters and MNES to simplify the process for proponents.

Further information on the EPBC Act is available on the Commonwealth Department of the Environment and Energy website: https://www.environment.gov.au/epbc/about.

Other projects, like large-scale irrigation projects, such as the Ord River Irrigation Scheme and proposals for cotton production in the West Kimberley, may trigger a referral under the EPBC Act. Failure to refer to the Commonwealth Department of the Environment and Energy for such large-scale projects can hinder the approvals process and increase costs to proponents.

The Biodiversity Conservation Act 2016

DBCA administers the *Conservation and Land Management Act 1984* (CALM Act) and the *Biodiversity Conservation Act 2016* (BC Act). The CALM Act provides for the establishment of national parks, nature reserves, and other land in the conservation estate. The BC Act provides for the protection of WA's native flora and fauna.

Regarding permits to cultivate non-indigenous plant species on a pastoral lease, assessments under the BC Act assist the PLB to determine whether an introduced plant species could negatively affect WA's native flora and/or fauna. While there are no legislative provisions in the BC Act that directly affect an application

for a section 119 permit, DBCA provides technical advice and guidance to the PLB on a range of matters, including:

- the biology and invasive history of the non-indigenous plant species
- their potential to threaten biodiversity should they escape and colonise other areas
- the significance of effects due to incremental spread of these species on biodiversity and the conservation reserve system
- the possible form and function of management conditions which might limit any potential adverse effects.

The PLB takes this advice into consideration when determining whether to issue a permit or not.

Benefits of the Guidelines

The key benefit of the Guidelines is the development of a toolkit of land management activities, which pastoral lessees and land managers can utilise as required. These activities include infrastructure development and maintenance, grazing management, methods of controlling weeds, feral and native animals, fire management, and the prevention, rehabilitation, and regeneration of land degradation. However, these Guidelines are not an exhaustive or definitive list of activities and techniques; rather, they provide examples of good (and bad) land management, and a series of links to other material that can assist land managers.

While the Guidelines will provide information to both the PLB and lessees, they will also be used to inform other documents, including field guides, and policies related to rangeland condition, stocking, and other related areas. Further work is required around compliance policies, potential remote sensing and/or satellite monitoring systems, and accreditation and training systems for existing lessees and new entrants into the pastoral industry, all of which will be informed by, and will inform, the Guidelines.

An example of an accreditation and training system can be found in the Queensland grazing industry's – and subsequent State Government Support for – Grazing BMP (Best Management Practices) accreditation program. Grazing BMP is an industry-led, proactive and voluntary approach to 'demonstrate the uptake of good farm management practices and ethical and environmental stewardship'. The program helps benchmark farmers' practices, identify issues and remedy them. There are five modules in the Grazing BMP course, including Soil Health; Grazing Land Management; People and Business; Animal Production; and Animal Health and Welfare.[15] The modules relating to soil health and grazing land management are of greatest relevance to these Guidelines, but the concept of an accreditation system for land managers that is industry-driven and supported by government would be welcome across sectors.

Such a system has increased in relevance due to the rise of animal rights activism in rural and regional areas of Australia, including the Western Australian pastoral

[15] Grazing BMP https://www.bmpgrazing.com.au/ accessed on 23 January 2019

estate. As a result of this activism, there has been an increased level of scrutiny on farmers and the way they conduct their business. This situation is becoming the new normal and pastoralists, politicians and peak bodies need to be mindful of this at all times, whether in respect of cattle handling, or how they respond to drought.

Animal welfare issues can be minimised if best practice pastoral land management techniques are employed. Taking care when establishing or managing infrastructure, preventing overgrazing by having a clear strategy for grazing management, while adhering to industry standards for managing feral animals, will go a long way to ensuring the pastoral industry is able to continue and flourish. Adhering to best practice and undertaking a process of accreditation or training, via a system such as Grazing BMP, may assist lessees and the industry more broadly in achieving best practice and, therefore, ensuring the industry's social licence to operate is maintained and bolstered.

Review

The Guidelines are intended to reflect best practice. As best practice evolves, so too must the Guidelines change. As stated above, these Guidelines are not intended to be the last word on good pastoral land management, but rather a guide to best practice. Therefore, the Guidelines should be reviewed every five years, or as new information becomes known. Changes to land management practice in industry will inform amendments to the Guidelines, as well as any new information coming from scientific organisations or Government departments.

Structure of the Guidelines

These Guidelines provide a detailed examination of and a series of recommendations for good pastoral land management. In doing so, the Guidelines are set out as follows:

- Following this introduction, a set of principles that informed the development of the Guidelines, and which should be major considerations for anyone engaged in pastoral land management, is outlined.
- The next chapter provides a general overview of land management, including discussion of what a land manager should consider when developing a lease management plan. The lease management plan needs to identify the objectives for the pastoral business, a detailed assessment of the land under the lease, including all the infrastructure (fences, artificial waters and roads and tracks), natural features such as land systems, pastures, and natural waters and, as a result, the productive capacity of the land. Once this assessment has been undertaken, the pastoral lessee can identify the best type of grazing management to suit the environment and the land systems, the priority action areas for infrastructure development and, if necessary, regeneration and rehabilitation of degraded areas.

The chapters that follow the Land Management chapter, respectively, **Infrastructure, Grazing management, Fire, weeds, and feral animals and Regenerating and rehabilitating degraded areas** provide detailed information on the issues, opportunities, and best practice approaches to managing these areas.

For each of these chapters, a series of additional resources are included, providing further information on techniques for achieving good practice.

In certain cases, individuals and/or organisations may be recommended within the Guidelines. However, this is not an endorsement by the PLB, DPLH, or DPIRD of those people or organisations and their work. Recommendations are received from industry, not-for-profit organisations, and Government agencies and are provided for reference purposes, as places to start if the Guidelines do not provide sufficient information for a particular purpose. Pastoral land managers are responsible for undertaking due diligence before taking advice from, or procuring the services of, anyone listed in these Guidelines.

2 Principles underpinning the Guidelines

Contents

These Guidelines are designed to provide clear and easily followed information to pastoral lessees regarding good-practice pastoral land management techniques and processes. A key element of the Guidelines are a set of principles that govern the need for good pastoral land management, and what the Guidelines are seeking to achieve. These principles should be kept in mind, as they give context to the techniques and processes contained within the Guidelines.

There are three broad principles that underpin the Guidelines, which focus on economic sustainability, ecological sustainability, and the impact of other interests on pastoralism. Those principles are:

1. Economic Sustainability:
    a. good land management outcomes and good economic outcomes are interrelated
    b. a triple bottom line approach to land management is best for ensuring economic and environmental sustainability.
2. Ecological Sustainability:
    a. lease holders are primarily responsible for land management, while the PLB, DPLH, and DPIRD will actively work with lessees to see the pastoral estate managed in an ecologically sustainable manner that ensures the ongoing productivity and profitability of the pastoral industry in Western Australia
    b. the condition of the rangeland must be understood, as must the natural processes shaping the rangelands landscape
    c. land condition should be considered in the context of the whole landscape or catchment area
    d. prevention of land degradation is more effective than rehabilitation.
3. Impact of Other Interests:
    a. native title and other aboriginal rights and interests
    b. mining and exploration impacts on land management outcomes
    c. tourism and associated impacts on land management outcomes
    d. trespassers onto pastoral leases.

Economic sustainability

The interrelatedness of land management and economic outcomes

Pastoral enterprises are businesses like any other – to remain in business, they need to produce income and profit. A key point of difference for a pastoral business is its reliance on the natural environment (native pastures) for economic development (fat, healthy livestock for sale). Therefore, a pastoral enterprise needs good, protein and energy-laden pastures. If the land is in poor condition, there is less pasture around and, potentially, pastures of the wrong type, leading to the lessee needing to destock or see that stock undernourished, resulting in lower financial return for the business.

On well-managed land, the pastures are likely to be healthy. Healthy pastures generally result in healthy livestock, which, in turn, means the pastoral business will see good economic returns. Additionally, healthy pastures and healthy profits mean that pastoralists can afford to remain on the land, employ staff, and provide the essential services – fire mitigation and firefighting, emergency assistance, among other things – that make such a strong contribution to remote community life.

The continued health of the region's economy is inextricably linked to the appropriate management of natural resources, as well as the ability to adapt and respond to internal and external influences such as labour availability and cost; global, national, regional or local commodity price fluctuations; and the emergence of new industries. Likewise, the ability of a land manager to manage natural resources sustainably is strongly linked to the profitability of an enterprise.[16]

The triple bottom line and pastoralism

Each of the elements listed above form part of the triple bottom line view of business management. The triple bottom line concept, which brings together three different statements of profit and loss (financial, social, and environmental – or the three Ps of profit, people, and planet[17]), is fundamental to the success of any pastoral enterprise. As noted in the Legislative Context section above, lessees have an obligation, pursuant to section 108(2) of the LAA, to manage their land according to best pastoral and environmental management practice. These are two of the three pillars of the triple bottom line approach. The purpose of these Guidelines are to provide pastoral lessees and their managers with a clear understanding of methods of best pastoral and environmental management practice.

Therefore, a pastoral business must have a positive number in the ledger for environmental management. This positive environmental figure also means that a lessee compliant with the terms of the lease and the LAA, further enhancing the sustainability of the business. To assist pastoral businesses in achieving a sustainable enterprise, the PLB has developed a definition of ecologically sustainable pastoral land management. The PLB defines ecologically sustainable pastoralism as follows:

> The management, development and use of natural resources relevant to pastoral operations being undertaken on the land, with an aim to meet the needs of today while conserving ecosystems for the benefit of future generations.[18]

[16] South Australian Arid Lands Natural Resources Management Board, *It's Your Place: A Roadmap for Managing Natural Resources in the SA Arid Lands Region 2017-2027*, Volume 1. Adelaide, Government of South Australia, 2017: 26

[17] 'Triple bottom line: It consists of three Ps: Profit, People and Planet', The Economist, 17 November 2009, online edition accessed 27 September 2018. https://www.economist.com/news/2009/11/17/triple-bottom-line

[18] Pastoral Lands Board, *Policy Statement: Ecological Sustainability*, Approved 14 December 2017

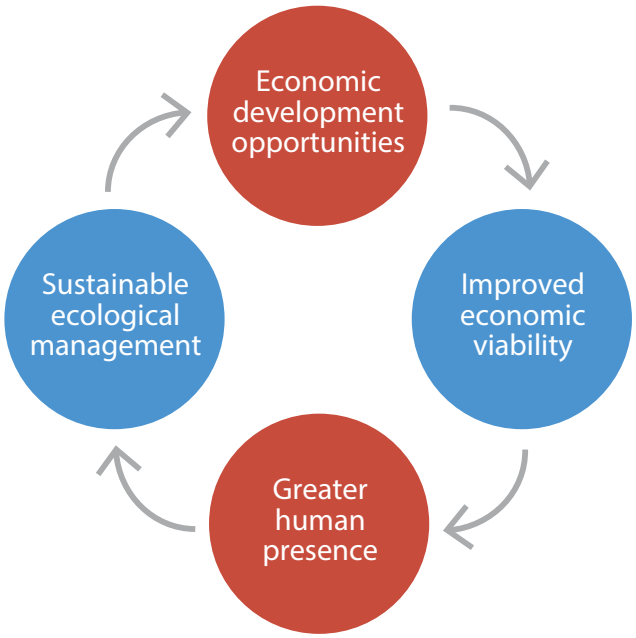
Further, the PLB policy statement regarding ecological sustainability recognises that pastoral activities will and have modified the environment on pastoral land. In consequence, ecologically sustainable use of pastoral land must be considered within the context of managing the extent of that modification, rather than prohibiting pastoral leases from using the land for pastoral purposes.[19]

Finally, the social element must be considered. If a pastoral business does not value its people, they will move on and a great deal of experience, corporate knowledge, and knowledge of the land, will be lost. Further, given native title has been determined to exist over most of the pastoral estate, many pastoralists will regularly engage with traditional owners. The manner of that engagement can have significant impacts on Aboriginal people's wellbeing, and affect any future native title negotiations, such as Indigenous Land Use Agreements (ILUAs) for diversification permits or other land use changes.

Pastoralists, especially those on family-run leases, also hold aspirations that they will be able to pass a lease on to their children, or provide them with a future by paying school fees for a boarding school in Perth, university tuition and board, and so on. Therefore, the social element of the triple bottom line is vital to the success of a pastoral business. Failure to care for the social element of the triple bottom line may, in the end, cause damage or delays to the realisation of longer-term benefits to the financial aspect.

Businesses that rely on the environment for their livelihood, such as pastoral lessees, are particularly encouraged to utilise the triple bottom line approach. Figure 3 below illustrates how the triple bottom line concept applies to the pastoral industry.

Figure 3: Triple bottom line as it relates to the pastoral industry



Diagrammatic representation of the Triple Bottom Line concept as it relates to the pastoral industry

[19] Ibid

Ecological sustainability

The PLB acknowledges that past approaches to pastoral land management have not provided the best outcomes for either pastoralists, government, or the land. This is demonstrated by at least eight reports, dating back to 1940, that highlight the significant structural and systemic problems with the way the pastoral Rangelands have been managed, by both pastoralists and government.[20] These land management methods can be summarised as follows, in sequence:

- Government requires lessees undertake to manage the land in an ecologically sustainable manner, pursuant to the LAA.
- Government performs periodic (and increasingly fewer) inspections of leases.
- Government writes to lessees whose leases present problems such as severe land degradation, requiring remediation by a specific date.
- Due to a lack of resources, most leases with identified problems are not followed up. Where they are, Government threatens Default or Forfeiture to enforce compliance.
- Rarely does Government follow through with threats, and compliance issues remain.

As a result, a new approach, predicated upon cooperation and collaboration, incentives and assistance, is required for all parties to achieve the outcomes required to ensure a sustainable pastoral industry.

These Guidelines are a part of this new approach, providing land managers with tools to assist them to implement good practice land management in the pastoral estate. Additionally, these Guidelines have been developed in consultation with pastoralists, Government agencies including DPIRD, DBCA, and DWER, pastoral industry bodies, and NGOs, as part of that commitment to work with industry to achieve good land management outcomes.

Land management is primarily the lessee's responsibility

While the primary responsibility for land management outcomes rests with the lessee, and the PLB regulates and monitors those outcomes, the PLB, through these Guidelines and other policies, is building a more collaborative model for good land management outcomes. DPLH and the other agencies are also moving towards a collaborative model, in support of the strategic direction articulated by the PLB.

As noted previously, section 108 of the LAA provides that a pastoral lessee must manage the land under lease to its best advantage as a pastoral property, to the satisfaction of the PLB. Additionally, the PLB is responsible for ensuring pastoral leases are managed on an ecologically sustainable basis. These Guidelines are designed to assist the PLB and the Lessees to achieve their legislative responsibilities in respect of land management.

[20] Office of the Auditor General Western Australia, *Management of Pastoral Lands in Western Australia, Perth*: Office of the Auditor General Western Australia, 2017: 33-4

A range of other agencies are also responsible for ensuring land managers fulfil their obligations and do not contravene environmental and land management legislation. Below is a list of relevant agencies, each of which administers an Act cited in the LAA and the lease, and to which the lessees must adhere:

- Pastoral Lands Board
- Department of Planning, Lands and Heritage (DPLH)
- Department of Primary Industries and Regional Development (DPIRD)
- Department of Water and Environmental Regulation (DWER)
- Department of Biodiversity, Conservation and Attractions (DBCA).

The details of the legislative instruments administered by each of the agencies listed above are located in the discussion of legislative context in the introduction above.

Understanding land condition

Understanding the condition of the land under the lease, including areas in good, fair, or poor condition, is a key component of good land management. This knowledge should extend to knowing which pastures are the most productive. This information is required to plan a grazing management regime that can maintain good land condition. Knowing the land systems on the land under the lease will aid in the development of a fencing plan, as fencing according to land type can help prevent selective grazing in a given paddock. Selective grazing of one pasture type over another within the same paddock can lead to overgrazing of the more desirable pasture, which, in turn, can lead to land degradation.

This knowledge of land systems and pasture types can then translate into better pastoral land management and, consequently, better land condition. The better the condition of an area of land, 'the more effective it can be in trapping and retaining scarce resources and therefore able to retain or even improve on that condition'.[21] Improved condition means an increase in the presence and abundance of palatable perennial plant species, which are then better able to support the grazing of livestock, meaning greater productivity and more income for the lessee.

As a result, pastoral lessees should survey the land under the lease and determine the condition of the land prior to establishing a land management plan to ensure the rangeland condition is maintained or improved, as required. DPLH and DPIRD are developing land condition standards that will assist pastoralists when assessing the condition of their land. For more information, see the Land Condition section of this chapter, below.

Land condition within a catchment area context

The need for integrated catchment management in farming country has long been recognised. While stations have been managed largely in isolation, partly due to their size, pastoralists appear individually

[21] Don Burnside, Alec Holm, Alan Payne, and Georgina Wilson, *Reading the Rangeland: A Guide to the Arid Shrublands of Western Australia*. South Perth: Department of Agriculture, Western Australia, 1995: 17

keen to help each other out.[22] Approaches that help pastoralists understand the management problems and opportunities available to their stations in relation to their neighbours, and that highlight their place in the catchment as a whole are of immense benefit.

As a result, organisations and groups that regularly interact at a catchment or regional level are natural groupings for pastoral lessees to engage with each other, share ideas, and develop greater understandings of how actions on one lease in the area may affect the land on surrounding leases. In this context, Land Conservation District Committees may be an appropriate place to engage in whole-of-catchment or whole-of-landscape planning for land conservation and remediation. These groups are responsible for carrying out projects, works or practices for preventing, remedying or mitigating land degradation and for promoting soil conservation and reclamation,[23] and may be appropriate forums for discussions and planning at a landscape or catchment level.

Coordinated and effective regional action regarding biosecurity is already being undertaken across most of the pastoral estate through Registered Biosecurity Groups (RBGs) established under the BAM Act. The RBGs are discussed further in Chapter 6.

Natural processes of the landscape

The WA Rangelands are vast and, as a result, greatly varied. The variety of land systems and the differences between processes influencing one land system and another within a single sub-region mean, 'any land manager is flying blind without an understanding of the processes that are shaping the landscape and its vegetation'.[24] Without that knowledge, much damage may be done without the land manager realising it. In the WA Rangelands, 'very little may happen for a long time, followed by sudden changes in the balance or survival of species caused by very wet or very dry years'.[25] Erosion may result in irreparable soil loss – processes to establish new soil in arid areas are very slow, reliant on natural weathering of rocks – while plant species loss may alter the character of a whole area, often permanently.

Given the magnitude of the impacts that lack of knowledge of the natural processes shaping the landscape can cause, land managers should seek out that information and consult with experts, where necessary. Local DPIRD offices should be contacted in the first instance, as they can provide information or contacts who will be able to assist. Contact details for DPIRD regional offices are listed below, by region and location:

[22] Hugh Pringle and Ken Tinley, 'Ecological Sustainability for Pastoral Management', *Journal of the Department of Agriculture, Western Australia, Series 4*: Volume 42(1), Article 8: 32

[23] Department of Primary Industries and Regional Development, 'Land Conservation District Committees', https://www.agric.wa.gov.au/land-use-planning/land-conservation-district-committees accessed 3 October 2018

[24] Don Burnside, et al., *Reading the Rangeland*: 15

[25] Ibid

Table 1: Kimberley DPIRD Offices

Broome	Street address	27 Hunter Street, Broome WA 6725	Telephone	08 9194 1400
	Postal address	PO Box 5502 Broome WA 6725	Fax	08 9192 2946
Derby	Street address	Coleman centre Derby WA 6728	Telephone	08 9191 1555
Kununurra	Street address	Durack Drive Kununurra WA 6743	Telephone	08 9166 4000
			Fax	08 9166 4066

Table 2: Pilbara DPIRD Office

Karratha	Street address	Unit 1/17-19 Crane Circle Karratha WA 6714	Telephone	08 9143 7000
			Fax	08 9143 0017

Table 3: Mid-West / Gascoyne DPIRD Offices

Carnarvon	Street address	South River Road, Carnarvon WA 6701	Telephone	08 9956 3333
	Postal address	PO Box 522 Carnarvon WA 6701	Fax	08 9941 8334
Geraldton	Street address	20 Gregory Street Geraldton WA 6530	Telephone	08 9956 8555
	Postal address	PO Box 110 Geraldton WA 6530	Fax	08 9921 8016

Table 4: Goldfields / Nullarbor DPIRD Offices

Kalgoorlie	Street address	377 Hannan Street Kalgoorlie WA 6430	Telephone	08 9092 2733
Esperance	Street address	PMB 50 Melijinup Road Esperance WA 6450	Telephone	08 9083 1111
			Fax	08 9083 1100

Processes in the Northern Rangelands have affinities with both the semi-arid and monsoonal high rainfall areas elsewhere in northern Australia.[26] In the Southern Rangelands, climate, rainfall, and types of pasture available are markedly different to those in the north. Therefore, a region- and lease-specific understanding the climate, the seasons, the land systems, and the natural processes associated with them is vital to the ability of pastoral lessees to manage the land under their lease in an ecologically sustainable – and profitable – manner. This is even more important in the context of climate change.

Ken Tinley and Hugh Pringle observe that, with climate change modelling predicting increased cyclone activity and therefore rainfall in the Northern Rangelands and decreased rain activity in the Southern Rangelands, the importance of managing the land in concert with the natural processes of a given region increases. They argue that by fitting 'management closely to the existing climatic regime, and keeping track of the weather patterns through Weather Bureau predictions, it is possible to work with the changes to be prepared for whatever eventuates'. Tinley and Pringle refer to this as 'a strategy combining anticipatory and adaptive management'.[27]

Prevention of degradation is more effective than rehabilitation

Good land management practices are required to ensure that the resource is protected and remains productive in the long term, by, among other things:

- actively managing grazing pressure on the land under the lease
- placing fences and tracks appropriately in relation to water flow
- responding to seasons (for example, by destocking if necessary when drought arrives, restocking when seasons turn and grass has set seed)
- keeping alert to the early signs of erosion.

Keep in mind that vegetation is the cheapest form of protection against erosion. The roots of plants hold the soil in place, the leaves and stems soften the impact of rain as it falls, and leaf litter traps nutrients and mulches the soil, enabling new plants to be recruited. These activities are all natural and free. However, remediation activities, including earthworks and planting of seed, for example, are expensive and time-consuming. The cost of rehabilitating land in very poor condition is significant, generally requiring mechanical intervention. A gap analysis by the Queensland Department of Agriculture and Fisheries of grazing management practices for improving water quality run-off notes, data show the cost of rehabilitation of very poor

[26] PE Novelly and D Warburton, *A Report on the Viability of Pastoral Leases in the Northern Rangelands Region Based on Biophysical Assessment*. South Perth: Department of Agriculture and Food, 2012: 3

[27] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*. Perth: Rangelands NRM, 2013: 20

condition land can range from $14.11 per hectare to $379.00 per hectare, depending on the type of rehabilitation activity. The cheapest activity was aerial seeding, while the most expensive was deep ripping.[28]

Land and grazing management activities can be time-consuming, and running less stock than the assessed carrying capacity can seem like an economic loss in the making. However, pastoral stations that have undertaken these types of activities have been able to continue producing when others have had to destock. Further, the better the land condition during a drought, the quicker the land will recover when it rains again. The gap analysis also pointed to conservative stocking as one of the most successful grazing management strategies, both in terms of land condition and profitability:

> Pasture yield, composition and ground cover were… far highest in the rotational spelling and moderate stocking rate treatments, followed by the two variable treatments, but was by far the poorest in the heavy stocking rate treatment The key finding was that its heavy stocking treatment was neither sustainable nor profitable and was far more risky than the other treatments.[29]

Additionally, protecting the natural resources and not depleting pastures is an essential part of a productive and profitable pastoral business. There are situations in which overgrazing has seen an increase in unpalatable plants, meaning the overall vegetation cover has not changed, but the palatability of the plants in paddocks has been reduced, thereby reducing the productivity of the land. In other circumstances, overgrazing has led to a reduction in ground cover, exposing the soil to wind and water erosion.

The loss of pastoral rangeland condition due to overgrazing equates to a loss in potential production; DPIRD estimated that in 2016, based on a five-year average of ABARES receipts and costs, the 'loss of profit from pastoral rangelands degradation was $78 million each year'.[30]

These Guidelines provide information for land managers on techniques and strategies that may assist in preventing land degradation – a much more cost-effective and otherwise financially rewarding approach than rehabilitating degraded land. Continuously productive land provides ecosystem services that nourish livestock and maintain overall ecosystem health, benefitting both the pastoral lessee and the environment.

[28] Timothy Moravek, Peggy Schrobback, Miriam East, Megan Star and Steven Rust, *Understanding the economics of grazing management practices and systems for improving water quality run-off from grazing lands in the Burdekin and Fitzroy Catchments*. Reef Plan Action 4: Gap Analysis 2016. Brisbane: State of Queensland, 2017: 20

[29] Moravek, et. al. *Understanding the economics of grazing management practices and systems*: 15 20

[30] Department of Primary Industries and Regional Development, *Status of the Western Australian Pastoral Rangelands*, Perth: DPIRD, 2018: 23

Impact of other interests on land management outcomes

Other interests can and do intersect with pastoral leases and consequently affect land management outcomes on the lease. These other interests can include, native title, mining, tourism, and trespassers, among others. Land managers must be aware of their rights and the rights of others to access the land under the lease.

Native title and other Aboriginal rights and interests

Native Title rights and interests are a fact of life in the pastoral estate of Western Australia. The majority of the WA Rangelands is either subject to a native title claim or determination. As a result, pastoralists need to be aware of their obligations and the rights of native title holders and claimants.

In a strictly legislative sense, pastoral lessees might only engage with native title parties when applying for a diversification permit under LAA Part 7 Division 5, or when seeking a change of tenure for part of their lease. However, there are other important matters to consider.

First, section 104 of the LAA allows Aboriginal people to enter parts of the land under the lease, stating:

> **Aboriginal People's right to enter parts of pastoral leases**
>
> Aboriginal persons may at all times enter upon any unenclosed and unimproved parts of the land under a pastoral lease to seek their sustenance in their accustomed manner.

This means that pastoral lessees need to engage with Aboriginal people, usually traditional owners and/or native title parties, on a regular basis, to facilitate their access to the land under the lease for the purposes outlined above.

Additionally, there may be Aboriginal heritage sites on a pastoral lease, which Aboriginal people may wish to visit from time to time for ceremonial and other purposes. In this context, regular liaison with the local Aboriginal people is essential.

Under Part II of the *Aboriginal Heritage Act 1972* (AHA), Aboriginal people to whom objects and sites traditionally belong are permitted to use and visit those objects and places for purposes sanctioned by their traditions. Further, those places and objects are protected from interference. Additionally, Part IV of the AHA, which deals with the protection of Aboriginal sites, provides that an owner of the land (including pastoral lessees) must seek approval from the Registrar of Aboriginal Sites or the Minister for Aboriginal Affairs, via the Aboriginal Cultural Material Committee, to disturb land that may damage or alter an Aboriginal site.[31]

Aboriginal traditional owners may, if engaged appropriately, provide significant insights in respect of good land management practice on pastoral leases. A practical way of incorporating that knowledge and those perspectives into a land management plan would be by using Aboriginal fire management regimes. Aboriginal land management is widely acknowledged on the Western Australian pastoral estate, particularly in respect of

[31] See *Aboriginal Heritage Act 1972* Sections 16, 17, and 18

traditional fire management regimes. A 2006 report by the Western Australian EPA noted, at several points, the importance of drawing upon the knowledge of Aboriginal people in respect of fire management in the Kimberley.[32]

Additionally, pastoral lessees could seek to be involved in an Aboriginal Ranger Program, similar to that announced by the Western Australian Government as part of its 2017 election commitments. The commitment called for $20 million to be invested over five years to expand the Aboriginal Ranger Program,[33] providing additional opportunities for Aboriginal people to work on Country, gain skills, and build capacity to look after country and culture.[34] While this program is currently focussed on the conservation estate, such a program could be applied to the pastoral estate.

A Kimberley pastoralist suggested that lessees could consider undertaking environmental programs with traditional owners under a kind of ranger program linked to an environmental offsets approach to pastoral diversification. He argued that pastoralists require diversification opportunities to safeguard the viability of their pastoral enterprises and by engaging traditional owners to care for the land not being developed, not only was biodiversity being preserved, but indigenous knowledge was being used and jobs created for traditional owners. He suggested, by way of example, a feral cat eradication program to protect bilbies on land not being used for more intense purposes.[35]

These types of programs have the potential to provide genuine benefits to lessees, traditional owners, and the environment, while also tapping into indigenous knowledge and land management expertise.

Understanding of and interest in Aboriginal land management methods and knowledge has grown in recent years, on the back of a range of publications, most notably two award-winning studies, Bruce Pascoe's *Dark Emu: Aboriginal Australia and the Birth of Agriculture*, and Bill Gammage's *The Biggest Estate on Earth: How Aborigines Made Australia*.[36] Both of these books make it clear, using evidence from the journals and other writings of early European explorers, pastoralists and Aboriginal protectors, that the landscape Europeans encountered when they arrived in Australia was actively managed, as Gammage argues, 'alert to season and circumstance, committed to a balance of life'.[37]

[32] Environmental Protection Authority, *Fire Management in the Kimberley and other Rangeland Regions of Western Australia: Advice of the Environmental Protection Authority to the Minister for the Environment under Section 16(e) of the Environmental Protection Act 1986* – Bulletin 1243. Perth: EPA, 2006

[33] NITV Online, 'WA Political Parties promise Indigenous Ranger Funding if Elected'. SBS, 12 January 2017. https://www.sbs.com.au/nitv/nitv-news/article/2017/01/12/wa-political-parties-promise-indigenous-ranger-funding-if-elected Accessed 28 May 2019

[34] Department of Biodiversity, Conservation and Attractions, *Aboriginal Ranger Program* website. https://www.dpaw.wa.gov.au/parks/aboriginal-involvement/504-aboriginal-ranger-program accessed 5 December 2018

[35] Rob Edwards, '20190412 File Note Fact Finding Field Trip 2 – Kimberley – Good Pastoral Land Management Guidelines 8-11 April 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019: 3

[36] Bruce Pascoe, *Dark Emu: Aboriginal Australia and the Birth of Agriculture*, second edition Broome, WA: Magabala Books, 2018; Bill Gammage, *The Biggest Estate on Earth: How Aborigines Made Australia*, second edition, Crows Nest, NSW: Allen & Unwin, 2012

[37] Gammage, *The Biggest Estate on Earth*: 2

Notably, both Gammage and Pascoe observe that much of the damage done to the cultivated or park-like landscapes the early Europeans had written about, was done by livestock introduced to support the colonies. Sheep, in particular, overgrazed the land and led to the hardening of soils, greater floods, and attendant land management issues.[38]

Ranger programs for fire management and feral animal eradication can help restore some of the balance of life, to which Gammage refers, while providing benefits to all parties, indigenous and non-indigenous. These may also be the beginnings of a broader approach to land management incorporating Aboriginal knowledge and techniques.

Mining and exploration effects on land management outcomes

The Rangelands, particularly from the Pilbara south, are rich in minerals and sustain a highly profitable mining industry. Mining accounts for approximately 90 per cent of Western Australia's exports, the vast majority of which are from minerals (14 per cent of the mining exports are petroleum, much of which is extracted offshore),[39] and contributes $38 billion to the State's economy.[40]

Due to this large economic output, mining in the Rangelands invariably overlaps the pastoral estate. Many mines exist on pastoral stations, as do exploration tenements and prospecting licences, and a large number of companies and individuals are engaged in mining activities on them. Given the nature of a mining right or tenement, the types of activities associated with mining are mostly incompatible with grazing livestock, which can lead to land management issues for the pastoral lessee and conflict with miners.

In 1990, a detailed survey of the impact of mining and mining exploration on pastoral operations was undertaken by the then-Department of Agriculture and Food. That study noted that approximately two-thirds of reporting lessees stated, 'their property was affected by mining and/or exploration'. Exploration involving soil disturbance was reported on 57 per cent of leases. One-fifth also stated that exploration disturbance affected an area more than 100ha.[41] As a corollary, pastoral businesses were 'most commonly affected by the disruption of established grazing management systems, the reduction of stock numbers and forced closure of the paddocks affected' by intensive mining activity. Lessees also noted increased erosion, which they attributed to poorly sited and constructed roads, tracks, and seismic lines. Furthermore, one-eighth of lessees reported some form of pollution from mining, whilst 'nearly one-fifth reported damage to station infrastructure'.[42]

[38] Pascoe, *Dark Emu*: 23

[39] KPMG and CME, *2018-2028 Western Australia Resources Sector Outlook*, Perth: Chamber of Minerals and Energy WA, 2018: 12

[40] Chamber of Minerals and Energy Website, http://www.cmewa.com/ Accessed 30 August 2019

[41] HJ Pringle, GA Carter, JL James, and REY O'Connor, *The impact of mining and mining exploration on range resources and pastoral pursuits in the Pilbara, Gascoyne, Murchison and Goldfields regions of Western Australia*, Perth: Department of Agriculture and Food WA, 1990: 30

[42] Ibid

Additionally, given the disruption to grazing management systems of the establishment of a new mine or exploration activity on a pastoral lease, affected lessees often are forced to destock. Some exploration, especially alluvial mining, removes livestock access to good grazing country, affecting carrying capacity on the land under the lease. Sometimes lessees are compensated, but not always. These issues continue to be raised, some 30 years later, despite advances in legislation, regulations, and oversight of mining operations in the Rangelands.[43]

However, having a good knowledge of the land under the lease can help reduce land management issues caused by mining operations. One pastoralist in the Goldfields used knowledge gained from undertaking a detailed study of his lease with a consultant (an EMU Plan – see Chapter 3 for details) to ensure a mining company built their road in a different area and in a different way to what had been proposed. He was able to point to maps to convince them of his proposed approach and prevented land management issues developing as a result.[44]

Further, there are many benefits for lessees, such as new infrastructure being constructed, initially to provide mining access, which is then passed across to the pastoral lessee. Some of the types of infrastructure being provided by mining companies to pastoralists include:

- new bores
- new dams
- new roads.[45]

Some lessees are also able to provide services to the mining companies, such as bulldozing, whether for roads or gridlines to support exploration. Such contracts can help offset losses incurred due to a reduction in carrying capacity.

Unauthorised tourism, trespassers and associated impacts on land management outcomes

Over the years there have been many reports of tourists and other trespassers entering pastoral land and causing problems. These trespassers enter the land for a number of reasons, mostly benign. Some are tourists looking to enjoy the great outdoors, camp by a river and fish. Others enter pastoral land seeking to hunt native wildlife, such as kangaroos, or feral animals such as wild pigs.

Members of the public do not have an automatic right of access to land under a pastoral lease. Pastoral land managers must be contacted for permission to enter land under the lease, because as lessees, they hold a right to quiet enjoyment of the land under the lease. One key exception, noted above, is the reservation

[43] Anecdotal evidence received by author at a range of stakeholder events across 2018/19

[44] Rob Edwards, *20191111 File Note: Bullseye Bulga Downs Field Days 6-7 November 2019*, Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – Crown Land Administration – Policy – Pastoral L*ands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10783245: 6

[43] Pringle et. al. *The impact of mining and mining exploration on range resources and pastoral pursuits in the Pilbara, Gascoyne, Murchison and Goldfields regions of Western Australia*: 22

under section 104 of the LAA that allows Aboriginal people to enter the land to acquire food, whether by hunting or collecting plant-based bush tucker. Another exception is for Government officers carrying out their legislated duties – for example, DPLH employees inspecting a pastoral lease.[46]

Pastoral lessees have, in the past, been quite forgiving of members of the public entering the land under the lease. However, due to poor behaviour, pastoralists have been less inclined to allow anyone onto their leases. Some examples of this poor behaviour include:

- cutting fences
- gates being left open
- litter being left behind
- unauthorised shooting of wildlife
- killing and slaughter of livestock.[47]

Anecdotally, these activities are an ongoing problem, and the costs can be quite high. Loss of earnings from poaching of cattle is an obvious cost, but the costs of repairing cut fences or gates that have been broken through are also high. Where trespassers have cut a fence, their vehicles can initiate erosion problems, creating wheel ruts and damaging native vegetation. Further, cattle escaping through cut fences can pose a risk to the public, especially if the cattle roam the roads at night. Another land management issue associated with unauthorised tourism and trespassing, particularly where lessees have an established grazing management plan, can be the disruption of that plan, potentially leading to overgrazing of certain paddocks or pastures. In chapter 5 below, the effects of overgrazing are discussed in detail.

[46] Section 34 of the *Land Administration Act 1997* refers

[47] For some examples, see Tyne McConnon, 'Pastoral Stations in remote Western Australia battle and influx of trespassing tourists', ABC Rural Online, 4 July 2014, https://www.abc.net.au/news/rural/2014-07-04/station-owners-control-access-to-stations/5572478; Lucie Bell and Tyne McConnon, 'Kimberley cattle station owners condemn illegal cattle kills', ABC Rural Online, 24 January 2014, https://www.abc.net.au/news/rural/2014-01-24/cattle-kills/5217106; Lucie Bell and Tom Edwards, 'Five fishermen charged with trespassing on Pilbara cattle station', ABC Rural Online, 18 November 2015, https://www.abc.net.au/news/rural/2015-11-18/men-charged-for-pastoral-station-trespass/6950754; and Ebonnie Spriggs and Lucie Bell, 'Pilbara pastoral station to ban public after poaching, arson attacks', ABC News online, 29 July 2015, https://www.abc.net.au/news/2015-07-29/pilbara-pastoral-station-to-ban-public-after-poaching-arson/6654892 Accessed 2 September 2019

3 Land management and planning

Contents

What is land management?

Land management is the sum total of all activities undertaken by pastoral lessees on their land to achieve land use outcomes, including financial, lifestyle and good environmental outcomes. Good land condition is one of those outcomes, which is important from multiple perspectives. First, good land condition is essential to continuing good economic outcomes for pastoralists; second, the Pastoral Lands Board requires that land condition be maintained to a minimum standard for compliance purposes. Therefore, land management and land condition are inextricably linked. Good land condition is the key outcome of good land management, ensuring a pastoral business is profitable and sustainable long-term, while also meeting the standards required by the PLB.

Good land management and poor land management are exercises in degrees of activity. A good land manager is likely to have clearly defined plans and objectives, be active, and be meeting those objectives to a degree that is acceptable to the lessee and the PLB. Whilst the objectives may differ between individual lessees, the PLB will have defined minimum standards in respect of land condition that must be met. A poor land manager may either have no plan or a vague plan and not be particularly active and/or not meeting those objectives. In these circumstances, the likelihood of the land manager achieving the minimum standards of land condition the PLB requires are low, especially over the medium to long term.

As these Guidelines demonstrate, the difference between good and poor land management can be about timing. For example, destocking at just the right time to prevent overgrazing of a pasture, or identifying and remedying a small erosion area before the next significant rainfall occurs can make a world of difference to land condition. Further, fencing by pasture type or land system can help ensure that grazing patterns are even across a paddock, meaning no particular pasture type within a paddock is left untouched while more palatable pastures are overgrazed.

However, good pastoral land management is not simply about managing livestock grazing on the land. There are a range of other elements to good pastoral land management, and these guidelines discuss them in detail, providing examples of, and explanations of how to implement, good practice. Good pastoral land management requires detailed business and land management planning, because a pastoral business must maintain a minimum standard of land condition, and land condition is also key to the profitability of the grazing enterprise.

Land management planning

As noted above, one of the most important aspects of good land management is having – and implementing – a good plan. That plan is designed to ensure that the land manager's objectives are achieved, and land condition is maintained at least to the PLB's minimum standards.

This chapter will examine land management as a holistic process, from setting goals to developing a plan and implementing it. A pastoral land management / business plan should include:

- the objectives of the pastoral business
- a mapping process, which
  - provides an audit of existing infrastructure
  - identifies the land systems on the land under the lease, including the condition and productivity of land systems and pasture types, enabling stocking rates to be determined
- a prioritisation process for:
  - infrastructure development
  - establishing a grazing regime appropriate to the region, land systems, and the maintenance of good land condition
- determining whether external assistance is required in order to develop the station plan.

In the sections that follow, each step of this business planning process is described and a summary of what is required in order to establish a land management plan.

Further, this chapter will provide a list of resources and points of contact for pastoral lessees undertaking this process.

Detailed discussion of specific elements of good land management discussed here are located in dedicated chapters below. They include:

- infrastructure management
- grazing management
- fire, feral animals and weed management
- regeneration and rehabilitation of degraded areas.

Objectives

The objectives for each land manager and/or pastoral business will differ. However, there are five general types of objectives that tend to motivate pastoral lessees across the rangelands. These are described in the table below, together with some key considerations for each of these categories. Irrespective of the objectives for the business, though, lessees must adhere to the following two key elements of lease management:

1. The lease **must be operated as a pastoral business**, which means the commercial grazing of authorised stock must be the primary activity
2. The lease must be managed in an ecologically sustainable manner and to its best advantage as a pastoral property.

Table 5: Types of Pastoral Operations in the Western Australian Pastoral Estate

Objective	General type of pastoralist	Considerations
Maximisation of profit	Corporate or entrepreneurial pastoralists, including family pastoral companies	Seeking to achieve maximum financial benefit from the land under lease Need to balance financial benefits with the need to meet the PLB's minimum land condition requirements; Land condition is a key component of the ability to maximise profits in the longer term
Lifestyle	Some family pastoralists and individuals	Profit is not the main purpose Need to run sufficient livestock to ensure the property is profitable enough to maintain the lifestyle; Need to ensure the land condition is maintained to the PLB's minimum standards
Cultural or traditional	Aboriginal traditional owners who run a pastoral lease	Desire to maintain their connection to country while also providing employment and cultural associations for their people Need to ensure the station is run as a pastoral enterprise; Need to ensure the land condition is maintained to the PLB's minimum standards
Conservation	Environmental groups or environmentally-minded pastoralists	Main purpose to preserve or restore the environmental values of the land under the lease Need to ensure the land condition is maintained to the PLB's minimum standards Need to ensure the land is run as a pastoral enterprise
Mining access	Mining company	Seeking to facilitate land access agreements with pastoral lessee by integration of the mining tenement within a pastoral lease owned by the company. Need to ensure the station is run as a pastoral enterprise; Need to ensure the land condition is maintained to the PLB's minimum standards

How to achieve objectives

This section describes the key steps required to achieve the objectives of any of the groups listed above.

Map the station

The first step to achieving the objectives is to undertake an audit of the station. This means mapping and compiling a list of the existing infrastructure on the lease, as well as the land systems and pastures. The station map should show the locations of the following:

- lease boundaries
- fences / paddocks (with names or numbers) / yards
- waters (natural, including watersheds and artificial)
- roads and tracks
- land Systems / pastures.

Land systems

Pastoral surveys

During the 1950s and 1970s a range of land system surveys were undertaken in the Northern Rangelands, initially by the CSIRO and then jointly by the Departments of Agriculture and Lands and Surveys. At present, DPIRD solely manages the Rangeland survey project with survey work still ongoing. The land system surveys provide a descriptive reference of the land resources within a rangeland region and accompany land system maps. The accompanying technical bulletins provide details about geology, geomorphology, soils and vegetation in a given region.[48] Such surveys are vital to an understanding of the ecology and natural processes occurring in a given rangeland landscape, covering topics relevant to resource condition in terms of pastoral impact, catchment management, ecological disturbance and susceptibility to water erosion, flooding or wind erosion. Nearly all lands under pastoral lease tenure in Western Australia have been mapped and described to the land system scale, with one or two surveys still being completed.

[48] See, for example, N Schoknecht and A L Payne, *Land Systems of the Kimberley Region, Western Australia*. Technical Bulletin No. 98. South Perth: Department of Agriculture and Food, 2010; P.A. Waddell, A.K. Gardner and P. Hennig. *An inventory and condition survey of the Western Australian part of the Nullarbor region*. Technical Bulletin No. 97. South Perth: Department of Agriculture and Food Western Australia, 2010; A.M.E. Van Vreeswyk, A.L. Payne, K.A. Leighton and P. Hennig. *An inventory and condition survey of the Pilbara region of Western Australia*. Technical Bulletin No. 92. South Perth: Department of Agriculture Western Australia, 2004; and P Hennig, P J Curry, D A Blood and K A Leighton, *An Inventory and Condition Survey of the Murchison River Catchment, Western Australia*. Technical Bulletin No. 84. South Perth: Department of Agriculture and Food, 1994

DPIRD has summarised the key details of the Regional Land System Surveys into maps. These maps identify, station-by-station, the land systems and their productivity for pastoral purposes. The maps also contain the locations of fences, paddocks, yards, water points, tracks, and other infrastructure. Pastoral lessees should be given copies of these maps upon acquisition of, or as part of the due diligence process prior to acquisition, of a pastoral lease.

DPIRD and DPLH hold copies of these maps, and can provide them to lessees on request.

The surveys are masterpieces of scientific analysis and categorisation and are essential documents for pastoral lessees seeking to understand the land under their leases.

More information

These surveys can be found on the DPIRD website at https://www.agric.wa.gov.au/rangelands/rangelands-surveys-%E2%80%93-western-australia and http://researchlibrary.agric.wa.gov.au/tech_bull.

Land condition

Understanding rangeland condition and trend is vital to any form of land management on a pastoral lease. In the first instance, land managers must understand whether their land is in good, fair or poor condition. As Novelly and Warburton note, 'the presence of palatable, perennial species defines range condition', or rather, 'they are a proxy for range condition, with range condition synonymous with the density of desirable species relative to the potential of the particular vegetation type in question'.[49] Clunies-Ross and Mitchell agree, noting it is possible 'to assess long term condition by comparing the current perennial vegetation cover to what the potential of a particular pasture type is'.[50] They add that land system maps, discussed above, are helpful in developing an understanding of the pasture types,[51] while pasture field guides (see below) provide additional information regarding palatability, nutritional value, good, fair, and poor condition, among other things.

Next, a land manager must know whether the trend in land condition is improving, remaining steady, or declining over time – vital to whether and which type of intervention might be required to maintain or improve land condition.

[49] PE Novelly and D Warburton, *A Report on the Viability of Pastoral Leases in the Northern Rangelands Region Based on Biophysical Assessment*, South Perth: Department of Agriculture and Food Western Australia, 2012: 20

[50] Mary-Anne Clunies-Ross and Andrew Mitchell, *Pasture Identification: A Field Guide for the Pilbara*, Perth: Greening Australia, 2014: 6

[51] Ibid

The Pastoral Lands Board presently rates land condition against five ratings, which are:

Excellent or very good. The site's cover, structure and composition of shrubs, perennial herbs and grasses is near optimal, free of obvious reduction in palatable species or increases in unpalatable species.

Good. Perennials present include all or most of the palatable species expected; some less palatable or unpalatable species may have increased, but total perennial cover is not very different from optimal.

Fair. Moderate losses of palatable perennials and / increases in unpalatable shrubs or grasses, but most palatable species and stability desirables still present; plant cover is either decreased through a general loss of perennials or is increased by invasion of unpalatable species.

Poor. Conspicuous losses of palatable perennials; plant cover is either decreased through a general loss of perennials or is increased by invasion of unpalatable species.

Very poor. Few palatable perennials remain; cover is either greatly reduced with a loss of the normal structural community and much bare ground arising from loss of stability desirables, or has become dominated by a proliferation of unpalatable species.[52]

Each land condition rating requires a different level of intervention by the land manager. As a result, pastoral lessees should survey their lease and identify the condition of the land prior to establishing a land management plan to ensure the rangeland condition is maintained or improved, as required. Identifying land condition across a pastoral lease will be aided by utilising the station map, which, as noted above, should include infrastructure, land systems and, as discussed here, data on land condition.

Good data on land condition is essential to undertaking land management activities. Acquiring that data requires knowing what good, fair, or poor land condition looks like. Below is a description of what to look for, with photo examples for reference.

Areas in good condition

Areas of good rangeland condition are characterised by high quality ground cover, structure, and composition of shrubs, perennial herbs and grasses. Such a site will also be mostly free of reduction in palatable species, while some of the less palatable or unpalatable species may have increased in number. Further, pasture in good condition will exhibit signs of recruitment of younger plants, demonstrating the health of the land system and its ability to retain moisture to assist in seed germination. Several companion species will also be evident.

[52] PLB, *Rangeland Management Compliance Policy and Procedures*: 9

This good condition land will be effective 'in trapping and retaining scarce resources', making it more able to retain or improve condition. Burnside et.al. observe that on soil in good condition, 'a fall of 15mm may be sufficient to start plant growth, but at least 30mm may be needed on degraded soil where water is poorly absorbed' and therefore less available to plants. The natural processes of shade creation and mulching from plant litter also allow for moisture to be preserved, thereby sustaining the existing condition and creating the conditions for further plant growth, even under the harshest of conditions.[53] Additionally, vegetation is the best and cheapest form of protection against erosion. Vegetation holds the soil together, slows the flow of water (enabling more infiltration of water into the soil), and reduces the impact of heavy rain on the soil, reducing the chances of erosion.[54]

[53] Burnside, et.al. *Reading the Rangeland*: 17

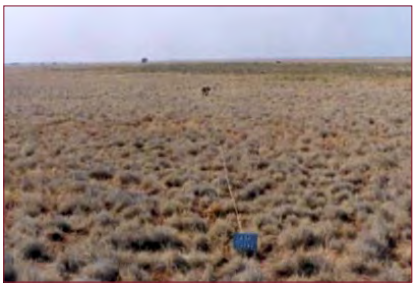
[54] C Stanton and D Waterson, *Introduction to Soil Erosion*, Edition 1 – January 2007. Alice Springs: Department of Natural Resources, Environment and the Arts, Northern Territory Government, 2007: 9

Figure 4: Photos of pastures in good condition from across WA's pastoral regions

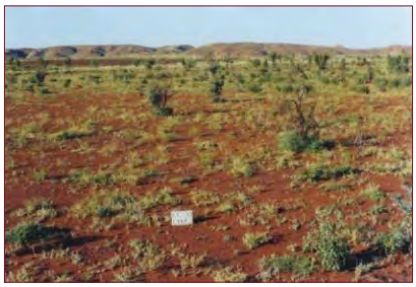
West Gascoyne – Claypan Grass Pasture in good condition

Northeast Goldfields – Broad Leaved Wanderrie Grass Pasture in good condition

Northeast Gascoyne – Woollybutt Pasture in good condition



Pilbara – Roebourne Plains Grass Pasture in good condition



Pilbara – Soft Spinifex Pasture (recently burnt) in good condition

Pilbara – Soft Spinifex Pasture (unburnt several years) in good condition)

Kimberley – Mitchell Grass Alluvial Plain Pasture in good condition

Kimberley – Blue Grass Alluvial Plain Pasture in good condition

Kimberley – Salt Water Couch Pasture in good condition

Sources:

Southern Rangelands – David Blood, Andrew Mitchell, Jane Bradley (ed), and Jim Addison. *Field Guide to Common Grasses of the Southern Rangelands*, Rangelands NRM, 2015

Pilbara – AL Payne and AA Mitchell, *Pasture Condition Guides for the Pilbara*, Miscellaneous Publication 19/2002, Perth: Department of Agriculture Western Australia, October 2002

Kimberley – K Ryan, E Tierney, P Novelly, and R McCartney, *Pasture Condition Guide for the Kimberley*, Bulletin 4846, Perth: Department of Agriculture and Food, October 2013

Problem areas

In areas where land condition is not rated good, a range of issues may be identified, and to varying degrees. The worst-case scenario is bare earth with signs of significant erosion and almost no palatable plants present in the landscape. Other potential scenarios vary between that extreme and a more moderate loss of palatable (desirable) perennials and an increase in unpalatable species. Additionally, the increased presence of annual grasses and herbs in place of perennials can demonstrate a loss of condition. However, as the photographs below demonstrate (particularly the Pilbara soft spinifex examples), pastures that are full of plant life may not appear to be degraded, but their pastoral potential has been significantly degraded by invasion of non-desirable plants.

These areas should be mapped carefully and ranked in order of degree of degradation, so as to inform planning for interventions to prevent further degradation and for rehabilitation purposes. These Guidelines provide a range of good land management techniques that can assist in preventing degradation and repairing degraded pastures. Additionally, a range of excellent pasture field guides (below) provide detailed information on pastures and pasture condition across the pastoral estate.

Indicator species

Using plants, particularly perennials to help read the condition of the land is important in assessing the stability and productivity of grazing resources. Changes in plant species composition, particularly the presence, increase or decline in density of species can reliably indicate changes in rangeland health and condition.

To assess the vegetation condition, plants are divided into four indicator value categories – **decreasers**, i**ncreasers**, **intermediates**, and **no indicator value**. By monitoring these species and vegetation changes, land managers are able to assess if their grazing management practices are maintaining or improving rangeland condition. Close monitoring of the increaser/decreaser balance can also be effective in assessing long term trends in pasture condition.[55]

A range of factors determine the relative indicator value of a particular species of plant. These include:

- palatability
- nutritional value
- ecosystem stability
- persistence
- dominance.[56]

The plants that first show the effects of grazing, and are most impacted by grazing, are the most attractive and sensitive – the desirables. Desirables are decreasers – i.e. their desirable nature means they are eaten first and, if over grazed, will decrease in health and density in a pasture. Conversely, less desirable, or undesirable, plants will tend to increase in abundance as grazing pressure impacts upon the desirable plants in a pasture.[57]

[55] Clunies-Ross and Mitchell, *Pasture Identification: A Field Guide for the Pilbara*: 6

[56] Blood, et. al. *Field Guide to Common Grasses of the Southern Rangelands*: 19

[57] Clunies-Ross and Mitchell, *Pasture Identification: A Field Guide for the Pilbara*: 6

Figure 5: Photos of pastures in poor condition from across WA's pastoral regions

West Gascoyne – Roebourne Plains Grass Pasture in poor condition

Northeast Goldfields – Woollybutt Pasture in poor condition

Central Gascoyne – Buck Wanderrie Pasture in poor condition

Pilbara – Roebourne Plains Grass Pasture in poor condition

Pilbara – Soft Spinifex Pasture in poor condition (Cockroach bush perennial increasers invaded after burn)

Pilbara – Soft Spinifex Pasture in poor condition (Poverty bush has taken over the pasture)

Kimberley – Mitchell Grass Alluvial Plain Pasture in poor condition

Kimberley – Blue Grass Alluvial Plain Pasture in poor condition

Kimberley – Saltwater Couch Pasture in poor condition

Sources:

Southern Rangelands – David Blood, Andrew Mitchell, Jane Bradley (ed), and Jim Addison. *Field Guide to Common Grasses of the Southern Rangelands*, Rangelands NRM, 2015

Pilbara – AL Payne and AA Mitchell, Pasture Condition Guides for the Pilbara, Miscellaneous Publication 19/2002, Perth: Department of Agriculture Western Australia, October 2002

Kimberley – K Ryan, E Tierney, P Novelly, and R McCartney, Pasture Condition Guide for the Kimberley, Bulletin 4846, Perth: Department of Agriculture and Food, October 2013

The table below summarises the different types of indicator species and their characteristics, with examples drawn from the Pilbara.

While the species may differ across the Rangelands, the principle remains the same. Desirable plants will decrease in abundance with grazing, and undesirable plants will increase as the desirable plants decline. This is the clearest way in which pasture health can be determined.

Table 6: Pasture Indicator Species and Characteristics

Indicator Group	Characteristics
Decreasers (desirables)	Decreaser species tend to decrease in health and abundance as grazing pressure increases. These are usually moderate to highly palatable preferred species also known as desirables. E.g. ribbon grass (*Chrysopogon Fallax*), barley Mitchell grass (*Astrebla pectinata*), weeping Mitchel grass (*Astrebla elymoides*), tall kangaroo grass (*Themeda sp.* Hamersley Station) and plume sorghum (*Sorghum plumosum*).
Increasers (undesirables)	Increaser species are generally avoided by stock and tend to increase in health and abundance as grazing pressure increases. These are generally unpalatable species known as undesirables. E.g. wiregrasses (*Aristida spp.*) and blood rush (*Senna artemisioides subsp. Oligophylla*).
Intermediates	Species which may initially increase under grazing, but being moderately or slightly palatable, later decrease under continued increasing grazing pressure (e.g. swamp grass (*Eriachne benthamii*)). The presence of absence of intermediate species should not be used with any confidence as an indicator of the 'health' of rangeland vegetation.
No indicator value (stability desirables)	Species which are largely unaffected by grazing and which usually only decrease in number after natural disturbance such as hail damage or fire (e.g. mulga (*Acacia aneura complex*), snakewood (*Acacia xiphophylla*)). These species are not palatable or only slightly palatable (or out of reach of browsing animals) and are known as 'stability desirables'. They confer stability on the landscape and contribute to important landscape functioning processes such as water retention and nutrient cycling. Annuals are also considered to have no indicator value due to their short-lived qualities.

Source: Mary-Anne Clunies-Ross and Andrew Mitchell, *Pasture Identification: A Field Guide for the Pilbara*, Perth: Greening Australia, 2014: 6

Pasture management

Rangeland condition is not limited to questions of how many plants are present on the ground, or whether there is evidence of erosion. As discussed below, monitoring land condition is a vital component of land management, and regular monitoring of volume, size, and number of plants is incredibly useful to land managers. However, without an understanding of the *types* of plants present, or whether those plants are palatable to livestock, such data is of little use.

Managing pastures requires an understanding of the pasture types that exist in a given area, how they respond to grazing, the seasons in which they grow, and what good pasture might look like.

Seasonal response is a key element in understanding a pasture. There are two different categories of perennial grasses – C3 and C4 – and each is identifiable based on their physiology and response to temperature. C3 grasses tend to grow in the cooler seasons and are more tolerant to frosts and can generate less dry matter (bulk) than C4 species. C4 perennial grasses tend to grow in the warm and hot seasons; although they produce a larger amount of bulk than C3 perennials, their feed value (protein and digestibility) may be lower than that for C3 grasses. Therefore, having a mix of C3 and C4 plants in a pasture can create good outcomes, providing fresh, growing feed at different times of year and across a range of different conditions.[58]

The other key to pasture management is understanding the palatability of plants in a given pasture. All plants possess chemical and physical traits that determine palatability. DPIRD defines palatability as 'the degree to which a grazing animal finds a plant attractive to eat; this can vary with the age of the plant or the type of soil it is growing on'.[59] The more palatable, the more desirable the plant is for livestock consumption. This means that, with grazing pressure, these plants tend to decrease, while less palatable plants increase. Discussion of decreaser and increaser plants is found in the Indicator Species section below.

Pasture types

Due to the vastness of the Western Australian pastoral estate, pasture types vary from region to region. Climatic conditions vary significantly between the Northern and Southern Rangelands, and even between sub-regions within these categories. Soil types, the timing of seasonal rainfall, and other factors all affect the different types of pasture present in the Rangelands.

Identifying a pasture type requires an understanding of three key things: a distinctive mix of plant species, soil type, and landscape position. For example, the Mitchell Grass Alluvial Plain Pasture type, found in the Kimberley, is a 'mixture of Mitchell grasses and other species occurring on black soil alluvial plains'.[60]

[58] David Blood, Andrew Mitchell, Jane Bradley (ed), and Jim Addison. *Field Guide to Common Grasses of the Southern Rangelands*, Perth: Rangelands NRM, 2015: 18

[59] DPIRD, 'Rangelands Glossary', DPIRD Website https://www.agric.wa.gov.au/rangelands/rangelands-glossary Accessed 3 September 2019

[60] K Ryan, E Tierney, P Novelly, and R McCartney, *Pasture Condition Guide for the Kimberley*, Bulletin 4846, Perth: Department of Agriculture and Food, October 2013: 1

Certain grasses, called identifier grasses, are important in identifying pasture types, as they are typically associated with (although not limited to) certain pasture types. Identifier grasses are so-called because they tend to be present regardless of the pasture condition. While they are easiest to find in good condition pastures, identifier grasses are usually still common when a pasture is in fair condition.
Ryan et. al. note that as the land condition worsens, 'you may have to look hard' for identifier species, as they are sometimes only present as 'a few scattered plants or butts'.[61] An important consideration is that an indicator species in one pasture type can (and often is) present as a component of another pasture type. For this reason, the identification of pasture type follows a defined sequence. That sequence is outlined below:

Soil type + Position in landscape + Idenitfier grass(es) = Pasture type

Working through a series of questions can help you determine the pasture type:

Soil Type

Colour:
red, brown, yellow, grey, black?

Texture:
sand, loam, clay?

Position in landscape

Does it most closely resemble a plain, a hill, or an upland?

Identifier grass(es)

Which grasses contribute to the species mix?

Pasture type

[61] Ryan, Tierney, Novelly, and McCartney, *Pasture Condition Guide for the Kimberley*: 8

The pasture name is given according to the identifier grass(es) and the position in the landscape. For example, Mitchell Grass Upland Pastures. For a more detailed discussion of pasture type identification, please see the Pasture Field Guides below.

In addition, the Gascoyne Catchment Group has developed an App for iPhones and iPads (it works best on iPads) that assists in identifying and monitoring pastures for the Gascoyne region. A Pilbara version was also launched in 2019. For more information on the App and its operation, contact the Gascoyne Catchment Group. Contact information is on their website: https://gascoynecatchments.com.au/projects/#tool

Pasture field guides for the Western Australian Rangelands

Each region of the WA Rangelands has a different climate, soil conditions, rainfall pattern, and land systems. Because of this diversity, pastures also differ significantly across the Rangelands. Therefore, pastoral lessees require information specific to their regions and land systems to understand the productivity and condition of the pastures on their leases. There are a number of guides to the pasture types of the various regions of the WA pastoral estate. They are:

Northern Rangelands:

- K Ryan, E Tierney, P Novelly, and R McCartney, *Pasture Condition Guide for the Kimberley, Bulletin 4846*, Perth: Department of Agriculture and Food, October 2013 https://www.agric.wa.gov.au/rangelands/pasture-condition-guide-kimberley
- Mary-Anne Clunies-Ross and Andrew Mitchell, *Pasture Identification: A Field Guide for the Pilbara*, Perth: Greening Australia, 2014 https://rangelandswa.com.au/wp-content/uploads/2017/04/PastureIDGuide_Pilbara_web.pdf
- AL Payne and AA Mitchell, *Pasture Condition Guides for the Pilbara, Miscellaneous Publication 19/2002*, Perth: Department of Agriculture Western Australia, October 2002 https://researchlibrary.agric.wa.gov.au/misc_pbns/7/

Southern Rangelands:

- Don Burnside, Alec Holm, Alan Payne and Georgina Wilson, *Reading the Rangeland: A Guide to the Arid Shrublands of Western Australia*, South Perth: Department of Agriculture, 1995 https://researchlibrary.agric.wa.gov.au/pubns/2/_
- David Blood, Andrew Mitchell, Jane Bradley (ed), and Jim Addison. *Field Guide to Common Grasses of the Southern Rangelands*, Perth: Rangelands NRM, 2015 https://rangelandswa.com.au/wp-content/uploads/2017/04/Rangelands-Southern-Grass-Guide-Sep15-WEB.pdf
- A Fox and TR Eckersley, *Pasture Condition Guide for the Murchison River Catchment*, Perth: Department of Agriculture and Food, 1991 https://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1018&context=lr_scsc

Detailed pasture condition guides are available for most pastoral regions. Some are region or catchment specific, while others, such as *Reading the Rangeland*, cover a very broad swathe of territory, from Exmouth to Meekatharra, to Leonora and Kalgoorlie, and all points in-between.

Pastoral condition reports – Commissioner for Soil and Land Conservation

The Commissioner for Soil and Land Conservation (Commissioner) holds certain statutory responsibilities in respect of pastoral land, as outlined in the introduction. One responsibility is to provide the PLB with annual reports on the 'current condition of land under pastoral leases in the State'.[62] These reports provide an assessment of rangeland condition, which 'is determined with regard to the presence of perennial pasture species that are productive and highly palatable to livestock, and soil condition'.[63]

The Commissioner generates the land condition reports, with the assistance of DPIRD officers, utilising the Western Australian Rangeland Monitoring System (WARMS), which provides landscape-scale monitoring of land condition and trend.[64] WARMS is a valuable tool for Government and pastoralists in understanding the general trends across the pastoral regions.

However, as it is at landscape-scale, not lease-level, pastoral lessees cannot rely on WARMS data to inform their land management decisions.

WARMS data are collected every three years on grassland sites (Kimberley and Pilbara), while data from shrubland sites are collected every six years (previously, such data was collected every five years, but was changed to align better with grassland monitoring).[65] The frequency with which DPIRD collects data is appropriate for landscape-scale trend assessments. However, this needs to be balanced with more regular data to prove up trends and show more localised changes.

Therefore, the Commissioner also utilises remote sensing via the use of Moderate Resolution Imaging Spectoradiometer (MODIS) satellite imagery. MODIS data employed by the Commissioner includes fractional vegetation cover data, which are analysed to determine trends in vegetation cover, and Normalised Difference Vegetation Index (NDVI) data, which are used to assess seasonal greenness during each growing season 'to provide an indication of seasonal quality (in terms of timeliness and amount of rainfall) and the ability of the pasture to intercept and use the rainfall'. The combined vegetation cover trend and response to seasons (seasonal quality) information is used by the Commissioner to identify areas where rangeland condition is at risk of decline.[66]

[62] *Land Administration Act 1997*, Section 137(2)

[63] AN Watson and PWE Thomas, *Condition and Trend of the Western Australian Pastoral Resource Base 2017*, Perth: Department of Primary Industries and Regional Development, 2018: 1

[64] Department of Primary Industries and Regional Development, 'Monitoring Rangeland Condition', https://www.agric.wa.gov.au/rangelands/assessing-rangeland-condition Accessed 25 January 2019

[65] Ibid

[66] AN Watson and PWE Thomas, *Condition and Trend of the Western Australian Pastoral Resource Base 2017*, Perth: Department of Primary Industries and Regional Development, 2018: 3

This data is analysed on an annual timescale, which adds detail and depth to the three-to-six year WARMS data to help identify season-driven and management-driven changes to land condition.
This information provides vital intelligence for the PLB and for lessees who are actively managing their land. For the PLB, it identifies areas in which lessees may be in difficulty due, for example. to a series of poor seasons, while, for the pastoral lessee, it can provide a sense of how their lease management and land condition measures up to regional-level data.
This data can then be used by Government to engage with pastoral lessees and develop potential land management solutions in a collaborative fashion.

For more information on pastoral condition and trends, the DPIRD website provides a wide range of information. The reports by the Commissioner of Soil and Land Conservation can be found at:

https://www.agric.wa.gov.au/rangelands/pastoral-condition-and-trends-reports-commissioner-soil-and-land-conservation.

Pastoral monitoring at the lease level

While remote sensing is very useful in determining overall landscape condition trend, on-ground assessments, 'are still the most reliable spatial dataset for condition' at the lease level.[67] Until 2009, DPIRD undertook regular traverse assessments of pastoral land, which involved travelling across the landscape and undertaking assessments at specific points on each pastoral lease, In the absence of these traverse assessments, it may be necessary for pastoral lessees to undertake their own on-ground assessments and monitoring of land condition.

For the pastoralist wanting to know whether the land management action that was established in the previous dry season is having the desired effect or, in order to ensure that land is not being degraded in general, frequent lease-level monitoring data collection may be more appropriate. Because changes in land condition are subtle and occur over time, managers need 'a process to inform themselves of these subtle changes in order to ensure their management does not result in loss of landscape health', and in order to respond to negative changes quickly, to 'avoid lasting loss of plant and landscape health'.[68]

Given change in the Rangelands is gradual, 'imperceptible and normally occurs in time scales well beyond our ability to process',[69] determining rangeland condition trend

[65] Watson and Thomas, *Condition and Trend of the Western Australian Pastoral Resource Base 2017*: 3

[66] Blood, et.al. *Field Guide to Common Grasses of the Southern Rangelands*: 13

[69] David Blood, Andrew Mitchell, Jane Bradley (ed), and Jim Addison. *Field Guide to Common Grasses of the Southern Rangelands*, Perth: Rangelands NRM, 2015: 13

requires good, reliable data. Good data on rangeland condition must be consistent, collection methods repeatable (and frequently repeated), and data must be collected in the same place and at the same time of year (seasonal variance is then taken out of the equation).

Best-practice land condition and trend monitoring requires regular lease-scale monitoring with both ground and aerial monitoring. Such an approach is utilised in the Northern Territory, Queensland, and other jurisdictions. In the Northern Territory, this combination of methodology is referred to as a two-tier system, where Tier 1 is ground monitoring and Tier 2 is aerial or satellite monitoring.[70]

Ground monitoring

Ground monitoring can be as simple or as complicated as business needs dictate. The simplest and cheapest form of monitoring is comparison of two photographs taken at different times. Photographs of country taken in this way are a 'powerful means of conveying change information between times',[71] showing shifts in volume and size of vegetation, as well as any signs of erosion.

In the Northern Territory, Tier 1 of their monitoring approach is ground-based monitoring. Tier 1 uses photos and visual assessment of photo-point sites to assess pastoral land condition and changes over time. Pastoralists are encouraged to use the photo-point sites to become more aware of pasture plants and the level of pasture used by stock.[72] Discussion below, in respect of pasture management and identification of pasture types, is consistent with this approach. While Tier 1 sites are visited every three years (with an average of 10 sites per property), pastoralists are encouraged to revisit their property's sites every twelve months or after a significant climatic event, such as rain, drought, or fire, to re-photograph the sites and complete site data sheets. Some pastoralists are photographing their Tier 1 sites every six months.[73]

This concept, including encouraging pastoralists to identify the plants at each monitoring site, is also found in the Gascoyne Catchments Group app, discussed above. The App requires photographs taken at each site, and then they are uploaded, to be used as both a plant identification and land condition monitoring tool. The app is programmed to include the Gascoyne and the Pilbara. For more information on the App and its operation, contact the Gascoyne Catchment Group. Contact information is on their website: https://gascoynecatchments.com.au/projects/#tool.

[70] DENR (NT), 'About Rangelands Monitoring' https://denr.nt.gov.au/land-resource-management/rangelands/information-requests/about-rangelands-monitoring accessed 26 February 2019

[71] Blood, et.al. *Field Guide to Common Grasses of the Southern Rangelands*: 13

[72] DENR (NT), 'About Rangelands Monitoring' https://denr.nt.gov.au/land-resource-management/rangelands/information-requests/about-rangelands-monitoring accessed 26 February 2019

[73] Ibid.

Aerial monitoring (by aeroplane/ helicopter/drone or remote satellite)

Aerial monitoring can have two uses. First, use of an aeroplane, helicopter, or drone may be beneficial when analysing the types of land condition issues extant on a pastoral lease. Ken Tinley and Hugh Pringle, who developed the Ecosystem Management Understanding (EMU) method for repairing degraded land systems, demonstrate the advantages of the aerial view when planning interventions in a degraded landscape.[74] Tinley and Pringle explain the advantage of the aerial view thus:

> From the ground or vehicle the view of heavily grazed land involves a trick of foreshortened perspective, making remnant strips and patches of plant cover appear denser or in better condition than they really are. Even gullied areas don't look as threatening when viewed from ground level as their dimensions and extent are mostly out of sight. Seen from the ground it is thus easy to believe that 'all the country needs is some rain and she'll be right!' Only the aerial view exposes the dimensions, linkages and extent of erosion – and this is of first importance in order to identify any potential threats to the best stock country.[75]

The key benefit of the aerial view is in the process of assessing the condition of the land under the lease and then using the information amassed to identify priority areas. The power of seeing the problems in the broader context of the land systems extant on the lease by air is significant, and can lead to better land management outcomes.

Second, aerial monitoring can be undertaken via satellite. Again, this can have two uses. First, as with flying over the land in a helicopter or aeroplane, satellite may be used to assess land condition for the purposes of land management priority setting and analysis. Second, satellite monitoring can be used to identify land condition and trend in land condition over time, as either a land management or compliance tool.

In the first instance, as Tim Wiley has demonstrated, even widely accessible satellite imagery tools, such as Google Earth, can provide insights into land condition and land management in the rangelands.[76] Wiley employs a catchment function analysis approach to looking at land management issues in the De Grey River Catchment in the Pilbara region of Western Australia. He argues, following Pringle and Tinley,[77] that catchments are functioning systems that regulate water flow and therefore plant and animal life in a region. They include features such as the 'underlying geology, soil types, hills and valleys, rivers, flood plains, plants, animals and people'.

[74] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 2: Manual*. Perth: Rangelands NRM, 2013: 30

[75] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*. Perth: Rangelands NRM, 2013: 10

[76] Tim Wiley, 'Catchment Function Analysis using Google Earth Mapping', *Australasian Agribusiness Perspectives,* Volume 20, paper 1 (2017): 1-330

[77] HJR Pringle and KL Tinley, 'Are we overlooking critical geomorphic determinants of landscape change in Australian rangelands?', *Ecological Management & Restoration*, 4(3), 2003: 180–186

Wiley continues,

> By analysing the landscape / catchment as a functioning system it can become evident where the critical points in the landscape are. At these critical points, relatively small interventions can have an impact over much larger areas. Addressing these areas ensures the greatest 'bang for your buck'.
>
> Identifying and focussing on the critical points in the landscape is particularly important in the rangelands due to the vast scale of pastoral properties. It is easy to become overwhelmed by the scale of what is required on these stations. But by understanding how a station's landscape functions it is possible to strategically target the critical areas with management intervention.[78]

Intervention in these critical areas can then provide an efficient and cost-effective method of regenerative land management.

In the second instance, detailed satellite imagery can provide data to support the assessment of the condition and health of the Rangelands both at a moment in time and over time. Such a tool could be of use to both land managers and government, allowing efficient pinpointing of change in the rangelands and enabling more productive remedial responses to address any decline. Satellite imagery has the potential to identify the extent, timing and location of changes in vegetation cover, providing significant benefit to investors, government, and especially pastoralists and the land management decisions that they make.

In Tier 2 of the Northern Territory's two-tier monitoring system, the methodology calls for both satellite imagery and aerial photography to monitor changes in land condition over time. Permanent field sites are established to provide ground-based data that is used to verify information derived from interpretation of the remote sensing data.[79]

The Queensland Department of Agriculture and Fisheries has established a system called FORAGE, which combines a large amount of data ranging from climate data, tree cover information, seasonal outlook data, ground cover index data, satellite imagery, and modelled pasture growth to produce tailored reports for individual properties. In doing so, FORAGE is able to provide up-to-date information on seasons and the potential feed for an individual property, so as to enable the landholder to plan in advance for the conditions. The system can also provide historical data that enables a land manager to monitor land condition trend and management approaches over time.[80]

Future Beef provides analysis of a list of tools that can assist the land manager in planning for land management activities. It looks at four key tools, namely FORAGE, VegMachine, NRM Spatial Hub, and Stocktake Plus, highlighting each tool's strengths. A link to this analysis is contained below, as well as links to more information on the three tools analysed by Future Beef, but not discussed above.

[78] Ibid.: 2

[79] DENR (NT), 'About Rangelands Monitoring' https://denr.nt.gov.au/land-resource-management/rangelands/information-requests/about-rangelands-monitoring accessed 26 February 2019

[80] Department of Agriculture and Fisheries (Qld), 'About FORAGE' https://www.longpaddock.qld.gov.au/forage/about/ Accessed 5 September 2019

Good practice monitoring of land condition

Monitoring systems like the Northern Territory Tier 2 program and Queensland's FORAGE System represent examples of best practice in gauging condition and trend on pastoral land condition. For more information on these approaches, see below:

- Department of Environment and Natural Resources (NT), 'About Rangelands Monitoring' https://denr.nt.gov.au/land-resource-management/rangelands/information-requests/about-rangelands-monitoring
- Department of Agriculture and Fisheries (Qld), 'About FORAGE' https://www.longpaddock.qld.gov.au/forage/about/
- Future Beef, 'Grazing land management decision support tool checklist', Future Beef Website https://futurebeef.com.au/knowledge-centre/grazing-land-management-decision-support-tool-checklist/
- VegMachine https://vegmachine.net/help.html
- NRM Spatial Hub – now known as FarmMap4D Spatial Hub. https://www.farmmap4d.com.au/about-us/
- Stocktake Plus - http://www.stocktakeplus.com.au/about-stocktake-plus/

Priority setting

Once a map of land systems, existing infrastructure, and pastures, including areas of good, fair and poor condition, has been developed, the next step is to determine which land management activities need to be done to achieve their desired outcomes. The types of questions lessees should ask at this point in the planning process include:

- Do I need new infrastructure?
- Is there infrastructure that needs repair or replacement?
- What type of grazing regime should I implement in order to utilise the land systems and pastures to their best advantage?
- How should I manage grazing pressure in order to retain the required land condition?
- How many head of cattle or sheep should I run in order to achieve my objectives?
- Are there any areas of the land under the lease that require remediation?
- What are my priorities?

Armed with these questions, the station map will inform priority setting, which, in turn, can establish a work plan for infrastructure development, increased productivity, conservation, and remediation, depending on the business's goals and the land condition identified in a given area.

For this reason, it may be of benefit for the land manager to undertake an Ecosystem Management Understanding (EMU) or Ecologically Sustainable Rangeland Management (ESRM) planning process.

EMU is a land system-based approach to developing an understanding of landscape processes and how they interrelate with land management. The primary purpose of EMU is to 'introduce managers and planners to recognising natural patterns and processes and learning to work with them toward the health and recovery of landscapes and habitats'. They key features of the EMU approach include the following:

- EMU is a practical approach to ecological land management building on the land-user's own knowledge of the land.
- Drainage catchment units and sub-units are used as the functional geo-ecological basis to understanding and managing land.
- Salient Factor Analysis of information derived from map overlays done on site.
- Air reconnaissance (flying over the landscape to gain a comprehensive view of the landscape patterns, relationships, dimensions, and linkages that enable the land manager to read the land and identify key areas to be managed or repaired.
- The combination of area relevant mapped information and aerial and ground traverses engenders a top-down perspective and analysis interactive with bottom-up ground verification and management action.
- The EMU exercise is a simple yet profound way for developing competence in land literacy and to work with the natural processes entraining them to do most of the healing and recovery work.
- Changes in landscape function are monitored by means of date recorded map overlay notes, a tick-box record, and fixed point photos.
- Harvesting and spreading rainwater is used as a primary basis to landscape recovery.
- Strategies for the rotation and control of numbers of stock or wildlife are recommended where necessary.
- A core objective of EMU is biodiversity conservation as the variety and condition of the native flora and fauna is the ultimate basis to the viability of any land use or enterprise based on natural landscapes.[81]

Ken Tinley and Hugh Pringle observe that, with climate change modelling predicting increased cyclone activity and therefore rainfall in the Northern Rangelands and decreased rain activity in the Southern Rangelands, the importance of managing the land in concert with the natural processes of a given region increases. They argue that by fitting 'management closely to the existing climatic regime, and keeping track of the weather patterns through Weather Bureau predictions, it is possible to work with the changes to be prepared for whatever eventuates'. Tinley and Pringle refer to this as 'a strategy combining anticipatory and adaptive management'.[82]

[81] Ken Tinley and Hugh Pringle, 'About EMU', http://www.emulandrecovery.org.au/About-EMU Accessed 29 May 2019

[82] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*. Perth: Rangelands NRM, 2013: 20

[82] Hugh Pringle and Ken Tinley, 'Ecological Sustainability for Pastoral Management', *Journal of the Department of Agriculture, Western Australia, Series 4*: Volume 42(1), Article 8: 32

Another station management planning approach is ESRM planning. ESRM Planning takes a whole-of-property approach that seeks to strike the right balance between maintaining the rangeland natural resource base and achieving the business goals of the pastoral land manager. An ESRM plan is flexible, depending on the needs or interests of the property, and can include:

- land systems and condition (geology, soils and vegetation)
- climate (rainfall and growing season)
- livestock enterprises
- other enterprises
- grazing management
- land rehabilitation
- landscape function (including drainage systems)
- biodiversity
- infrastructure (fencing, water, stock handling)
- weed management
- fire management
- feral herbivore and predator status and management
- monitoring and reporting systems.[83]

When undertaking this process of mapping and prioritisation, independent experts can sometimes assist lessees to determine the best approach. Pastoralists should ensure that when they are seeking external help, that person or organisation will not write the plan for the lessee, but rather write it with the lessee, so that the lessee has control of the process of determining priorities. If the land manager does not own the priorities, there is less likelihood that those priorities will be implemented.

For more information about EMU and ESRM, see:

- EMU (Ecosystem Management Understanding). For more information, see http://www.emulandrecovery.org.au/home
- EMU Plans – Rangelands NRM helps pastoral lessees to develop EMU plans. For more information, see https://rangelandswa.com.au/?s=EMU
- ESRM Plans (Ecologically Sustainable Rangelands Management) – Rangelands NRM helps pastoral lessees develop ESRM plans. For more information, see https://rangelandswa.com.au/projects/esrm-rehydration/

Meat and Livestock Australia has a wide range of business planning tools for pastoral businesses available on their website:

- MLA direction setting tools: https://mbfp-pastoral.mla.com.au/setting-directions/tools/

See Chapter 7 for a more detailed discussion of rehabilitation and regeneration of degraded landscapes.

[83] Rangelands NRM, 'ESRMs and Rehydration', published 24 January 2017, https://rangelandswa.com.au/projects/esrm-rehydration/ Accessed 29 May 2019

Good Pastoral Land Management
Guidelines

4 Infrastructure

Contents

Infrastructure development and maintenance is a vital part of good pastoral land management. Good infrastructure can be the difference between a successful pastoral business and one that is struggling due to erosion, thirsty animals, or uncontrolled grazing pressure.

This chapter provides tips and examples of good and bad infrastructure placement and maintenance, to assist lessees to:

- Get things right in the first instance – it's always better to take the time to construct the infrastructure in the correct manner than to have to fix it when it's gone wrong (it is also cheaper).
- Recognise issues before they become significant problems – early intervention can save a lot of time, money and effort.
- Fix things when they have gone wrong. There is no silver bullet and the magnitude of the problem will determine the effort required to fix it.

Purpose of infrastructure

Infrastructure development and maintenance should provide:

- regular and reliable stock access to good clean water
- options for managing grazing pressure
- efficiency of movement and mustering of stock
- appropriate protection of sensitive landscapes (e.g. riparian areas)
- access to all points on the lease for effective management
- natural flow of water across the landscape.

Well-placed water points that are maintained in good working order are essential, both to ensuring stock have access to good clean water, and to manage grazing pressure. Careful road and track development provides access to all points on the lease for a range of management activities, while also ensuring the natural flow of water across the landscape is not interrupted. Sensible fence placement and management ensures that stock have enough land within a paddock in which to roam and graze without placing undue pressure on pastures, while also enabling management of pastures via rotation and other techniques. Further, well-constructed fence lines will enable water to flow naturally across the land.

Infrastructure plans

Infrastructure plans are an essential element of good business planning, as well as good land management. Having a clear plan for the land under the lease should always include a map of the existing infrastructure and, where appropriate, ways to improve (and locations for such improvements) that infrastructure. Infrastructure plans should include:

- water point placement and management, including:
  - natural water points
  - artificial water points (current and proposed)

- road and track development and management (current and proposed)
- fencing placement and management (current and proposed)
- raceways / laneways (current and/or proposed)
- location of sheds and yards (current and proposed)
- names or numbers of paddocks
- location of the house.[84]

However, this chapter will not address the locations of current infrastructure. For example, most stations will have a homestead, which is unlikely to be moved. However, fencing alignment and water point location may change according to good land management principles or the needs of the business. Therefore, this chapter will discuss water points, roads and tracks, fences, laneways, and yard placement.

Water point placement and management

The goal for every pastoral station is to have artificial water points that are able to provide sufficient water in quality and quantity to maintain herd health, even in dry seasons. Indeed, reliable access to good water is vital for stock productivity and ecosystem function.[85] Further, some pastoral leases are located within Public Drinking Water Source Areas, with three surface Catchment Areas and twenty-five Water Reserves gazetted within the Rangelands under the *Country Areas Water Supply Act 1947* (CAWS Act), meaning land managers must comply with all statutory requirements under the CAWS Act and Drinking Water Source Protection Plans and Assessments.[86]

The importance of good water point placement and management has been illustrated in recent times by cases in which cattle have been found dying or dead due to dehydration on pastoral stations in the northern rangelands.[87] This demonstrates a need to ensure proper management and maintenance of artificial waters at all times, but especially during dry seasons, as well as ensuring equipment, such as pumps, are fit for purpose and reliable.

This section will discuss:

- natural water points, such as rivers, streams, water holes, and springs
- artificial water points, including bores and dams
- use of technology to actively assist in the management of waters.

[84] Department of Environment, Water and Natural Resources, *A Practical Guide to Rural Land Management: Course Booklet*, third edition. Adelaide: Government of South Australia, 2016: 5 with some modifications and additions

[85] Department of Water Western Australia, *Pastoral activities within rangelands*. Water Quality Protection Note, *WQPN35*, November 2006: 1

[86] Ibid.: 1-4; and the map showing location of Drinking Water Source Protection Areas on page 9 of *WQPN35*

[87] Calla Wahlquist, 'Two WA Cattle Stations Could Face Animal Cruelty Charges after Hundreds of Deaths', *The Guardian*, Australian Edition, 30 January 2019 https://www.theguardian.com/world/2019/jan/30/two-wa-cattle-stations-could-face-animal-cruelty-charges-after-hundreds-of-deaths Accessed on 30 January 2019; Zach Relph and Cally Dupe, 'Second Animal Welfare Issue Emerging in WA's North', *Countryman*, 29 January 2019 https://thewest.com.au/countryman/news/second-animal-welfare-issue-emerging-in-was-north-ng-b881087872z Accessed 30 January 2019; AAP, 'Hundreds of Cattle Die from Dehydration in Kimberley', *The West Australian*, 3 January 2019 https://thewest.com.au/business/agriculture/hundreds-of-cattle-die-from-dehydration-in-kimberley-ng-b881064529z Accessed 30 January 2019

This section provides information to assist land managers to ensure their animals have good access to clean water at the lowest possible economic and environmental cost.

Natural water points

Natural water points include rivers, streams, waterholes and springs. These waters are vital to any pastoral enterprise, but are also frequently vulnerable to damage from stock. This damage can be in the form of overgrazing around the waters, cattle pads creating nick points for erosion to start, or animals fouling the water with faeces and urine. Therefore, the management of natural waters is essential, both for the success of a pastoral enterprise and ecological function.

Benefits of using natural water points

- **Cheapest source of water for pastoral enterprises.** Natural surface water points, whether perennial or seasonal, have no establishment costs.
- **Permits to take natural surface water are not required**, provided works are not required to enable the taking of that water.

Limitations of livestock access to natural waters

- Overgrazing of riparian vegetation. In the Kimberley, during the late dry season and the build-up when cattle water needs are highest, most natural waters will have dried up (other than permanent water bodies). Cattle concentrate in small areas, resulting in overgrazing around the water, destruction of riparian habitats and erosion.[88] Over-utilisation of these water sources has led to the 'acute degradation of the most valuable landscapes' in the pastoral estate.[89]
- Fouling water and silting waterholes. Continuous cattle numbers at waterholes foul the water and silt up waterholes, making them unsuitable for watering stock.
- Attracting predators. Presence of natural predators such as saltwater crocodiles.
- Riverbanks become infested with weeds, cattle spread weeds to other areas.[90]

As can be seen by these examples, proper management is required when relying upon natural surface water.

[88] T. Sinclair and F. Bright, *Pastoral stock water workbook.* Perth: Department of Agriculture and Food, Western Australia, 2005: 5

[89] Tinley and Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 30

[90] Sinclair and Bright, *Pastoral stock water workbook*: 5

Managing the riparian zone

Caution must be exercised when using natural water sources and the riparian zone needs to be managed with care. Manage the riparian zone to improve and protect water quality by:

- Preventing direct stock access to watercourses
- Filtering nutrients from surface run-off
- Slowing down flows, which reduces erosion
- Controlling soil erosion and salinity
- Shading the watercourse, which reduces the water temperature and prevents algae blooms.[91]

Further, well-managed riparian zones provide habitat and food for wildlife and improves biodiversity. They also serve as vital habitat corridors, allowing the movement of flora and fauna between remnant vegetation zones as well as being diverse habitat areas in their own right, supporting abundant communities.[92]

There are two main management strategies that can protect riparian zones and reduce the negative impacts of stock access to rivers and streams:

- Limited access points.
- Complete restriction of access.

Limited access points

Pastoral land managers could limit the number of points at which stock can access the river, which in turn would reduce damage to the riverbank as well as the amount of urine and faeces deposited in the stream. The benefits, design considerations, location, and limitations of this approach are outlined below:

Benefits

- One of the cheapest and simplest methods of supplying water to stock.
- If constructed properly, access points require very little maintenance.

Design

- Access points are made by putting a break in the riparian zone fencing and running two fences out into the water to the low water mark and fencing off the end to prevent the stock wading further into the stream.

Construction

- An access point is a bank shaped to form a slope of 1:6 (10 degrees). The ramp surface should consist of compacted soil or gravel, or be covered with flat stone or concrete to minimise damage to the bank and water's edge, while providing a sure footing for the stock. If not practical, the access point can simply be the natural point bar that forms in the bend. The width of the access point can vary from 2-20 metres and will depend on the number of sites available and stock requiring water.
- A lack of shelter will prevent the stock from lingering.

[91] Department of Environment, Water and Natural Resources, *A Practical Guide to Rural Land Management: Course Booklet*, third edition. Adelaide: Government of South Australia, 2016: 43

[92] Ibid.: 43

- Locating the access point on the inside of a bend where water movement is slowest will reduce the risk of scour and erosion.
- Angle the access ramp away from the direction of flow.
- Commencement of the ramp should be at least one metre back from the top of the bank.

Limitations

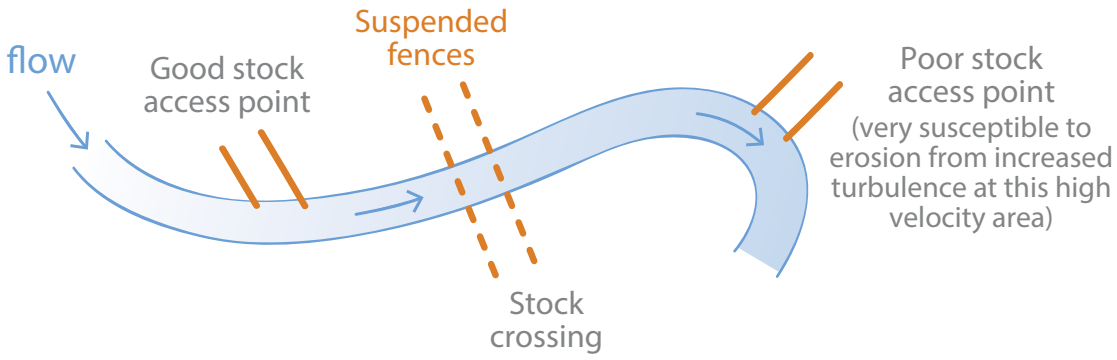
- Limited access points do not completely prevent manure or nutrients from entering the stream.
- Serious erosion can occur at the ramp and further downstream if care is not taken with the location, construction and maintenance of the access ramp.[93]

Maintenance of the access point

- Regular inspections are essential to ensure erosion and other problems do not arise.
- Maintain fencing around riparian zone and access area to contain livestock.
- Additional rock and gravel may be required from time to time, to maintain the access area surface and prevent animals from getting bogged.

This approach is one possible way of reducing damage to the riparian area around a river or other permanent water source, while still ensuring stock have ready access to water.

Figure 6: Stock control, including stock access points, in the riparian zone



Note the angle of entry for the good stock access point, as explained in the Construction section above.

Source: Adapted from Michael Askey-Doran, 'G. Managing Stock in the Riparian Zone', in Siwan Lovett and Phil Price (eds.) *Riparian Land Management Technical Guidelines, Volume 2: On-Ground Management Tools and Techniques*. Canberra: Land and Water Resources Research and Development Corporation, 1999: 114

[93] Water and Rivers Commission Western Australia, *Livestock management: Watering points and pumps*. Water notes for rivers management. WN7, January 2000: 2

Complete restriction of access

This option involves pumping water out of the river to a tank and trough system. This option still takes advantage of the natural surface water, while preventing stock from accessing the river and thereby reducing the likelihood of environmental damage and other risks associated with stock accessing riparian zones, identified above.[94] In this scenario, stock access to the river is prevented by fencing.

Benefits

- Environmental values of the riparian zone are protected.
- Cheap and readily accessible water is available for stock.

Design

- Guidelines for fencing riparian areas will be provided in the fences section of this chapter.
- Discussion of pumping water to a tank and trough is found below, in association with artificial waters, as the concepts are the same.

Limitations

- Pumping of water may reduce environmental flows in a river or stream.
- Fencing a full river bank may prove impractical at the scale required for a pastoral lease.

Maintenance of the fencing and pump

- See the relevant sections for fences and pumps below.

Artificial water points

Artificial water points, such as dams, weirs, bores, and wells, are a vital element of good pastoral land management. Given the semi-arid environments that predominate in the pastoral estate of Western Australia, and the infrequent and often unpredictable rainfall, land managers need regular and reliable sources of clean water for their livestock, and artificial waters provide much of that water. Access to clean water is essential to livestock productivity.

The strategic placement of artificial waters is also essential to help manage rangeland condition. Properly located water points will spread grazing more evenly and reduce selective grazing, while inadequate distribution of water points can cause localised land degradation close to waters, while valuable pastures at greater distances from the watering points remain ungrazed.[95] Key considerations regarding the placement of artificial water points include:

- Water points should not be located in fragile areas.
- Water point placement decisions should take into account the influence of water quality and degree of preference for particular vegetation types.

[94] Department of Water Western Australia, *Pastoral activities within rangelands*. Water Quality Protection Note, *WQPN35*, November 2006: 4

[95] Department of Agriculture and Food, *The grazing of cattle in the southern pastoral areas of Western Australia*. Land Resources Best Practice Series (4), 2006: 1

- Water points should be distributed no more than ten kilometres apart and away from fence lines.
- The grazing range from a water point for cattle rarely exceeds five kilometres, creating an average grazing area of approximately 78 square kilometres.[96]

While the maximum distance between artificial water points is listed above as ten kilometres, many pastoral lessees are placing waters much closer together. Many stations have waters spaced at between five and six kilometres apart, while others, particularly in the Kimberley, are placing waters two kilometres apart.[97] The Queensland Department of Environment and Resource Management argues that, while livestock can walk up to ten kilometres for water, uneven grazing can be evident even where water points are spaced four to six kilometres apart.[98]

In this section, dams and bore holes, the most common artificial waters in the pastoral estate, are the main focus.

Regulation of water extraction

When seeking to build a dam to harvest water from a watercourse, or build a bore to extract water from an artesian source, it is likely a permit or licence will be required under the *Rights in Water and Irrigation Act 1914* (RIWI Act). Applications must be made to the Department of Water and Environmental Regulation (DWER). Where a pastoral lessee wishes to build a dam in the Goldfields or the Murchison regions (outside the Gascoyne River and Tributaries), the lessee may not require a permit or licence in certain circumstances.

If you are considering building a dam, please contact DWER and discuss your proposal with them, as you may need a licence or permit to undertake the construction work in the watercourse.

Regulations for dams

The RIWI Act, administered by DWER, governs the establishment of dams on pastoral land. Section 5B(1)(a)(iii) and (iv) of the RIWI Act provides that a pastoral lessee may make a dam or tank on the land (subject to local by-laws), provided that

> if as a result of doing so —
>
> (iii) the flow of water in a watercourse, or the amount of water in a wetland, is not diminished; or
>
> (iv) there is no significant adverse effect on the quality of water, or any ecosystem, in a watercourse, or a wetland.

[96] Ibid

[97] See: Rob Edwards, '20190315 File Note Fact Finding Field Trip 1 – Gascoyne-Murchison-Pilbara – Good Pastoral Land Management Guidelines 11-15 March 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019; and Rob Edwards, '20190412 File Note Fact Finding Field Trip 2 – Kimberley – Good Pastoral Land Management Guidelines 8-11 April 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019

[98] Department of Environment and Resource Management, *Managing grazing lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 13

Further, a lessee is allowed to build a dam or tank on the land, not on a watercourse or wetland, for watering cattle or other stock, provided that dam is not for watering stock being raised under intensive conditions (i.e. a feedlot).

However, under section 11(1)(a) of the RIWI Act, a pastoral lessee cannot build a dam or

> do anything, or install any works or object, that causes obstruction of or interference to a watercourse or wetland or its bed or banks, unless the person holds a permit granted by the Minister authorising the person to do so. (emphasis added)

Regulation for bores

A licence under the RIWI Act is required if the proposed bore will tap an aquifer. However, should the bore be for a non-artesian aquifer, you may be exempt from applying for a licence The RIWI Act specifies, in section 26A, that the construction or alteration of an artesian well (bore) without a licence is an offence. Section 26B of the RIWI Act provides that the construction or alteration of a non-artesian well (well) without a licence is an offence, if the well is to be constructed in a proclaimed area, subject to certain exemptions. Those exemptions include:

1. The development is within the water table (non-artesian) aquifer; and
2. Water is only used for domestic purposes such as:
    - domestic and ordinary use
    - watering an area of lawn or garden less than 0.2 ha
    - fire fighting
    - watering cattle or other stock not raised under intensive conditions as defined in section 21(4) of the *Rights in Water and irrigation Act 1914*.

Note: A licence will be required if the property requires more than 1500 kL/year from the groundwater resource in a proclaimed area.[99]

- **The entire pastoral estate of Western Australia falls within a proclaimed area,**[100] which means that land managers must apply for a licence to construct a new bore or well, or to enlarge, deepen, or alter an existing bore or well, under section 26D of the RIWI Act, unless subject to the exemptions listed above.

[99] Department of Water and Environmental Regulation, 'Water Licensing: Exemptions', DWER Website http://www.water.wa.gov.au/licensing/water-licensing/exemptions Accessed 18 October 2019

[100] See the map of Groundwater Proclamation Areas 2009 at http://www.water.wa.gov.au/__data/assets/pdf_file/0019/1675/86307.pdf Accessed 30 April 2019

DWER should be contacted if there is any interference with the bed and banks of a watercourse in relation to placement of pipes, building a dam, stock access/crossing points, or roads. Where dams are off a watercourse, DWER does not need to be consulted. However, if any doubt exists, contact DWER's Water Licencing area:

DWER Licence enquiry hotline
1800 508 885

licence.enquiry@water.wa.gov.au

Good practice for dams

Dams can be excellent tools for shoring up water supplies on a pastoral lease. Dams are permanent structures designed to capture and/or hold water, either as a blockage on an existing waterway, or as an earth tank into which water is diverted. An earth tank is a dam that is constructed by excavating the land to create a suitably large and deep depression for holding water. In the pastoral industry, there are generally two uses for dams:

- walk-in dams
- source dams.

A walk-in dam, as the name suggests, is a dam that livestock can walk into to get a drink. On the other hand, a source dam is a dam that is used to pump water to a tank and/or trough, at which livestock drink.

Source dams are dams established to provide water beyond the dam area, via piping water to one or more tanks elsewhere on the property, which, in turn, pipe water into troughs for livestock. This method, piping water away from a dam (or bore), rather than direct access to the source, is best practice, according to the Water Quality Protection Note, *Pastoral Activities Within Rangelands* published by the then-Department of Water in 2006.[101] Detailed discussion of pipe and pump will occur in the section dealing with bores below.

Design

Once a permit has been granted, or the dam is to be placed away from a watercourse, construction may begin. However, dams require careful planning, in terms of:

- site location
- materials to secure the dam
- depth and breadth
- whether to allow stock access to the dam.

[101] Department of Water Western Australia, *Pastoral activities within rangelands*. Water Quality Protection Note, WQPN35, November 2006: 5

For the South Australian Arid Lands Natural Resources Board (SA ALNRB), the above considerations inform their objectives for dam development. The objectives, which apply to the erection, construction, modification enlargement or removal of a dam, wall or other structure that will collect or divert, or collects or diverts, water flowing in a watercourse, are:

- Ecological effects: Diversion should protect surface water flows, the quality of water resources (by preventing or minimising impacts from pollution and other contaminants), and the quantity of water resources (by minimising undue depletion and wastage). Dams, walls or other structures must not have a detrimental effect on the natural state and function of watercourses, lakes or floodplains.
- Design: Dams, walls or other structures shall be designed and constructed to avoid having detrimental impact on water quality or introduce contaminants and to minimise evaporation, water loss and prevent seepage to groundwater.
- Location: Dams, walls or other structures must not be located in, or immediately upstream or downstream, of areas that are ecologically sensitive or known to provide critical refuge to aquatic biota (e.g. permanent water holes).
- Construction, maintenance and removal: should minimise the destruction of riparian vegetation. Should not adversely affect the ability of other persons to lawfully take surface water. The removal of a dam, wall or other structure requires the natural ground level be reinstated and the topsoil and vegetation stabilised to limit impacts on the downstream environment.
- Activities shall not have a detrimental impact on cultural, heritage or social value.[102]

Note that the provisions of the RIWI Act are consistent with some of the objectives of the SA ALNRB, with respect to the environmental impact of dams. However, for Western Australian-specific information on environmental and regulatory issues in respect of dams, please see the DWER Water Quality Protection Note no. 53, *Dam Construction and Operation in Rural Areas*.[103]

There are two types of dams for pastoral purposes: **walk-in dams**, to which stock come and drink, and **source dams**, from which reticulation can service waters in other areas of the property. Many dams in the Western Australian pastoral estate are walk-in dams: they tend to be shallow, with large water surface areas compared with the volume held in them. The ***PLB recommends source dams*** over walk-in dams, where possible.

[102] South Australian Arid Lands Natural Resources Management Board, *It's Your Place: Business and Operational Plan 2017/18-2019/20*, Volume 2 Appendix 1: Water Affecting Activities Policy. Adelaide: Government of South Australia, 2017: 15

[103] DWER, *Dam Construction and Operation in Rural Areas*, Water Quality Protection Note, *WQPN53*, September 2019

Benefits

Walk-in dams:

- Reliable source of fresh water for livestock.
- Cheap to construct.

Source dams:

- Secure source of water that can be pumped to storage or water points for livestock.
- Ready and accessible water source for drought-proofing the property, firefighting, and so on.[104]

Limitations

Walk-in dams:

- High evaporation rates, particularly in the northern rangelands, due to the shallowness of the dams.
- High maintenance costs, due to the need to maintain the walls, repair flood ways and undertake de-silting.
- Erosion due to cattle pads can undermine the integrity of the dam walls.[105]

Source dams:

- Similar evaporation rate issues to walk-in dams if it is a shallow dam.
- High maintenance costs, due to the need to maintain the walls, repair flood ways (if the dam is in a catchment – otherwise not necessary) and undertake de-silting, as well as maintenance of pumps and pipes for reticulation to tanks or troughs.

Construction and maintenance

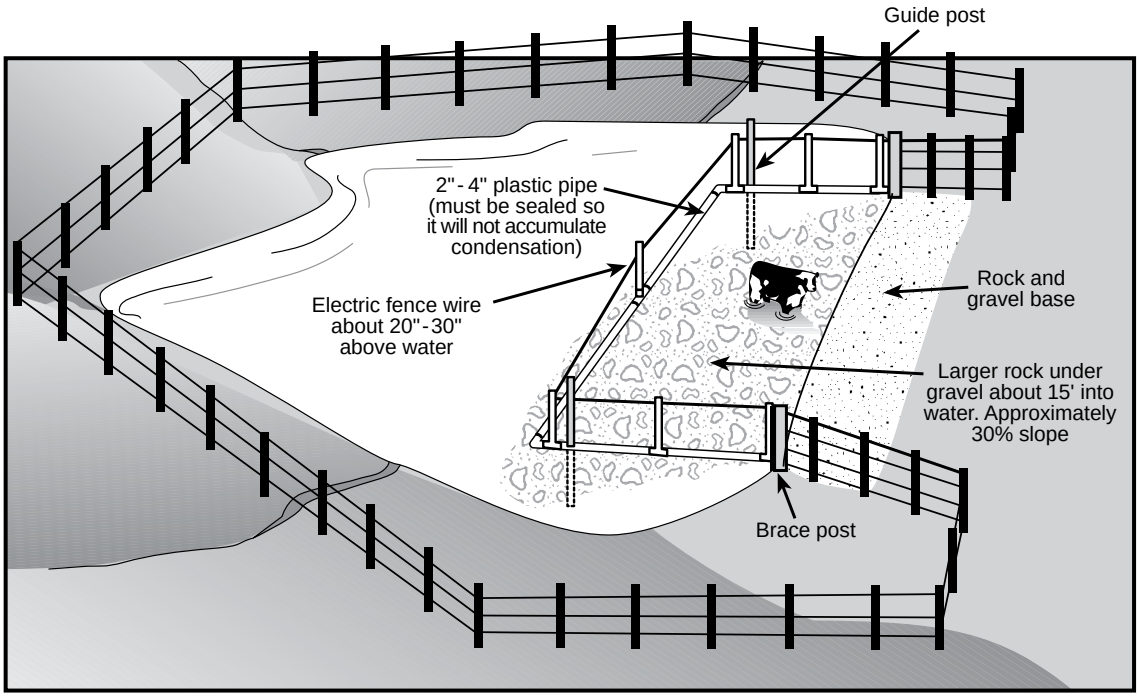
Problems associated with evaporation, de-silting, flood repair and erosion due to cattle pads can be overcome using small catchment walk-in dams. Walk-in dams are reliable and cheap, but need to be carefully surveyed to match the catchment's runoff to the storage volume of the dam and are sited upstream from creek channels. This ensures sufficient runoff into the dam in low rainfall years. Dams such as these have steep batter slopes of at least 3:1 (18 degrees), which increases storage depth and has a smaller surface area, greatly reducing evaporation when compared to traditional dams.

The steeper slope, contrary to common misconception, does not cause cattle to get bogged down and drown; rather, it means that cattle will not camp by the dam, due to the uncomfortable slope. This helps keep the water cleaner and reduces the grazing pressure around the dam. Walk-in dams should be fenced to allow only one point of access for stock to drink at, in keeping with recommendations around access to natural water points and Figure 7.

[104] DPIRD, 'Excavated Tanks (Farm Dams)', DPIRD website: https://www.agric.wa.gov.au/water-management/excavated-tanks-farm-dams Accessed 10 September 2019

[105] T. Sinclair and F. Bright, *Pastoral Stock Water Workbook*. Perth: Department of Agriculture and Food, Western Australia, 2005: 9

Figure 7: Example of a stock access point to a pool



Note the area is carefully fenced off, with a rock and gravel base and apron to prevent stock from becoming bogged and to avoid churning up the bed and bank and reducing water quality.

Source: Paul D Ohlenbusch and Joseph P Harner III, *Grazing Distribution*. Kansas State University, January 2003: 7

The benefits of a deeper dam far outweigh those of a shallow dam, both from an evaporation and a water quality perspective. Figure 8 demonstrates the value of a deeper dam over a shallow dam from an evaporation perspective.

The deeper dam loses far less water than the shallow dam, while additional evaporation prevention measures can greatly increase the efficiency of the dam. Four available evaporation prevention devices are:

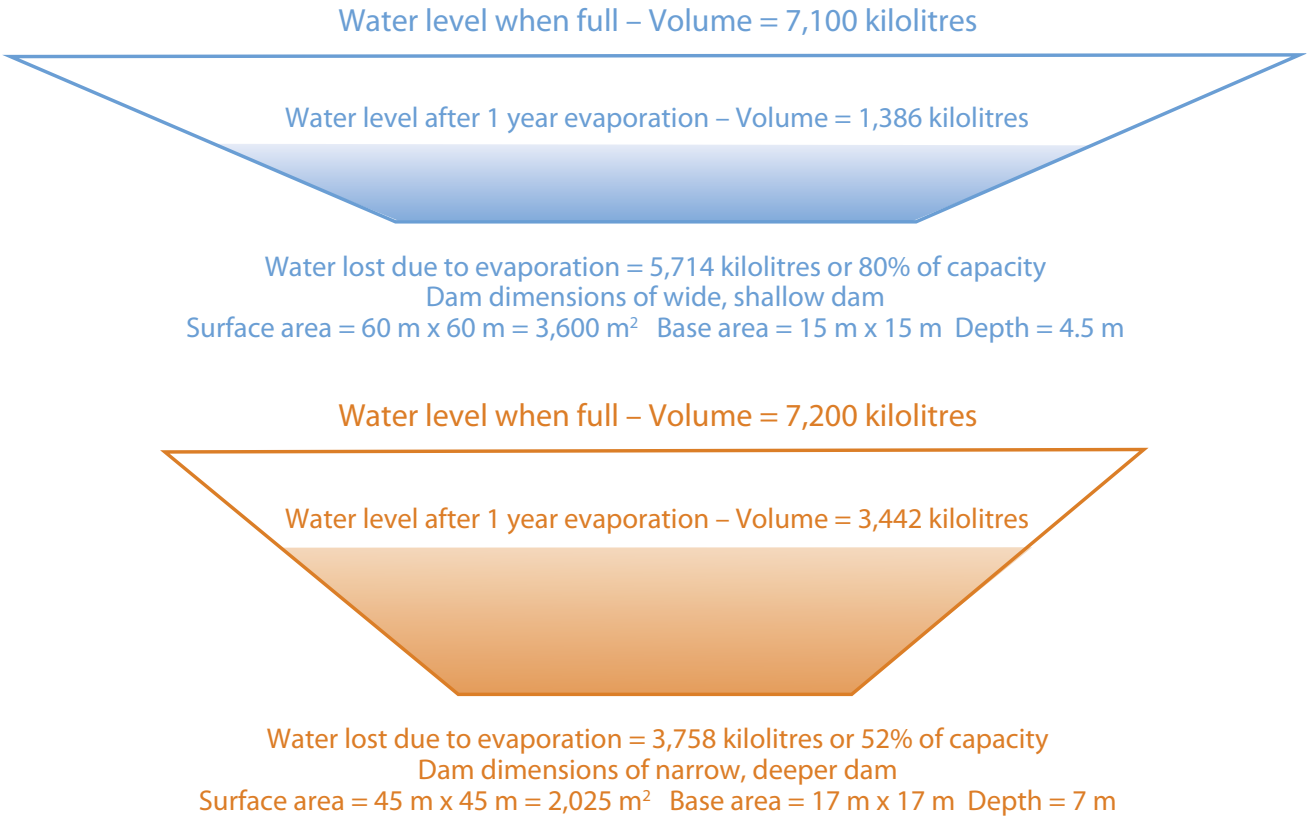
- **continuous plastic sheets:** floating covers act as an impermeable barrier that floats on the water surface to reduce evaporation
- **suspended covers:** shade structures are suspended above the surface of the water to reduce solar radiation, wind speed and trap humid air
- **modular covers:** comprise multiple individual units that float on the surface of the water. Performance will depend on how tightly the modules are packed together
- **chemical covers:** form a thin oily layer on water surface.[106]

[106] Colleen James and Andrew Bubb, *WaterSmart Pastoralism Handbook*. Alice Springs: Desert Knowledge CRC, 2008: 15

Each of the above techniques for assisting in the reduction of evaporation are more cost-effective if the surface area of the dam is smaller – another reason to build deeper dams.

Tinley and Pringle argue that fencing dams to prevent stock access is 'a prerequisite to managing total grazing pressure' around the dam.[107] This is particularly true for source dams, not walk-in dams. Fencing the dam has the added benefit of preventing a source dam being polluted with animal waste, as well as reducing the risk of erosion of the dam walls from cattle pads.

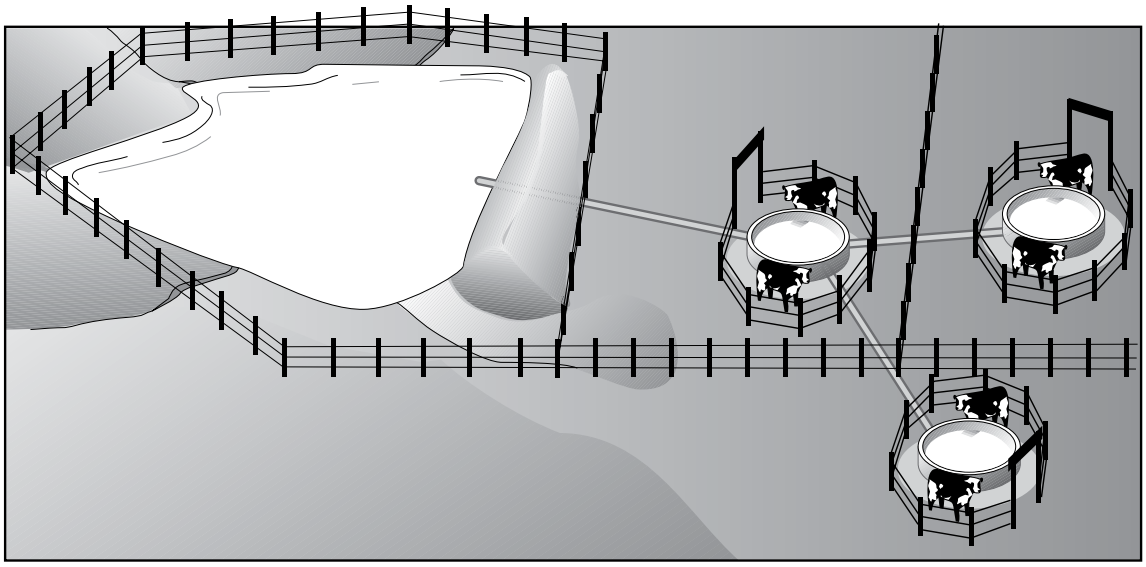
Figure 8: Evaporation loss from dams



Source: Colleen James and Andrew Bubb, *WaterSmart Pastoralism Handbook*. Alice Springs: Desert Knowledge CRC, 2008: 15

[107] Tinley and Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 30

Figure 9: Example of a fenced-off reticulated dam



Note the dam provides water directly to a series of troughs in separate paddocks

Source: Paul D Ohlenbusch and Joseph P Harner III, *Grazing Distribution*. Kansas State University, January 2003: 7

Managing access to water is a key aspect of ensuring grazing pressure is controlled. For example, where a pasture has been destocked for regeneration following a fire – watering points can be closed down, which may help reduce kangaroo and feral herbivore numbers in that pasture. As the Queensland Department of Environment and Resource Management (DERM) observes, in many areas, 'kangaroo numbers have increased as more permanent watering points have been established for livestock'.[108] Chapter 5 discusses methods of managing total grazing pressure, while techniques for managing feral and native animals are discussed in chapter 6.

Bores

Bores and wells are used to access groundwater resources. While the terms are sometimes used interchangeably, wells differ from bores in that wells access shallow groundwater resources that do not come from an aquifer, whereas bores access aquifers and may require drilling to a significant depth to do so. Regardless whether a bore or a well is required, land managers will likely be required to apply to DWER pursuant to the RIWI Act to undertake the work. See the Regulation for Bores section above for more details.

Design

When constructing a bore, several issues must be considered. The SA ALNRB Principles are a useful guide to those considerations, and include, *inter alia*:

[108] Department of Environment and Resource Management, *Managing grazing lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 5

Ecological effects:

- Wells should protect the quality of underground water resources (by preventing or minimising impact from pollution and other contaminants) and the quantity of underground water resources (by minimising undue depletion and wastage). Should also protect sensitive aquatic biota and water dependent ecosystems and protect their natural resilience.

Socioeconomic:

- Wells should protect the integrity of underground water resources and the interactions of connected water resources.
- Should also protect sites of cultural, heritage and social amenity value. Activities shall not have an unacceptable detrimental impact on cultural, heritage or social values.[109]

These principles broadly align with the Objects of Part III of the RIWI Act.[110]

During the design phase, careful consideration of the location of groundwater extraction points is imperative. As noted elsewhere, water points should be distributed no more than ten kilometres apart, and away from fence lines,[111] although many pastoral managers argue that waters should be distributed at approximately six kilometres apart. Some pastoralists are moving to establish waters every two kilometres.

Distribution of waters every six, or every two, kilometres does not mean establishing bores at these intervals. As can be seen in the examples provided above, the establishment of waters tends to rely on a small number of bores and several tanks being fed by those bores. The water is pumped from bores to tanks, which feed troughs.

According to DERM, water points 'should be placed on the opposite side of the paddock from the prevailing winds', because stock are 'more likely to walk towards water into a prevailing wind but then graze away from the watering point with their backs to the prevailing wind'.[112]

Benefits

- Capping and piping of bores to troughs 'provides much more control over the location of water points'.[113]
- Bores provide more reliable water to stock than natural water points do, especially in dry conditions.
  - Significant water resources are available that pastoral lessees might not be aware of – contact DWER for more information. There is a wealth of information about water resources across

[109] South Australian Arid Lands Natural Resources Management Board, *It's Your Place: Business and Operational Plan 2017/18-2019/20*, Volume 2, Appendix 1: Water Affecting Activities Policy: 11-12

[110] See section 4, Objects of this Part, of the *Rights in Water and Irrigation Act 1914*

[111] Department of Agriculture and Food, T*he grazing of cattle in the southern pastoral areas of Western Australia*. Land Resources Best Practice Series (4), 2006: 1

[112] Department of Environment and Resource Management, *Managing Grazing Lands in Queensland*: 13

[113] Ibid

the pastoral estate on the DWER website. For example: http://www.water.wa.gov.au/planning-for-the-future/finding-water/groundwater-investigations/royalties-for-regions-groundwater-investigation-program

Limitations

- Bores placed in sensitive areas may lead to degradation of the land.
- Groundwater is not available in all areas – the Southern Rangelands, in particular, has areas in which groundwater is scarce or at depths that make drilling uneconomical.

Construction, maintenance and removal

- Wells should be constructed to ensure they access the target aquifer or aquifers.
- The siting of non-intensive stock/domestic wells must have no detrimental effect on any other operational well or permanent or semi-permanent pool, spring or flowing stream.
- The construction, maintenance and management of wells must not adversely affect the hydrological processes between aquifers or connected surface water resources. Construction must not degrade naturally occurring water dependent ecosystems or adversely impact processes dependent on system connectedness (e.g. the migration of aquatic biota).
- The equipment, materials and methods used to drill, repair, replace, alter or maintain a well, shall not adversely affect the groundwater quality or introduce contaminants. Where a well will intersect multiple aquifers, an impervious seal must be installed and maintained to prevent leakage between the aquifers.
- Wells shall be fitted with headworks, suited to the underground water temperature and pressure, and equipped in such a way to control flow and monitor the natural flow of water over the lifetime of the well.
- Groundwater extracted during the installation of a well (including testing the integrity of materials) shall be minimised to ensure water is not wasted.
- Wells that are no longer operational, or new wells not intended to be operational, shall be decommissioned and back-filled in accordance with well specifications with minimal impact on the environment.[114]

Careful construction and maintenance of bores and wells is vital to the quality of the water being extracted, the wellbeing of the animals relying on that water, and the environment. Additionally, DERM notes, 'watering points should be placed in areas where the soils are least susceptible to erosion'.[115] All wells and bores should be

[114] South Australian Arid Lands Natural Resources Management Board, *It's Your Place: Business and Operational Plan 2017/18-2019/20*, Volume 2, Appendix 1: Water Affecting Activities Policy. Adelaide, Government of South Australia, 2017: 11-12

[115] Department of Environment and Resource Management, *Managing Grazing Lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 13

sealed at the surface to prevent debris, faeces, animals, and other objects washing or falling into them. Further, the piping or pumping of water from bore or well to a trough or tank to a trough is best management practice.[116] Bores and their associated infrastructure may be damaged by livestock, so fences should be constructed around that infrastructure.

Pumping systems

Reticulation of a water supply for livestock is an economical approach to water management, requiring far less investment than would be required to establish bores every six kilometres. However, pumping water from a bore requires careful planning, including:

- What type of pumping system will be used:
  - Windmills
  - Fuel pumps; or
  - Solar pumps.
- What type of water storage system will be used:
  - Tanks; or
  - Dams.

Windmills

Windmills are iconic and relatively cheap pumping systems. However, windmill use has declined in recent years due to the amount of maintenance required and solar power becoming more affordable. The amount of power produced by the mill depends on its location.

Design

The performance of a windmill is primarily influenced by three things:

- the diameter of the fan
- the height of the tower
- the size of the pump.

The bigger the diameter of the fan, the more wind intercepted, increasing power output by the mill. The higher the fan tower, the greater the wind speed intercepted and the lower the effect of ground turbulence. Fitting a large pump will increase the amount of water pumped with every stroke, but also increase the wind speed required to start the pump. This may result in less water being pumped during a day.[117]

Benefits

Sinclair and Bright argue that there are two key advantages to windmills:

- their extremely long life
- most employees know how to fix them.

The best areas for windmills are the flatter coastal areas of northern WA, which have the most regular supply of wind of any pastoral region in Western Australia.[118]

[116] Department of Water Western Australia, *Pastoral activities within rangelands*. Water Quality Protection Note, WQPN35, November 2006: 5

[117] Water and Rivers Commission Western Australia, *Livestock management: Watering points and pumps*. Water notes for rivers management. WN7, January 2000: 3

[118] Sinclair and Bright, *Pastoral Stock Water Workbook*: 6

Limitations

Windmills are not as suited to the far north of Western Australia as they are to other regions due to regular wind droughts, which require auxiliary, motorised pumps to supplement wind power. Auxiliary pumps are expensive to run and maintain. The fickle nature of the wind means windmills usually require a storage tank with a capacity of about 7 - 10 days' supply. Further, hilly areas and tree thickets reduce the effectiveness of windmills by reducing wind speeds near ground level, although such problems can be overcome by increasing fan diameter and tower height. Windmills are also heavily affected by cyclones in the regions best suited to capturing wind to drive pumps.[119]

Figure 10: Windmill in the Murchison Region

Note several large water tanks in the vicinity, associated with a cattle yard

Source: Russell Shaw, 2019

[119] Ibid

Fuel pumps

Fuel pumps use either petrol or diesel, and are often used in the following circumstances:

- during wind droughts
- during high static head situations e.g., deep water table
- during high dynamic head situations, such as pumping through long/small diameter pipes
- to supply large volumes of water
- close to homesteads.[120]

Benefits

Fuel pumps are generally used where portability and occasional use are important. Diesel powered pumps are favoured whenever a continuous, or regular supply of water is required, irrespective of volume.[121] Fuel powered pumps can be used either as a direct drive to a pump, or an electrical generator that creates power to run a submersible pump.[122]

Figure 11: Example of a diesel pump at a bore as a temporary measure

Source: Rob Edwards, 2019

[120] T. Sinclair and F. Bright, *Pastoral Stock Water Workbook*. Perth: Department of Agriculture and Food, Western Australia, 2005: 7

[121] Water and Rivers Commission Western Australia, *Livestock management: Watering points and pumps*: 3

[122] Sinclair and Bright, *Pastoral Stock Water Workbook*: 7

Limitations

There are some limitations to using fuel pumps, particularly on a permanent basis, including:

- high maintenance requirements
- the constant need for refuelling and the associated costs of fuel haulage
- they are difficult to automate.[123]

Solar pumps

Solar pumps are another option. According to a publication produced by the Water and Rivers Commission of Western Australia in the year 2000, solar power is 'ideally suited to remote stock water supplies requiring low volumes of water'.[124]

Design

Solar pumps usually 'pump into a storage tank with a five-day capacity',[125] providing a water supply should cloudy conditions hamper the effectiveness of the solar panels. Therefore, pastoral lessees will need to determine what kind of storage system to use. As discussed above, water can be pumped to tanks or stock dams. Tanks, provided they are installed correctly and protected from livestock impacts, are better than dams in most circumstances, because water sitting in tanks does not evaporate. Further, not everywhere will have the clay soils necessary to build a dam – without clay soils, water will leach away, or cause the dam to breach.[126]

Solar panels should be located where cattle cannot gain access, such as on top of a tank or inside a robust fence, to protect them from damage. However, the panels must be located where shading cannot occur, and may need to be cleaned occasionally, as surface dust can reduce the efficiency of the solar panels.[127]

Benefits

Sinclair and Bright note the increasing quality of components and equipment for solar panels and pumps over time has increased the effectiveness of solar pumps and reduced the need for visitation and maintenance.

A NSW Farmers guide to solar powered pumping in Agriculture observes that solar is:

- a cost-effective and reliable energy source that is scalable, flexible, and low maintenance
- well-suited to the task of pumping water for stock waters. The year-round nature of pumping requirements, plus the 'relatively small volumes [of water] required for stock watering makes this a pumping task well-suited to solar [photo-voltaic] power.

[123] Water and Rivers Commission Western Australia, *Livestock management: Watering points and pumps: 3; Sinclair and Bright, Pastoral Stock Water Workbook*: 7[124] Sinclair and Bright, *Pastoral Stock Water Workbook*: 7

[124] Water and Rivers Commission Western Australia, *Livestock management: Watering points and pumps*: 3

[125] Ibid

[126] Sinclair and Bright: 10; David Stanton, *Farm Dams in Western Australia*. Perth: Department of Agriculture and Food Western Australia, 2005: 12

[127] Sinclair and Bright: 7

Figure 12: Fenced off solar array, bore house, and tank near Carnarvon Gorge, Queensland

Note: sturdy steel fence and size of tank, ensuring water supply on cloudy days

Source: Rob Edwards 2019

Water can be pumped during the daytime from a bore, dam or stream into a stock dam or elevated tanks for on-demand supply to troughs'.

Limitations

Pastoralists need to have reliable pumps that are fit for purpose, including pumps designed for the prevailing climatic conditions. For example, anecdotal evidence suggests that, in at least one of the animal welfare cases referenced at the beginning of this section, a key issue was the use of certain submersible pumps, which were not fit for purpose in the conditions found in the Pilbara. Some submersible pumps tend to fail when water temperatures reach and exceed 26 degrees Celsius,[128] which is regularly exceeded in the Pilbara summer. Having submersible pumps that are 'heat cleared' is essential in these conditions.

[128] Rob Edwards, '20190315 File Note Fact Finding Field Trip 1 – Gascoyne-Murchison-Pilbara – Good Pastoral Land Management Guidelines 11-15 March 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019: 11

For permanent waters, solar pumps are recommended – they are cost-effective, efficient, and can move sufficient volumes of water to meet the needs of livestock.

Reticulated water systems

Piping the water to a tank for use in a trough requires a significant amount of reticulation. In the example of a station map with waters provided above, there are up to six tanks being fed from a single bore.

Design

Good practice for undertaking reticulation requires careful planning for immediate and future requirements. This means that if there are plans for several troughs, the pipe diameter should be increased so that, in the future, more points can be added. Trying to move too much water though too small a pipe can increase pumping costs due to a high resistance flow.

Benefits

- Efficient use of resources – one bore can feed many troughs.
- Flexibility – ability to expand the reticulated system as business needs change, as well as move the location of water points if required.

Limitations

- Suitability of terrain for reticulation – hilly or rocky landscapes may not be best suited to reticulated water supplies because of:
  - the difficulty in pumping water up and down hills
  - the inability to bury pipes to protect them from damage, due to the rocky surface (see construction below).

Construction

Options for maximising value when establishing a reticulated stock watering system, include:

- bury pipes at least 20cm deep to reduce damage from stock, fires, and vehicle traffic
- record and/or mark where the pipes are laid out using gps
- use regular pipe breathers to reduce air locks
- install a gas separation tank if the water source has high gas content.[129]

Some Western Australian pastoralists argue that reticulation pipes should be buried, at a minimum, 40cm below the surface, due to potential overheating of the pipes and the water in the pipes. Some possible issues associated with overheating include:

- pipes expanding with heat, leading to leaks
- water that is too hot for the cattle to drink comfortably.

[129] Sinclair and Bright: 8

Figure 13: Exposed, leaky reticulation pipe from a bore to a trough, not good practice

Note cattle pads and churned up ground around the pipe. Cattle may have punctured the pipe with their hooves

Source: Rob Edwards 2019

Telemetry

An emerging aspect of managing stock waters on a pastoral lease is the use of telemetry, or remote monitoring. Remote monitoring has the capacity, via digital and/or analogue sensors, to monitor and control water points. Information from sensors at the water point is transferred to a central monitoring station (usually the homestead), via internet, radio, or telephone. The sensors can monitor water levels in troughs, tanks and/or dams, flow rates and pump running times, as well as visual monitoring via video. Telemetry can also be used to turn pumps on and off as required.[130] Such a system significantly reduces the need to travel long distances to check waters. Instead, maintenance can be targeted to where monitors identify a problem, rendering station maintenance far more efficient and cost-effective. Several stations across the rangelands are utilising telemetry as a key element of land management.

[130] Ibid

Telemetry can also be used for several other purposes, both water- and non-water related, including:

- to monitor creek and river levels, which is particularly useful when pumping water from a natural water source to a tank or dam, or in monitoring flood risk
- to track stock via e-tags, which also shows grazing patterns and stock movements
- automatic drafting of cattle to determine weight gain and weight classification
- monitoring of fences and determining with reasonable accuracy the location of any broken fence (works with electric fences in particular)
- to monitor weather stations
- to transmit camera footage on troughs and trap yards
- for security cameras
- to provide text messaging capability for safety and operational uses.[131]

Much of this telemetry is reliant on the internet of things. The internet of things operates on a narrow bandwidth and, as a result, can only transmit a small amount. However, the significance of these telemetry devices is huge to a pastoral business's bottom line. For example:

- having remote monitoring of water tanks and troughs reduces the costs of water point drives by around $10,000 per year – far fewer trips out to check waters across the year
- tracking stock with e-tags will reduce the costs of mustering, because the locations of the stock will be known, meaning time and fuel is not wasted looking for the stock. Mustering time can therefore be cut in half.[132]

These examples demonstrate that remote sensing is increasingly playing a vital role in good practice management of pastoral leases.

[131] Rob Edwards, '20190412 File Note Fact Finding Field Trip 2 – Kimberley – Good Pastoral Land Management Guidelines 8-11 April 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019: 10; Rob Edwards, *20191111 File Note Bullseye Bulga Downs Field Days 6-7 November 2019*, Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10783245: 4-5

[132] Rob Edwards, *20191111 File Note Bullseye Bulga Downs Field Days 6-7 November 2019*, Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10783245: 5

Figure 14: Tank and trough formation with solar panels and telemetry

Note the antenna in top left of photo. Note camera oriented at trough to monitor cattle and trough infrastructure.

Source: David Stanton, *Farm Dams in Western Australia*. Perth: Department of Agriculture and Food Western Australia, 2005: 7

Road and track development and management

The development of roads and tracks is essential to a pastoral operation. Roads enable access to station infrastructure. Therefore, they need to be well-planned, well-constructed, and properly maintained. Failure to do so can cause a range of problems for the landscape and, consequently, the pastoral business. Tinley and Pringle note that poorly constructed roads and tracks can often interrupt natural sheet flows (the downslope movement of water), directing that water along the roads, instead of across them, leading to road rivers and road barriers. A road river sees the water run along the road, resulting in the road becoming an erosion gully. A road barrier stops the water from crossing the road, starving the downslope area of water.[133]

To avoid creating these and other land management issues, roads should be developed and managed with the following in mind:

- Planning tracks along contours and as close to the watershed as possible.
- Crossing drainage tracks and valley floors at right angles to flow.
- Leave the land level perfectly flat when sweeping new tracks.
- NEVER make windrows (long lines of soil/gravel ridges left behind by a grader blade) as these exacerbate dehydration, block overland flow causing water starvation downslope and can initiate erosion where they are breached.
- Keep off all tracks when wet.[134]

Design

Before building a new road, detailed planning and preparation is required. Ergon Energy has devised a series of principles for access track location, which are highly relevant here.

- First, land managers need to consider the type(s) of vehicle that will be using the track:
  - Will this be a basic station track for motorbike and ute access, or will it be used for transporting stock on a truck?
  - Different vehicles will have different requirements and limitations, which are further affected by seasonal conditions, such as heavy rain.
- The standard of the track will also be influenced by the soil type and its susceptibility to erosion.
- Will there be a need for stream crossings? Waterway crossings should be kept to a minimum to reduce disturbance to creek and riverbeds.

[133] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 30-31; 80

[134] Ibid.: 80

- Environmental and cultural heritage considerations need to be factored in – are there any environmentally sensitive areas, or is this a place of Aboriginal or European cultural heritage?[135]

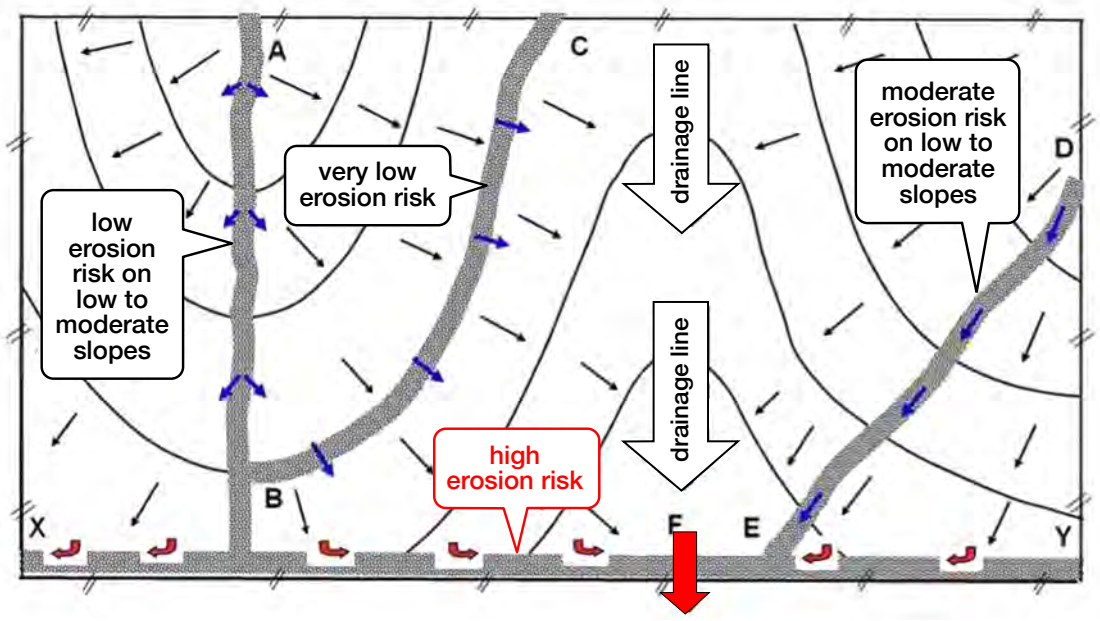
In addition, the Queensland Government notes that the 'erosion risk to roads and tracks depends on their slope and where they are situated in the landscape'. Further, 'tracks taking the shortest route often have erosion problems'.[136]

Figure 15 below presents different locations of tracks and roads in a landscape, and are shown as thick grey lines. In each example of a road and track, the erosion risk is highlighted in relation to the location of the track and the direction of runoff in the landscape, where the arrows demonstrate runoff direction.

When considering the location of a road or track in the landscape, the following refers to a different road or track as shown in the diagram below:

- Roads and tracks on ridges (A-B): ridges provide an excellent location for roads and tracks. Runoff drains away from ridges. Whoa-boys (low, trafficable banks across tracks that return harvested water back to their natural drainage systems) are usually required.

Figure 15: Road alignment to landscape features



Source: Adapted from Queensland Government, *Erosion control on property roads and tracks – cross-sections and locations*, Science Notes Land Series 239. Brisbane: Queensland Government, 2013: 3

[135] Ergon Energy, *Access Track Construction Standard and Specification*, Townsville: Ergon Energy Queensland, 2013: 4

[136] Queensland Government, *Erosion Control on Property Roads and Tracks – Cross-Sections and Locations*, Science Notes Land Series 239. Brisbane: Queensland Government, 2013: 3

- Roads and tracks on the contour (B-C): generally perform well, whoa-boys are not required and maintenance costs are minimal. Contour roads are also beneficial as they enable access to and inspection of the middle of a paddock.
- Roads and tracks directly up and down the slope (D-E): have a lower erosion risk than a road running diagonally across the slope. It may be steeper, but does not intercept overland flow, whoa-boys can be used to remove runoff.
- Roads and tracks diagonal to the slope (X-Y): most tracks along fence-lines will run diagonally to the slope. They often have a high risk of erosion due to a large catchment.
  They intercept overland flows and redirect runoff down the road or table drain. Provisions to allow overland flows (such as culverts and whoa-boys) must be made.
- Roads and watercourses (F): where formed roads cross drainage lines or creeks, an invert, floodway, causeway, culvert or bridge is required[137]
  - Inverts are constructed by removing the soil in the crossing and replacing it with a heavy gravel that resists flows. A sheet of geo-fabric below the gravel ensures that the soil and gravel remain as separate layers, which increases the effective life of the invert.
  - Culverts (pipes) need to be sized according to the area drained as they can be susceptible to blockage from siltation.

When selecting a suitable location for crossing a watercourse:

a) Avoid steep banks as they are an erosion risk and require considerable excavation.

b) Use whoa-boys on the approaches into the drainage line where necessary.

c) Cross drainage lines at right angles and avoid sites where clearing of vegetation is required.

Road and track construction

A basic element of road construction is to leave the road or track at the same level as the surrounding ground – do not elevate the road in such a way as to create a barrier, nor lower than the surrounding ground, which may create a road 'river', similarly depriving the land downslope of water and creating erosion along the line of the road or track. A Northern Territory Government guide to road development refers to 'boxed-in roads', which follow the key points Tinley and Pringle refer to above. The guide states that boxed-in roads enable water to continue along its natural path without being obstructed and causing unnecessary damage to the roadway.

[137] Ibid

In order to construct such a road, you must:

1. cut track to a depth of 20 – 30cm
2. backfill with suitable hard road base material
3. final grading to existing surrounding ground levels; and then
4. ensure that no windrows are left.[138]

In respect of construction specifications, the following are a useful guide:

Table 7: Road Formation Design and Standards

Design Parameter	Standard
Formation	Crowned with cross fall of 1-3 degrees on ridge top or flat ground Out-slope with 1-3 degrees outfall in side cut locations
Pavement Surface	Natural weathered surface with patch gravelling on clay soils where necessary to improve trafficability. The desirable surface is short grass to minimise erosion
Pavement Width	2.8 metres minimum, 4 metres maximum
Shoulder Width	0.6 metres
Clearing width for track	1 metre either side of earthworks (track formation)
Maximum Gradient	9 degrees but may be steeper where construction results in less disturbance and the surface provides good traction
Formation in Wet Tropics	3 metres wide formation, 4 metres high to vegetation

Note, however, that a key principle in respect of earthworks for the construction of roads or tracks must be that the soil should be disturbed as little as possible. Further, wherever possible, 'stockpile topsoil and litter (free of timber debris) in a recoverable position for respreading over disturbed areas. This material contains valuable seed and nutrients which will greatly assist revegetation[139]

Source: Ergon Energy, *Access track construction standard and specification*, Townsville: Ergon Energy Queensland, 2013: 6

[138] Vegetation and Land Management, Natural Resource Management Division, Fact Sheet: *Boxed-in Roads*. Alice Springs: Department of Natural Resources, Environment and the Arts, Northern Territory, 2006: 1

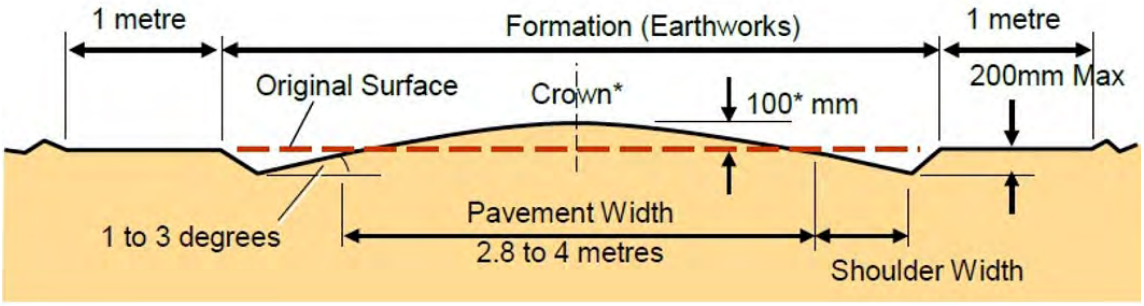
[139] Department of Land and Water Conservation, *Guidelines for the planning, construction and maintenance of tracks*. Sydney: New South Wales Office of Environment and Heritage, 1994: 4

Road formation

Crown surface formation

A crown surface formation in respect of roads has raised earth on the centre line of the track that then slopes down gently towards both sides, and a crown surface formation is suitable for tracks where water can be shed from both sides. Figure 16 below shows the design parameters for a crown formation. As noted in the table above, a crown formation is appropriate for roads and tracks on flat ground or ridge tops.

Figure 16: Crown formation for roads



*** The Crown is normally 100 mm above the natural surface after consolidation i.e. 1-3 degrees unconsolidated**

Source: Ergon Energy, *Access track construction standard and specification*, Townsville: Ergon Energy Queensland, 2013: 6

Figure 17: Example of a well-constructed road on flat surface, Murchison Region, WA

Note the road is at the same level as the surrounding countryside, there are no windrows, and the surface is flat or slightly crowned

Source: Rob Edwards, 2019

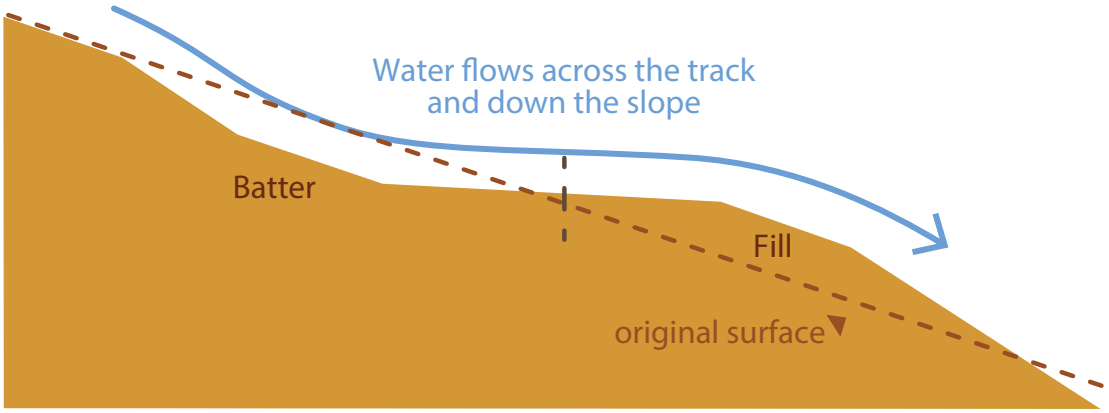
Out slope formation (hillsides)

However, when the road or track is being constructed along contour lines on a hillside, a crown formation is not appropriate: water would be trapped against the slope and follow the road, causing erosion. Instead, an out slope formation, which allows water to flow across the road and down the slope without changing the flow of water, is required. This formation is suitable for longer lengths of side cut where water cannot be shed via cross track drainage (e.g. whoa boys). Out slope formation should be used in the absence of cross track drainage structures, in the form shown in the illustration below.

A key element of construction of an out slope formation, as shown in Figure 18, is ensuring the side slopes that connect the road surface to the contour of the surrounding land (known as batters) are kept to a minimal length and are stable, to prevent erosion. Unstable batters can erode quickly, particularly in areas of heavy rainfall, so a range of batter stabilisation and minimisation techniques are required. Some of those techniques include:

- minimise batter slope length by avoiding steep cross slopes
- batter slopes need to be kept under critical maximum which depends on soil material
- leave a roughened (cultivated) batter surface to assist revegetation
- spread top soil in critical areas where rapid stabilisation is required
- revegetation is an imperative - use a spray mulch seeded with a cover crop or native seed to speed revegetation

Figure 18: Road formation on slope



Source: Ergon Energy, *Access track construction standard and specification*, Townsville: Ergon Energy Queensland, 2013: 8

- protect the batter from flows of foreign water, use catch banks and drains
- cater for any subsurface flows
- watch out for slumping and its effect on table drains.[140]

Figure 19 below, in contrast with the above, is an example of a poorly constructed road on a slope. Note the batters are eroded, the road slopes towards the batter, and has created a clear creek along the right-hand side of the road (centre left of the photo).

Figure 19: Example of poorly constructed road in hilly terrain, Kimberley Region, WA

Note road well below level of surrounding land and significant erosion has occurred

Source: Rob Edwards, 2019

[140] Agriculture Victoria, 'Tracks and roads: design and construction'. http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_toolbox_tracks_roads_construction Victorian Government (date accessed: 19 February 2019)

River Crossings

As noted above, and in a range of road and track construction and maintenance guides, when a road or track must cross a drainage line or a creek, that crossing should occur at right angles to the flow of water.[141]

Note that a permit to interfere with the bed and banks of a watercourse may be required from DWER for the construction of a new crossing or alterations to an existing watercourse road crossing.

To determine whether a permit is required or not, **contact DWER** (see contact details in the Water Points section above).

DWER provides additional information on river and creek crossings in publications found on their website:

- Department of Water, *Crossing Creeks: Stream Crossings on Farms*, Perth: Department of Water, 2008 (http://www.water.wa.gov.au/__data/assets/pdf_file/0018/3366/62319.pdf); and
- Department of Water, *Building Creek Crossings*, Perth: Department of Water, 2010 (http://www.water.wa.gov.au/__data/assets/pdf_file/0015/3165/91091.pdf)

Both guides include useful information about how to decide whether to build an all-weather crossing (i.e. a bridge or culvert crossing), or an in-bed ford. Aside from the practical considerations, which are discussed here and in the publications listed in this section, DWER provides four principles of good crossing design, which are:

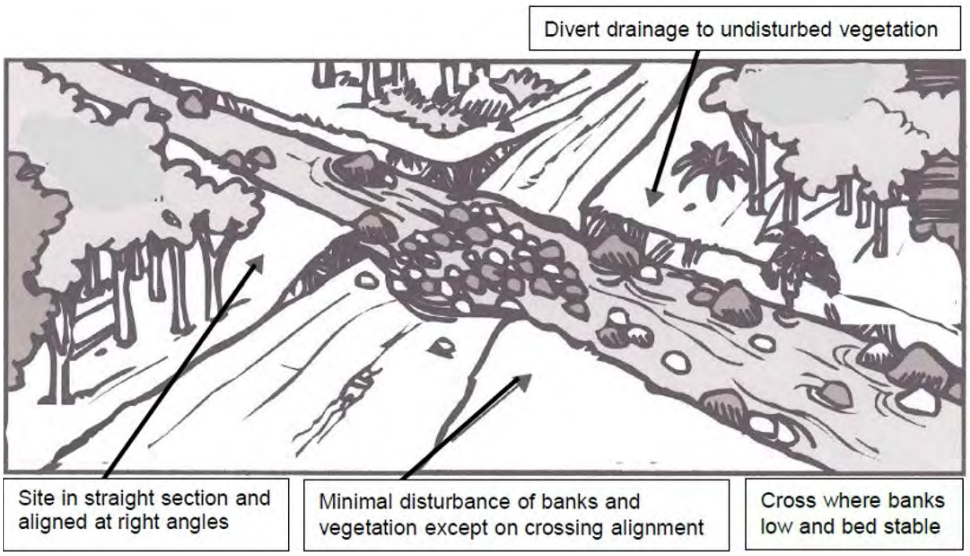
1. **Minimise interference with the natural channel form and capacity.**
   The channel is influenced by flows that work to maintain or rebuild the channel in a way that suits the long-term pattern of rainfall runoff from the catchment. The nature of stream behaviour must be taken into consideration.
2. **Select the best location.**
   Crossings should be located along existing straight reaches of the stream and away from bends and active or erosive parts of the channel. When selecting a location for ford or culvert crossings, naturally high points of the creek bed should be taken into consideration.
3. **Design for service demand.**
   The type of crossing will be determined by the level of access required. For example, if permanent access is required, even in rare floods, then a structure built above the flood level will be required. Alternatively, if stream flow is seasonal and wetting of vehicles is acceptable then a ford may be the best type of crossing. The number of crossings should be minimised and multi-purpose crossings used.

[141] Source: Ergon Energy, *Access track construction standard and specification*, Townsville: Ergon Energy Queensland, 2013: 10; Tinley and Pringle, *Rangeland Rehydration 1*: 80; and Queensland Government, *Erosion control on property roads and tracks*: 3

4. **Maintain passage for wildlife.** The creek crossing design should always enable passage of fauna through the waterway and riparian zone and not form a barrier. Wildlife may return to the area with better management of the creek.[142]

Figure 20 below provides additional information regarding the method of construction of a watercourse crossing.

Figure 20: Diagram of river crossing



Note the crossing in the image above is an invert, whereby gravel and stones have been placed in the creek bed to provide a stable surface for vehicles while also protecting the bed from erosion damage. Figure 21 below is almost identical to the image above

Source: Ergon Energy, Access track construction standard and specification, Townsville: Ergon Energy Queensland, 2013:10

[142] Department of Water, *Crossing Creeks: Stream Crossings on Farms*, Perth: Department of Water, 2008: 10-11 (http://www.water.wa.gov.au/__data/assets/pdf_file/0018/3366/62319.pdf)

Figure 21: Well-built river crossing, Kimberley Region, WA

Source: Russell Shaw, 2019

Windrows and how to avoid them

When building roads, one common problem is the creation of windrows. Windrows are long, narrow heaps of soil usually left over after grading a road, track, firebreak, or fence line. They are avoidable and detrimental to the land and soil for a number of reasons, including:

- They intercept natural water flow and increase the speed of water runoff.
- Concentrated water flow along windrows creates rill erosion (an eroded channel caused by high velocity concentrated flows) and gully erosion (removal of soil along drainage lines by surface water runoff).
- Windrows can starve downhill vegetation of water – leading to biodiversity loss.
- Gully erosion along windrows can damage fences, roads and tracks.
- You can cause damage to your vehicle by hitting windrows.[143]

So, how can windrows be avoided? When creating a road or track, remember the following:

- Do not create excessive amounts of graded material.
- Try lifting the grader blade and skimming the surface, instead of cutting deep.
- Use a stick rake instead of a blade on a bulldozer.

[143] Vegetation & Land Management, Natural Resource Management Division, *Introduction to Soil Erosion*. Alice Springs: Department of Natural Resources, Environment and the Arts, Northern Territory, 2007: 25; see also Queensland Government, *Erosion Control on Property Roads and Tracks*: 3

Figure 22: Erosion gully created by a windrow beside Gibb River Road, Kimberley Region, WA

Source: Rob Edwards, 2019

Figure 23: Freshly graded track with prominent windrow

Note: Vegetation & Land Management, Natural Resource Management Division, Introduction to Soil Erosion. Alice Springs: Department of Natural Resources, Environment and the Arts, Northern Territory, 2007: 25

Source: Courtesy of the Northern Territory Government

- Sweep any leftover material back onto the road or track.
- If you see someone leaving windrows, tell them to stop, or ask them to have them removed when they've finished grading the track.[144]

Draining water off the road

Table Drains

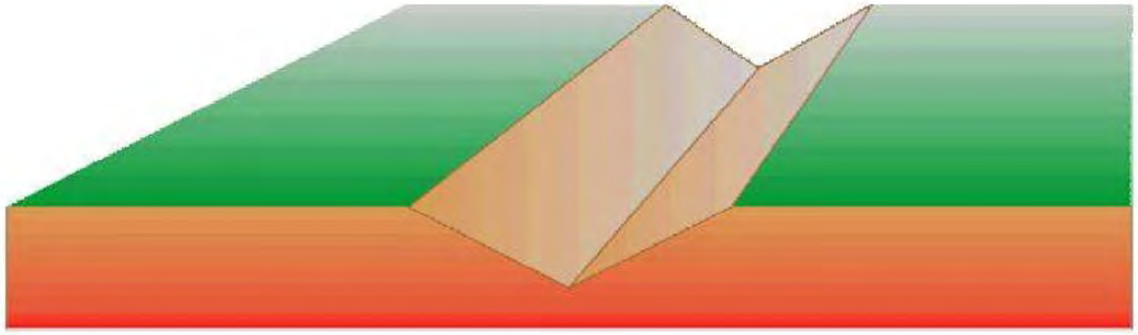
Once the road has been graded and established (without windrows), other design and construction issues must be resolved. Of particular importance are table drains, which will remove water from the road. Some construct table drains in a V-shape, which is not recommended, because they are more likely to cause erosion than prevent it. The sides of these drains are steep, and the drains narrow, concentrating flow and increasing water velocity.

Therefore, flat bottom table drains are recommended. Flat bottom table drains are, as the name suggests, wider drains with a flat bed, which have the following advantages over the V-shaped drain:

- they slow the speed of the water
- the angle of the sides of the drain are gentler than v-drains
- they are broader than v-drains
- vegetation can easily grow on the base and sides of the drain
- they can handle larger volumes of water
- less maintenance is required, meaning lower machinery costs.[145]

Stable flat bottom table drains will have vegetation growing in them, both on the base and the sides of the drains. Figure 25 below is an example of a stable flat-bottom drain.

Figure 24: Example of a V-shaped drain



Note: Vegetation & Land Management, Natural Resource Management Division, *Introduction to Soil Erosion*. Alice Springs: Department of Natural Resources, Environment and the Arts, Northern Territory, 2007: 24

Source: Courtesy of the Northern Territory Government

[144] Vegetation & Land Management, Natural Resource Management Division, *Introduction to Soil Erosion*: 25

[145] Ibid.: 24; see also, Agriculture Victoria, 'Tracks and roads: maintenance and monitoring', http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_toolbox_tracks_roads_maintenance Victorian Government (date accessed: 19 February 2019)

Figure 25: Example of well-constructed flat-bottom drain, Kimberley Region, WA

Note the grass growing on the banks and the bottom of the drain, demonstrating stability. The drain is also quite long, allowing the water to leave the area around the road slowly.

Source: Rob Edwards, 2019

Figure 26: Poorly-constructed flat-bottom drain, now stabilised, Kimberley Region, WA

Note significant erosion, although grass growing in drain demonstrates area has stabilised. Note the cow in background for scale.

Source: Rob Edwards, 2019

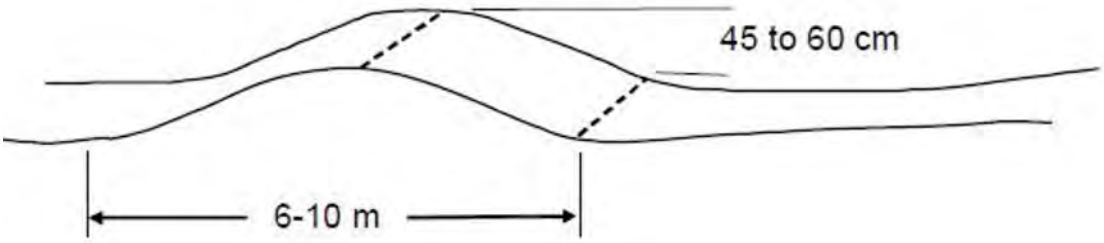
Whoa Boys

Whoa boys are low-profile, trafficable earth banks placed on sloping roads to divert water into table drains, where the water is then able to continue its natural path. Whoa boys resemble speed bumps and visitors to a property may surmise that this is their purpose.

The location and frequency of whoa boys are determined by the steepness of the slope, the direction of flow of water across the road, and the availability of stable outlet areas for the water the whoa boys are diverting. Key considerations for building whoa boys include:

- take note of the soil types as some are more susceptible to erosion than others
- choose locations with a stable outlet such as a grassed or stony area
- locate whoa-boys where there is a significant change in slope (Figure 28) or on the approach to a drainage line or creek
- align whoa-boys with contour banks in cultivated areas or where they can discharge into farm dams
- ensure that the top whoa-boy in an existing road is placed just above any rills occurring in the road. If the erosion appears to be active, it may be necessary to start even further up slope.[146]

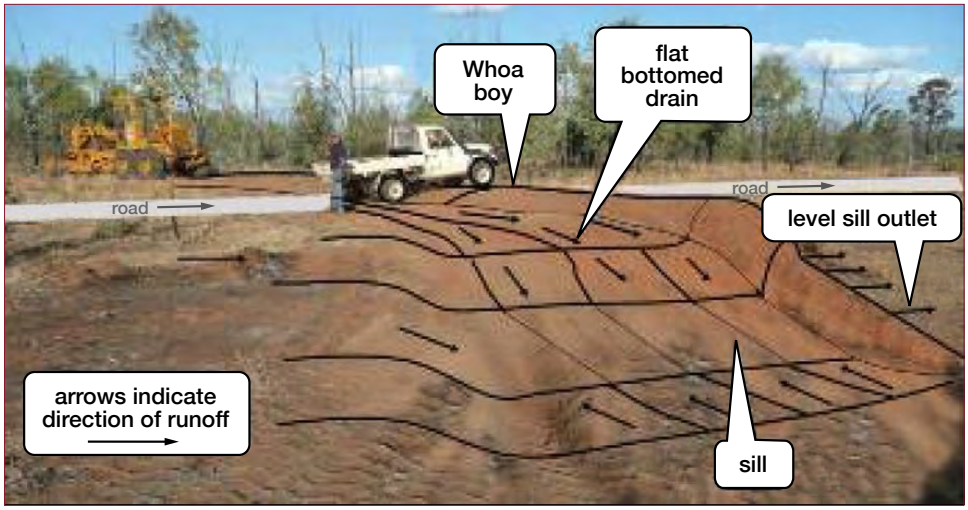
Figure 27: Cross-section of a Whoa Boy



Source: Adapted from DERM, *Fact Sheet L240: Erosion Control on Property Roads and Tracks – Managing Runoff*. Brisbane Department of Environment and Resource Management, 2010: 1

[146] DERM, *Fact Sheet L240: Erosion Control on Property Roads and Tracks – Managing Runoff*. Brisbane Department of Environment and Resource Management, 2010: 1

Figure 28: Example of best-practice Whoa Boy construction



Note the whoa boy diverts the water into a flat-bottomed drain.

Source: Adapted from DERM, *Fact Sheet L240: Erosion Control on Property Roads and Tracks – Managing Runoff*. Brisbane: Department of Environment and Resource Management, 2010: 3

For more details on whoa boy construction, refer to the Queensland Government *Fact Sheet L240: Erosion Control on Property Roads and Tracks – Managing Runoff*:

- https://www.publications.qld.gov.au/dataset/05c87bc5-6048-4767-85c8-36e660c38b1d/resource/1b4aecdc-2b61-4ef0-85e8-5d691cebe8c8/fs_download/sn-l240-erosion-control-on-property-roads-and-tracks-runoff.pdf

Regular maintenance

Poor road maintenance can compromise good road design and construction. Therefore, regular maintenance of roads and tracks is essential. This involves inspecting the roads regularly (annually at a minimum), and grading the roads and cleaning the table drains as required. The Victorian Government suggests grading and cleaning of roads and drains once every six months in hard setting soils and once every three months in loose soils, climate permitting. In areas where dynamic rainfall abounds, such as the Kimberley, maintenance of roads and tracks may only be possible at the end of the wet season and just before the next wet season begins. Road maintenance means:

- proper disposal of cleared material
- keep all planned drains operating

- keep road crown effective
- avoid development of windrows
- no 'V' shaped clearing of table drains (keep drains broad bottomed to reduce velocity of run-off)
- not cutting into the toe of batters
- avoid damaging discharge areas.[147]

The NSW Government agrees that maintenance is essential to maintaining high quality roads and tracks, noting that frequent maintenance should be carried out in the early years after construction, to ensure erosion control and track stability. Other key points regarding maintenance include a need to:

- inspect all tracks at least annually and following heavy traffic usage or exceptionally heavy rainfall
- restrict destruction of vegetation to removal of excess vegetation, preferably by slashing or spraying
- avoid unnecessary grading or blading to reduce soil disturbance
- encourage outfall drainage by removing any windrow along the outside edge of the track.

To ensure the stability of the road formation, a cover of vegetation and/or forest litter must develop on the surface of the track or road, on batters, and on the approaches to drainage line crossings. The stabilised road surface and protective vegetative cover on the bank outlets combine to reduce track erosion.[148]

How can I learn more about road building and management?

- Attend a grader school run by your local catchment group, the KPCA, or Rangelands NRM.
- Watch the 2007 DVD *Water Your Landscape, Not Your Roads: Best Practice Road and Track Management with Colin Stanton*, produced by the Government of South Australia, Arid Lands Natural Resource Management Board, supported by the Australian Government's National Landcare Program.
- Read the recently published road building guide by Rangelands NRM in collaboration with other NRM groups and governments across the rangelands:

Hugh Pringle, Darryl Hill, Paul Theakston, Colin Stanton and Russell Grant, *Outback Roads: Let it Go, Let it Flow. Water Your Landscapes, Not Your Roads!* Perth: Rangelands NRM, 2019.

Online: https://rangelandswa.com.au/wp-content/uploads/2019/05/0518-Rangelands-A5-Outback-Roads-Book-Mar19-WEB.pdf

[147] Agriculture Victoria, 'Tracks and roads: maintenance and monitoring', http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_toolbox_tracks_roads_maintenance Victorian Government (date accessed: 19 February 2019)

[148] Department of Land and Water Conservation, *Guidelines for the planning, construction and maintenance of tracks*. Sydney: New South Wales Office of Environment and Heritage, 1994: 5overnment (date accessed: 19 February 2019)

Fence placement and management

Fences are an essential element of land management. They are a key part of a station management plan, because fences help manage grazing pressure, protect vulnerable vegetation, preserve waterways, and manage feral animals. While grazing pressure and feral animal management will be discussed in greater detail in other chapters, note that fencing can and frequently does play a key role in those areas.

When considering establishing fences, important considerations include:

- Boundary fencing should be sufficient to contain cattle.
- Internal fences: enclosing a number of water points with similar land systems through strategic management unit fencing is economically justifiable. Management units should not contain strongly contrasting vegetation types that might result in over-grazing of preferred areas.
- Management unit design (size/ configuration) and water point distribution will need to take into account:
  - The grazing range of cattle.
  - Sensitive and fragile land systems, river frontage, coastal dune country, unmanageable areas of permanent natural water (e.g. ranges) or stony upland country of very low productivity require specific land management considerations, including the option of not being grazed at all.
  - The land forms and soil types. Appropriate fence alignments will reduce ongoing fence maintenance and minimise soil erosion.
- Vegetation clearance for the maintenance and construction of new and existing fence lines should be regarded as normal station management:
  - In shrub land or grassland landscapes, 5 metres of clearing either side of the fence is recommended.
  - In timbered landscapes the height of prevailing timber should be the determining factor to avoid fence damage in the event of falling trees.[149]

The Pastoral Lands Board view is:

- Where the native vegetation includes trees, clearing around fences may need to be up to 10 metres wide on either side of the fence.

In this section, the ways in which fence construction, placement, and management can affect broader land management issues (mentioned above) are outlined in detail, including a number of strategies for maximising the effectiveness of fencing to achieve land management objectives.

[149] Department of Agriculture and Food Western Australia, *The Grazing Of Cattle in the Southern Pastoral Areas of Western Australia*. Land Resources Best Practice Series (4), Perth: DAFWA, 2006: 1

Regulation

When building a boundary fence, it must be stock proof. Apart from any other considerations, pastoral lessees need to be aware that, since the passage of the *Highways (Liability for Straying Animals) Act 1983*, liability for injury or damage to people or vehicles caused by stock straying onto a highway may rest with the owner of the stock. Further, under the *Local Government (Miscellaneous Provisions) Act 1960* section 484, it is an offence for an owner to allow their cattle to stray into and be at large in a street or public place. The Act also gives local government authorities the power to take possession of stray cattle and be reimbursed by the owner for the costs of caring for them. The owner of the stock may also be fined.[150]

Under the EP Act section 51C, certain types of clearing are prescribed, or permitted, including clearing for the construction or maintenance of fences. These are set out in the Clearing Regulations, regulation 5, which provides a table outlining the types of clearing that are permitted, and the limits imposed on that clearing. Item 11 of the table states:

> Clearing of Crown land along a fence line to provide access to construct or maintain a fence –
>
> (a) Between alienated land and Crown land – if the clearing is no more than 1.5m from the fence line; or
>
> (b) Between Crown land and Crown land – if the clearing is no more than 5m from the fence line on onse side and no more than 1.5m from the fence line on the other side.

Fencing near waterways

As noted in the section on water points, stock access to rivers, streams, and other natural waters should be limited as much as possible. The former Water and Rivers Commission of Western Australia (now DWER), argues that it is important to restrict, although not necessarily exclude, livestock access to waterways, so that riverbanks can revegetate and stabilise. As noted in the Natural Waters section, this also improves water quality and protects riparian vegetation.[151]
The only way to restrict livestock access to waterways is through fencing.

Design

When fencing waterways, or portions of waterways where permanent pools exist, considerations include:

- Fencing should not affect the ability of the waterway to function – care must be taken not to divert flow or otherwise interrupt the waterway. The only time a waterway should be interrupted is for erosion control and/ or rangeland rehydration activities.[152]

[150] Pastoral Lands Board of Western Australia, 'Liability for Straying Stock on Roads', Perth: Department of Planning, Lands and Heritage, n.d. https://www.dplh.wa.gov.au/getmedia/13d22f96-c563-41dd-a103-76e7b8d60028/GD-PLB-9-Liability-for-straying-stocks-on-roads Accessed on 24 May 2019

[151] See: Department of Water Western Australia, *Pastoral activities within rangelands*. Water Quality Protection Note, WQPN35, November 2006: 4-5

[152] Water and Rivers Commission WA, *Livestock Management: Fence Location and Grazing Control: Water Notes for Rivers Management* 18, 2000: 2

- Flood risk needs to be considered. In flood prone areas, fencing further away from the waterway, parallel to the anticipated direction of flood flow, reduces fence damage. When stream crossing is required, use a suspended 'hanging' fence, ensure this area is capable of blowing out, is separate from other sections of the fence, and strong enough to support the additional weight by using high tensile wire. Additionally, corrugated iron, planks, chains, and even lightweight garden mesh can be suspended across the waterway.[153]

To determine the best placement of fences to protect waterways, aerial photographs are a very useful tool. Aerial photographs can show remnant vegetation and key landform features that need to be incorporated into the (fenced off) riparian zone. Overlaying the photograph with a map of the area's contours is also helpful, providing information about topography and, as a result, the best location for fences. For example, on steep and deep valleys, the fence should be located back from the crest of the high embankment to enable tree and shrub roots to anchor the embankment to the adjacent land.[154]

Benefits

Fencing off waterways can provide many benefits, both for stock and the environment, including:

- Fencing makes the environment less hazardous to stock.
- Fencing waterways protects fringing vegetation. Fringing vegetation acts as a natural filter to improve water stream quality.
- Fencing remnant vegetation may also provide shelter for stock.
- Improved habitat for native fauna.[155]

Limitations

- Fencing entire riparian zones on a pastoral lease is impractical due to the scale of the land under lease.
- Sometimes it is impossible to determine a definite riparian zone, or the area is heavily flood prone, making fencing difficult.

Construction

On a pastoral lease, fencing entire rivers is generally impractical. However, fringing vegetation can be protected in the most ecologically valuable areas by fencing around permanent river pools.[156] As the NSW Department of Primary Industries notes, 'Sacrificing land alongside waterways will reduce future soil loss from erosion'.[157]

Where it is impossible to determine a definite riparian zone, or the area is heavily flood prone, creating a river paddock to retain vegetation and perennial grasses

[153] Department of Primary Industries NSW, 'Fencing riparian zones', NSW Government website: https://www.dpi.nsw.gov.au/fishing/habitat/rehabilitating/habitats/fencing-riparian-zones (date accessed 18 February 2019); see also Water and Rivers Commission WA, *Livestock Management: Fence Location and Grazing Control*: 2

[154] Water and Rivers Commission WA, *Livestock Management: Fence Location and Grazing Control: Water Notes for Rivers Management* 18, 2000: 2

[155] Ibid.: 1; See also, McClelland Rural Services, *Managing Indigenous Pastoral Lands, Module Four: property management*. Rural Industries Research and Development Corporation, 2014: 17

[156] Water and Rivers Commission WA, *Livestock Management: Fence Location and Grazing Control*: 2

[157] Department of Primary Industries NSW, 'Fencing riparian zones'

that are carefully grazed, or, alternatively, cultivating the land for drought fodder, can reduce maintenance costs of fences and provide environmental and other benefits. Figure 29 below is a portion of a map from a Western Australian pastoral station with clearly defined river paddocks. The paddocks are named River, making clear the intent of the fencing regime.

Fence by land system type

When determining where to place fences on a pastoral lease, one important consideration is how the fences will affect grazing pressure. In areas with no fences, or where highly palatable pasture is located in the same paddock as less palatable pasture, stock will tend to graze the more palatable plant species and leave the rest. This can lead to overgrazing of particular areas of a paddock and, consequently,

Figure 29: Example of river paddocks on a pastoral lease

Note the black lines on the map are fences.

Source: Department of Primary Industries and Regional Development

land management issues, including erosion and/or significant reduction in the abundance of palatable pasture and replacement with less palatable increaser plant species.

A key way to prevent overgrazing and to manage overall grazing pressure in this context is to fence according to land type, thereby avoiding a 'reduction in palatable productive pasture species and deterioration in soil surface conditions in part of the paddock while the rest of the paddock is underutilised'.[158] As noted in the Land Management chapter, pastures change according to land type, meaning that as soil, topography, and hydrology change, so too does the type of pasture available to stock to graze, which is why fencing to land type is such an effective approach to grazing management.

Scientists from the Department of Agronomy at Kansas State University also argue for cross-fencing – fencing by vegetation types or topographic areas – as a way of achieving more uniform grazing distribution. They argue that, before embarking on a fencing program, consideration must be given to the improvements required in the grazing pattern, the factors influencing current grazing patterns (water, topography, vegetation types, barriers crossing, etc.), and how the fencing pattern will affect the ability to manage the resulting pastures.[159]

The Northern Territory Government also notes that fencing different land types is a valid strategy, but that such a strategy requires careful management and, almost certainly, rotational grazing on a seasonal basis.[160] More detailed discussion of grazing strategies are discussed in the Grazing Management Chapter below.

Laneways

A laneway is a track or access line 'bordered by a fence to allow quick and easy movement of stock and machinery throughout a farming system'.[161] Further, as Russell Shaw notes,

> the purpose of laneways is to move stock from one paddock or water point to another with minimal labour. Laneways need to be wide enough to allow for the movement of stock without jamming the mob, pushing them onto the laneway fencing when the laneway is too narrow for the size of the mob. So laneways are generally constructed to take into account the size of the mobs being moved around the lease, moving with as little stress as possible.[162]

Some pastoral properties regularly move stock through laneways on their stations, from waters and paddocks to yards and as a paddock rotation. Figure 30, below, is an example of a well-constructed laneway.

[158] Department of Environment and Resource Management, *Managing Grazing Lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 12

[159] Paul D Ohlenbusch and Joseph P Harner III, *Grazing Distribution*. Kansas State University, January 2003: 8

[160] Department of Resources, *Cattle and Land Management Best Practices in the Top End Region 2011*, Darwin: Department of Resources Northern Territory Government, 2013: 6

[161] Cavrep, 'Handbook of Real Estate, Property, and Valuation: Fencing' http://www.cavrep.com.au/F/FENCING.html Accessed 12 September 2019

[162] Email Russell Shaw to Karel Eringa RE: laneway clearing. Lands File 50246-2004. Perth: DPLH 2019

Figure 30: Stationhands moving steers on Fossil Downs Station, WA

Source: Rick Ford

Design

Many key elements must be considered when designing a laneway, including:

- The laneway should connect as many paddocks as possible. The more paddocks that are connected to each laneway, the more efficiently the property, including stock movements and mustering, can be managed.
- The laneway should be sited along an existing fence line. This means only one extra fence line has to be built.
- Laneways should not be sited in areas fragile areas that are susceptible to soil erosion, where possible.

Width of a laneway is determined by the following:

- the size of the mobs to be moved through the lane
- the need for the formation of a road
- the value of the lane as a firebreak or stock protection area, against a grass fire
- lane widths of from 20 to 100 metres are recommended (depending on the size of the mobs being moved through them) for the following reasons:
  - the lane is wide enough to avoid mobs of stock from becoming 'choked' when being pushed along it
  - there is room for a vehicle to pass and 'head off' the mob if necessary
  - the lane is not too wide for a dog to handle stock
  - narrow laneways on clay soils require road formation and fill to avoid the heavy concentration of stock pugging the soil. Wider

laneways (20-100 metres) on stable soils may need no more than just road formation.[163]

Laneways can work without stockmen moving the mob from behind or with stockmen moving the mob on. In the second case, with stockmen working the mob, the laneway must be wide enough to allow the stockmen to get 'around the mob' without stressing or pressuring animals to push through or over the laneway fencing with potential losses to the business in time and injured animals.[164]

Benefits

There are significant benefits to be gained from establishing laneways, including:

- Stock mustering time can be reduced by half in situations where stock have to be moved over a considerable distance to and from a set of yards.
- Allows quick and easy access to most parts of the property by vehicle.
- Because a laneway confines stock, a good dog can bring stock into the yards by itself.
- If well grazed, provide a good firebreak and stock protection area in the case of a grass fire. Stock can be quickly driven into it to minimise loss.
- Unskilled labour can be used as mobs tend to break out of control when being driven through paddocks containing other mobs.
- Save time and effort in property inspection and stock movement.
- Avoid the possibility of boxing mobs during mustering.
- There are fewer gates to open for mustering and inspection.
- Mobs can be driven directly to their destination without time lost deviating through paddocks.
- Essential management and stock health programs are more likely to be carried out because of the ease of handling and mustering.
- Laneways can be used as temporary yards.[165]

Limitations

- Extra watering points may be required to service stock along the laneway.
- Additional fencing costs to build the laneway and, in some instances, road formation.[166]

Construction and maintenance

Construction of a laneway involves fencing work, which is discussed below. In addition, consideration must be given to how much clearing should be undertaken in the establishment of a laneway. Retaining trees and other vegetation

[163] Adapted from Cavrep, 'Handbook of Real Estate, Property, and Valuation: Fencing' http://www.cavrep.com.au/F/FENCING.html Accessed 12 September 2019

[164] Email Russell Shaw to Karel Eringa RE: laneway clearing. Lands File 50246-2004. Perth: DPLH 2019

[165] BW Carey, B Stone, PL Norman, P Shilton, Chapter 14: Property Infrastructure. In: *Soil Conservation Guidelines for Queensland*, Brisbane: Department of Science, Information Technology and Innovation, 2015: 22 Web Version: https://www.publications.qld.gov.au/dataset/soil-conservation-guidelines/resource/51f7740c-2435-4209-a56c-e97ac8157850

[166] Cavrep, 'Handbook of Real Estate, Property, and Valuation: Fencing' http://www.cavrep.com.au/F/FENCING.html Accessed 12 September 2019

is recommended, provided it does not interfere with the free flowing of livestock along the laneway. Shade is always welcome, especially where wide laneways may be used as holding paddocks from time to time. Therefore, the Queensland Soil Conservation Guidelines state, 'trees should be kept to just one side [of the laneway] to avoid difficulties when handling stock'.[167]

Types of fence

Fence construction depends on several factors, including the type of fencing system required. If it is a boundary fence, there are specific requirements, including a need for the fence to be especially strong and stock proof. If it is an internal fence, considerations include:

- whether the fence will be permanent or moveable
- which part of the landscape will be fenced (e.g. rivers and riparian areas, fencing off mountainous and generally difficult terrain to access)
- the purpose of the fencing (e.g. are the fences for ease of mustering, or to establish rotational grazing?).

The different specifications for boundary fences and internal fences will be discussed below.

Fence construction

Irrespective of the type of fencing, a number of key principles need to be followed, including:

- Do not leave windrows along fence lines.
- Fence lines will not erode if they run across the slope (not down the slope).
- Only clear what you need to.
- Allow natural drainage to flow across your cleared fence line.
- Install erosion prevention measures (whoa-boys, check banks etc.).[168]

Many of these issues are the same as those discussed in relation to roads. Indeed, the issues around windrows are the same whenever grading is undertaken. Windrows should be removed, to prevent the flow of water being interrupted and channelled, creating erosion gullies along the windrows and droughts downslope of the windrow. If a fence line must travel down a slope, erosion prevention measures, such as whoa-boys and check banks are essential. However, fences should generally follow the contours of a slope, just as for roads.

For fence construction materials in the WA rangelands, there are a number of considerations, including:

1) Steel posts generally (wood susceptible to termites, shorter lifespan even when treated, and is also far more vulnerable to fire).

[167] Carey et. al., Chapter 14: Property Infrastructure: 22

[168] Vegetation & Land Management, Natural Resource Management Division, *Introduction to Soil Erosion*: 28

2) Electric fences (more efficient than multi-strand wire fences and reduce wire costs – can be solar).

3) Barrier fences (dog proof, for example – especially where running sheep).

4) Virtual fences.

Boundary fences

As noted in the regulation section, boundary fences must be stock-proof. Further, a stock fence, whether to contain sheep or cattle, must also factor in large feral herbivores, such as horses, donkeys, or camels, and be able to exclude them from the lease where possible.
There are specific considerations around sheep fencing, which are discussed in a separate section below.

Cattle fences

Construction

For a boundary fence one popular formulation is the following:

- 4 strand barbed wire for the boundary
- picket spacing at 8 metres
- strains at 400-500 metres, recommended (depending on the length of the rolls of wire)
- 2mm barbed wire comes in 400-meter rolls, while 1.8mm and 1.6mm barbed wire comes in 500 metre rolls.

However, four strand fences will not work along all boundaries of any given boundary, but it is a good place to start. Some go three strands, with pickets 10 meters apart, which is also an option.[169]

In respect of end assemblies and strainer assemblies, such as those in Figure 31 below, calculations would be similar to those for the rolls of wire, since strainers are to be placed at the end of each roll of wire. DPIRD states strainer assembly posts must be buried at least one metre into the ground,[170] meaning the additional metre must be included when contemplating post heights.

[169] Russell Shaw Email Reply to Rob Edwards RE: Fencing, 9 May 2019. Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10505268

[170] DPIRD, 'Fencing for Beginners', DPIRD Website https://www.agric.wa.gov.au/small-landholders-western-australia/fencing-beginners?page=0%2C0 Accessed 12 September 2019

Figure 31: Example of a boundary fence on an East Kimberley pastoral station

Note: Ideally, the fence now complete, the windrows in evidence at the edges of the graded area should be removed

Source: Russell Shaw, 2007

In the example of a boundary fence above, the fence is constructed using four strands of barbed wire, with picket spacing at 8 metres for the boundary, with droppers in between the pickets.[171] In respect of end assemblies and strainer assemblies, such as those pictured below, calculations would be similar to those for the rolls of wire, since strainers are to be placed at the end of each roll of wire (400m). According to DPIRD, strainer assembly posts must be buried at least one metre into the ground,[172] meaning the additional metre would need to be included when contemplating post heights.

[171] Russell Shaw Email to Rob Edwards RE: Fencing, 13 May 2019. Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10506712

[172] DPIRD, 'Fencing for Beginners', DPIRD Website https://www.agric.wa.gov.au/small-landholders-western-australia/fencing-beginners?page=0%2C0 Accessed 12 September 2019

Figure 32: Two corner assemblies using pipe rail fencing, cemented into the ground

Note: Strain is taken on corner assemblies to maintain the fence upright and taught. Similar structures should be placed at 400m intervals to maintain the strain, although not always in corner formation

Source: Russell Shaw

Figure 33: Fence strainers at a gate

Source: Department of Planning, Lands and Heritage Board Support

Fences should also be fortified where near high-pressure areas, such as corners, gates, yards, and water points, should those water points be close to a fence. In those circumstances, a heavier barb or, in the case of ringlock fences (see discussion below), a heavier mesh. Posts would typically be placed closer together in these areas, perhaps as close as 5 metres.

Sheep fences

Typically, fencing for sheep utilises ringlock or hinge lock fences, which are built using a mesh fence, such as those in Figure 34.

Design

Typically, these fences are designed as listed below:

- Dimensions: 7/90/30 or 8/90/30 (gauge/width/height) designed to contain sheep or goats.
- These fences also include a single strand of wire above the ringlock, which can be barbed or unbarbed.[173]
- In some circumstances, these fences may also include a single electrified wire, to help reduce the likelihood of damage to the fences by grazing animals.
- These fences can be internal or boundary, and should stand between 1,100-1,800mm high from the ground to the top wire.

Benefits

- Establishing good fences helps with productivity and will enable better management of total grazing pressure across the station.
- Ringlock fences are important in keeping wild dogs out of pastures. This is especially important when grazing sheep, goats, or other small livestock.

Limitations

- This type of fencing is typically more expensive than conventional wire fences.

Further details on the use of ringlock fencing are found in the discussion of barrier fences below.

[173] Meat and Livestock Australia (MLA), *Factsheet 5: Infrastructure for Goats*, North Sydney: Meat and Livestock Australia, July 2017: 3

Figure 34: Examples of well-constructed ringlock fences

Note: Fence on left – without barbed wire top; on right – with barbed wire top

Source: Meat and Livestock Australia (MLA), *Factsheet 5: Infrastructure for Goats*, North Sydney: Meat and Livestock Australia, July 2017: 4

In the Western Australian Rangelands, some sheep fences are built with plain wires, rather than mesh or ringlock fencing. The cost of ringlock fencing can be prohibitive on stations, given their size. Therefore, some use six-strand fences of plain wire to contain their sheep, although this has the significant disadvantage of allowing access to wild dogs. Figure 35 provides two examples of wire sheep fences and hybrid sheep/cattle fences on a station in the Southern Rangelands. The hybrid fence contains six strands of wire, five of which are plain, and a barbed wire on top to prevent cattle pushing over the fence. The sheep fence contains six plain wires.

Figure 35: Hybrid sheep/cattle fence (left) and sheep fence (right), Southern Rangelands, WA

Source: Ashley Dowden 2020

Barrier fences

Barrier fences

Barrier fences, or exclusion fences, are vital to the viability of pastoral stations running sheep and/or goats in the WA pastoral estate, and especially in the Southern Rangelands. Indeed, in the sheep industry, 'there is no tolerance for wild dogs … due to the destruction they cause in direct attacks on lambs and adult sheep, and the production impacts from mis-mothering and stress on the mob'.[174] Some stations have shifted from sheep to cattle, a direct result of wild dog predation, as cattle are better able to defend themselves. However, cattle producers have reported 'significant and increasing levels and losses from wild dogs. Calves are particularly susceptible to attack, while attacks on adult cattle may not be lethal but significantly impacts their productivity'.[175] Therefore, all pastoralists are united in their need to protect stock from wild dog attack.

Design of barrier fences

Due to wild dog predation, and to prevent native wildlife (especially kangaroos) and feral herbivores from adding to the total grazing pressure on pastoral stations, barrier fences are increasingly being used. Barrier fences resemble the ringlock fences discussed above, with a couple of vital differences:

- they are higher, up to 2,400mm, compared to 1,100 – 1,800mm for a regular ringlock fence
- they often incorporate an apron to prevent animals from burrowing under the fence.

Figure 36: Examples of ringlock fences with electric wire offsets

Note: Electric wire offsets can reduce stock damage and provide an extra barrier to feral animals

Source: Australian Wool Innovation, *Wild Dog Exclusion Fencing: A Practical Guide for Woolgrowers*, Sydney: Australian Wool Innovation Limited, 2017: 20

[174] Western Australian Wild Dog Action Group, *Western Australian Wild Dog Action Plan 2016-2021*, Perth: Department of Agriculture and Food, June 2016: 3

[175] Ibid

Research has shown that wild dogs will attempt to get through a fence in three ways:

1. by trying to push through the fence, at or below snout-level
2. by trying to burrow under the fence (usually where the fence meets the ground
3. very rarely, by trying to climb or jump the fence – climbing or jumping is a learned behaviour, and therefore not usually seen in wild dogs.

Therefore, to control wild dogs effectively, a barrier fence must:

- incorporate an effective barrier at and below snout-level (450mm)
- incorporate an effective barrier along the bottom of the fence
- address the potential weak spots e.g. gateways, public roadways, gullies and floodways
- be regularly monitored and maintained, especially in the case of an electric fence.[176]

While woolgrowers have reported that a height of around 950mm is sufficient to control wild dogs, most exclusion fences are higher than this, due to a desire to control kangaroos and large feral herbivores as well.

When using a ringlock fencing solution for a barrier fence, and given wild dogs often attempt to burrow under the fence, an apron or footer is frequently utilised. An apron or footer is an extension of the fence, using the same prefabricated ringlock fencing as for the main part of the fence, which is placed along the lower sections of a fence to provide a physical barrier preventing burrowing. There are three main types of aprons or footers:

- fixed aprons/footers are formed by the bottom 300mm of the fence being allowed to flare out to the ground in a gradual curve
- hinged aprons/footers are attached to the prefabricated wire during manufacture via a hinge knot Hinged aprons can be made to lie flat on the ground at a 90-degree angle to the fence and can be buried (either deliberately, or by the build-up of soil over time)
- removable aprons/footers are attached to an existing fence, either as reinforcement or repair.[177]

Aprons are used 'on the more impenetrable barriers' and seem to be a feature of 'most serious exclusion fences'. According to the Kondinin Group, an apron is 'probably the best way to prevent animals breaching a fence who tend to burrow or push under as their first choice'.[178]

[176] Australian Wool Innovation, *Wild Dog Exclusion Fencing: A Practical Guide for Woolgrowers*, Sydney: Australian Wool Innovation Limited, 2017: 4

[177] Ibid.: 8

[178] Kondinin Group, *Exclusion Fencing: Fighting Ferals*, Research Report No. 288. Perth: Kondinin Group, January 2016: 5

Figure 37: Examples of different types of aprons for exclusion fences

Note: Left – fixed apron; Centre – hinged apron; Right – removable apron

Source: Australian Wool Innovation, *Wild Dog Exclusion Fencing: A Practical Guide for Woolgrowers*, Sydney: Australian Wool Innovation Limited, 2017: 8

Netting fence

Another type of barrier fence is a netting fence. Netting has traditionally been used to control vermin such as foxes and rabbits. This fence uses lighter weight fencing material and, as a result, will not have the same longevity as a ringlock fence. However, it can be used along the base of an exclusion fence, or as a removable apron. In addition, netting can be used as a floppy top to combat animals that readily climb fences, such as cats and foxes. A floppy top hangs over the top of the fence to the outside of the exclusion zone.[179]

For a case study of an exclusion fence in operation for some time, the *WA Wild Dog Action Plan 2016-2021* spoke to then-manager of Rawlinna Station (Nullarbor pastoral region), Ross Wood. The study, reproduced below, provides fence specifications, maintenance requirements, and an estimation of production benefits to the Station:

Fence specifications: The Rawlinna Wild Dog Fence encompasses approximately 12,600km^2 (1,260,000ha) of pastoral land. It is a rectangle approximately 140km x 90km and is approximately 480km in length. It is comprised of a skeleton fence 5ft high on which 6ft marsupial netting with 100mm weave is attached. The lapping of 1ft lays on the ground and has a strain wire to keep this flat. The fence line was generally not cleared to prevent water lying on lapped wires (preventing unnecessary rust) and was mostly unnecessary in any event as the area is mostly treeless. Myall wooden posts were used every 100m and steel pickets at 7m intervals. Plain wire was strained to 400m to support netting. The division between Rawlinna and Kanandah used wire produced in Belgium and was two 3ft rolls joined. Supply of original netting was the issue. The netting was constructed by several contractors and took approximately 4 years.

[179] Ibid.: 6

Figure 38: Example of an exclusion fence constructed with netting

Source: © Australian Wildlife Conservancy. Kondinin Group, *Exclusion Fencing: Fighting Ferals*, Research Report No. 288, January 2016: 6

Maintenance requirements: There was virtually no maintenance on the fence for the first 12 years. The fence was checked monthly to ensure the gates were closed. After 20 years, a netting rider was employed to maintain both Moonera and Rawlinna fences. This was a weekly trip along 850km to ensure any kangaroo holes or fox holes under the netting were fixed. Currently a netting rider is employed to control wild dog incursions as well as perform maintenance such as fixing holes in the body of netting, and fixing any camel damage and rusted lapping.

Production benefits: Once constructed, the enclosed dingoes were trapped and poisoned. Some 360 dogs were destroyed by a private dogger over several years. Although production over the years has been higher, the property currently [in 2016] stocks approximately 60,000 sheep. Fence maintenance, baiting and trapping carried out by the netting rider continues to keep wild dog predation to a minimum, as predation has a significant effect on lambing percentages and therefore eventual sales. An average of 15 staff/year are employed on Rawlinna.[180]

Further discussion of barrier fences and controlling feral animals are found in Chapter 6.

[180] Western Australian Wild Dog Action Group, *Western Australian Wild Dog Action Plan 2016-2021*, Perth: Department of Agriculture and Food, June 2016: 53

For more information on barrier or exclusion fences, see the following:

- https://www.wool.com/sheep/pest-animals/wild-dog-exclusion-fencing/

The link, which goes to the Australian Wool Innovation (AWI) website, contains links to the AWI's *Wild Dog Exclusion Fencing: A Practical Guide for Woolgrowers*, as well as the Kondinin Group's Research Report, *Exclusion Fencing: Fighting Ferals*. Both of these guides are excellent and provide detailed information on the types of exclusion fences available, technical information on constructing and maintaining fences, as well as, in the case of the Kondinin Group report, some sense of the costs associated with exclusion fence construction.

Internal fences

When considering construction of an **internal fence**, there exists a range of options when compared to a boundary fence. First, internal fences are not generally required to be as robust as boundary fences, meaning there are more potential fencing solutions, depending on management style and the type of grazing operation that a land manager employs. There are three specific types of fences that could be used, although the third can be used as a boundary fence as well as an internal fence:

1) electric fences (more efficient than multi-strand wire fences and reduce wire costs – can be solar)
2) virtual fences
3) ringlock (mesh) and barrier fences (esp. where running sheep).

Several different types of fence fit within the list above. The table below shows the most common forms of these fences, along with their advantages and disadvantages.

Table 8: Fence Types and their Advantages and Disadvantages

Fence type	Advantages	Disadvantages
Wire electric fence	Can be dropped/removed for weed removal Suitable for cattle and sheep Less likely to collect flood debris Comparatively cheap to erect and maintain Quick and easy to erect Curved fence line is possible Fewer posts required Longer life	Not suitable where vegetation overgrowth likely Droppers may be needed depending on post spacing Stock require training Costs increase with wire increases
Wire electric fence with mesh base (ringlock)	Effective against most stock (including lambs). Relatively quick to erect. Strong	Susceptible to flood damage Higher maintenance costs Increased erection costs Limited ability to follow natural stream curve Less droppers required
Barbed wire fence	Collects less flood debris Cheaper than mesh fences	Requires more posts and droppers Not as effective in stock control Limited ability to follow natural stream curve Susceptible to rust
Prefabricated mesh fence (ringlock)	Very effective in stock control (esp. lambs) Strong Contain inbuilt droppers reducing costs Quickly erected	Prone to collect flood debris Expensive High maintenance costs Limited ability to follow natural stream curve Susceptible to rust

Source: State of NSW via Department of Primary Industries NSW, 'Fencing riparian zones', NSW Government website: https://www.dpi.nsw.gov.au/fishing/habitat/rehabilitating/habitats/fencing-riparian-zones (accessed 18 February 2019)

Electric fences

Electric fences are a popular choice for internal fencing. Electric fencing is significantly cheaper, quicker to erect, moveable, and can fence along curves more effectively than conventional fencing. Electric fencing is cheaper than conventional fencing, because conventional fences need to be built stronger than the alternative.

Electric fences can be built to a lower standard than conventional fencing because they are more of a psychological than a physical barrier. Therefore, animals need training by placing animals within a permanently fenced area or cattle/sheep yard, with a hot wire placed inside the perimeter fencing. The permanent fencing prevents the animals from escaping should they charge the wire. It helps to have an open gate to teach them that there are safe areas, especially since they will be moving through gates in managed grazing systems.[181]

Design

When building an electric fence, consider the type of stock to be controlled by the fence. According to the Waters and Rivers Commission of WA, cattle fences will be higher and require less electrified ('hot') wires than if the station runs sheep:

- cows and cattle generally only need one hot wire
- sheep require at least four hot wires.[182]

However, the South Australian Murray-Darling Basin Natural Resources Management Board argues that sheep require three wire fences, two hot and one earth, and that this is 'sufficient to contain most animals and in many cases two wires will do once animals are educated'. The South Australians agree that cattle will usually require only one wire.[183]

While most cattle will be held by one wire, a team from the University of Missouri-Columbia in the United States has produced a more detailed analysis of the number of wires required to contain different types of cattle, ranging from cows and calves to wilder, or harder-to-hold cattle. See the table below.

[181] Donald Pfost, James Gerrish, Maurice Davis and Mark Kennedy, *Managed grazing systems and fencing for distribution of beef manure*. Columbia, MO: University of Missouri-Columbia, USA, 2000: 8

[182] Water and Rivers Commission WA, *Livestock Management: Fence Location and Grazing Control*: 4

[183] Kylie Nicholls, Judi Earl, Lewis Kahn, Siwan Lovett, and Phil Price, *Planned Grazing Management. Land, Water & Wool Fact Sheet*. Canberra: Land and Water Australia, with the South Australian Murray-Darling Basin Natural Resources Management Board, 2007: 11

Table 9: Electric Fencing Standards for Control of Cattle

Animals to be contained	Number of wires in the fence	Wire spacing above the ground
Cows	1	26-32 (66-80 cm)
Cows and calves	2	18-24, 24-36 (45-60, 60-90 cm)
Hard-to-hold cattle	3	11-18, 23-30*, 34-44 (27-45, 60-75, 85-110cm)

* This wire could be grounded for very dry conditions or for sandy or gravelly soils (which have low conductivity) so animals will touch a hot wire and a grounded wire

Source: Donald Pfost, James Gerrish, Maurice Davis and Mark Kennedy, *Managed grazing systems and fencing for distribution of beef manure*. Columbia, MO: University of Missouri-Columbia, USA, 2000: 6

For the Missouri team, fencing is inextricably tied to grazing management systems. They note that permanent internal fences are required for fixed managed grazing systems, while portable fences are used for flexible grazing systems.

Fixed fencing systems

There may be interior divider fences and lane fences (for driving cattle towards yards or into a new paddock), with one or more high-tensile electrified wires for cattle, depending on the range of sizes of the animals to be restrained.

Benefits of fixed fencing

- minimal daily labour
- low maintenance
- low cost per acre/hectare on large installations.

Limitations of fixed fencing

- high cost per acre/hectare on small installations
- limited management flexibility.

Flexible fencing systems

A typical flexible or portable fence system may use electrified tape or polywire on a reel for the interior divider fences, supported on lightweight, step-in plastic posts. Tape shows up better to cattle, but may have a shorter life than polywire, because tape flutters in the wind and is therefore more subject to wear and tear.

Benefits of flexible fencing

- high management flexibility – ability to move stock to new pastures and fence them in easily
- low cost per acre/hectare on small installations.

Limitations of flexible fencing

- more labour – stock will need to be monitored closely due to the relative weakness of the fencing
- high maintenance costs.[184]

Whether a land manager will employ a more fixed or flexible approach to internal fences, or even use internal fences, is a management decision that will ultimately relate to decisions around grazing and stock management.

Other considerations for electric fences include voltage outputs and delivery systems for the electricity. On this point, similar issues arise as those for power sources for pumps. In the pastoral estate, the most efficient and cost-effective approach is solar, with battery storage for night-time. Another option is electrical mains, but the effectiveness and practicality of this option in remote areas is low.

According to the Missouri team, electrical output characteristics should match the length of the fence to be energised and the expected operating conditions, including dry soil and shorting from weeds and grass. The required voltage to deliver a shock depends on such factors as ground moisture, wire size, the total length of wire, the amount of vegetation contacting or likely to contact the wire, and the length of the hair or wool on the animals being fenced. As a general rule, they suggest that up to 4,000 volts may be required on all portions of the fence for extremely dry conditions or for well-insulated animals such as sheep.[185]

However, at least one Western Australian pastoral lessee uses electric fences on their Pilbara property in the following manner, and to good effect:

> a single wire no other wire including barb but he juices the fence up to 10,000V and trains the cattle in the yard before they go into the paddock. The yard is internally ringed with a single wire at 10,000V.[186]

Other options: a series of wires attached to insulators on an existing fence, either two or three with a charge of up to 10,000V … or lower charged. I much prefer the 10,000V model, until I forget the fence is live, but it is a good deterrent for all animals including LFH [large feral herbivores], nothing wants to go back for a second hit.

Virtual fences

The CSIRO defines virtual fencing as 'an animal-friendly fencing system that enables livestock to be confined or moved without using fixed fences'. The Commonwealth Government agency has developed a system for virtual fencing using collars with coordinates, wireless technologies and sensors to control the location of livestock without the need for physical fences.[187]

[184] Donald Pfost, et.al. *Managed grazing systems and fencing for distribution of beef manure*: 4

[185] Ibid.: 5

[186] Russell Shaw Email to Rob Edwards RE: Fencing, 13 May 2019. Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10506712

[187] CSIRO, 'Virtual Fencing', 21 March 2019 https://www.csiro.au/en/Research/AF/Areas/Livestock/Virtual-fencing?ref=/CSIRO/Website/Research/AF/Areas/Digital-agriculture/Virtual-fencing accessed 14 May 2019

Technology around virtual fencing has been available for some time. The Western Australian Waters and Rivers Commission noted in 2000 that virtual fencing was an 'economically viable and efficient alternative to traditional fencing for pastoralists'. The Commission states that stock are given ear tags, which 'emit an irritating sound to encourage them to stay outside a virtual exclusion zone', and the zone is created by 'a transmitting device which can be easily maintained and the boundary can be altered remotely'.[188]

The CSIRO version, which has benefitted from some 18-19 years of development, utilises a collar, rather than ear tags, but the principles are the same. Alongside the irritating sound comes an electrical shock, should the animal stray across the virtual fence. With time, the combination of 'non-aversive (audio) and aversive (electrical stimuli) cues … allow the training of [livestock] to avoid exclusion zones, while not compromising their behaviour and welfare'.[189]

Benefits

- Increased productivity and profitability through improved feed utilisation and better matching of animal demands to feed supply and quality
- improved environmental and sustainability outcomes such as reduced overgrazing and better weed control and nutrient management
- improved labour efficiencies and reduced capital investment in fencing.[190]

Limitations

Virtual fencing technology is not yet available for commercial purposes in Western Australia. Some concerns exist around animal welfare. The RSPCA in WA has reservations about any system that provides a shock to animals, or causes distress in any way, and this is a key element of the virtual fencing program – training the animal not to cross the virtual fence via audio cues and, ultimately, electrical shock.[191]

At present, it is available for use under experimental conditions in South Australia and Victoria, and for commercial purposes in Queensland and Tasmania.[192] Watch this space.

For general information on fence construction, see:

- DPIRD, 'Fencing for Beginners', DPIRD Website https://www.agric.wa.gov.au/small-landholders-western-australia/fencing-beginners?page=0%2C0

[188] Water and Rivers Commission WA, *Livestock Management: Fence Location and Grazing Control*: 4

[189] CSIRO, 'Subprogram 4: Using virtual herding technology to better manage sheep'. Dairy Australia Website: https://www.dairyaustralia.com.au/feed-and-nutrition/current-research/smart-farms/virtual-herding#.X8mPls7iuUk Accessed 13 September 2019

[190] CSIRO, 'Virtual Fencing', 21 March 2019 https://www.csiro.au/en/Research/AF/Areas/Livestock/Virtual-fencing?ref=/CSIRO/Website/Research/AF/Areas/Digital-agriculture/Virtual-fencing accessed 14 May 2019

[191] RSPCA, 'What is virtual fencing (or virtual herding) and does it impact animal welfare?' RSPCA Knowledge Base website: https://kb.rspca.org.au/knowledge-base/what-is-virtual-fencing-or-virtual-herding-and-does-it-impact-animal-welfare/

[192] Dairy Australia; Department of Agriculture and Resources, 'Virtual Herding Research Update', Issue 6, March 2019: 4 – see https://www.dairyaustralia.com.au/feed-and-nutrition/current-research/smart-farms/virtual-herding#.X8mPls7iuUk accessed 14 May 2019

For detailed information on all manner of infrastructure development and management matters, see:

- BW Carey, B Stone, PL Norman, P Shilton, Chapter 14: Property Infrastructure. In: Soil Conservation Guidelines for Queensland, Brisbane: Department of Science, Information Technology and Innovation, 2015, Web Version: https://www.publications.qld.gov.au/dataset/soil-conservation-guidelines/resource/51f7740c-2435-4209-a56c-e97ac8157850

Stockyards and holding paddocks

Stockyards and holding paddocks are essential infrastructure for a pastoral business. Stockyards are necessary for the good management of livestock, including mustering for sale, veterinary care, head counts, and other matters. Given their importance, and the fact that yards are some of the most heavily used areas on a pastoral station, great care needs to be taken in respect of their location and design. Further, due to the importance to safe handling of cattle, both for productivity reasons and occupational safety and health, there are a range of key aspects of stockyard design that must be included. These are discussed below.

Design

Locating and designing yards and holding paddocks is also an exercise in balancing the management needs of a property with the risk of erosion. Yards and holding paddocks are heavily used parts of the property and, like gates and laneways, tend to become bare and compacted leading to erosion problems. The following points should be considered when planning and constructing stockyards and holding paddocks:

- Locate stockyards centrally. Access to the major holding yard can be provided either by a laneway or through connecting paddocks.
- Ready access to a secure water supply will be required.
- All-weather access for stock transport will be required.
- Ensure there is security against theft of stock.
- Locate yards on soils that drain well. Avoid heavy clays—loams or sandy loams are best.
- Land should be relatively flat but a little slope is ideal for surface drainage.
- Orient stockyards so that prevailing winds will blow dust away from other facilities.
- Consider including some trees or other shelter for wind breaks and shade.[193]

When designing the stockyards, a number of safety elements must be considered, and many of these must take into account animal behaviour. For example, with cattle:

- Cattle have a 300 degree field of vision, meaning they can see threats from almost all directions.
- Cattle are natural herders, so if they see the herd beside them in a race or forcing yard, they will stop. Solid sides on races, loading ramps, and forcing pens can help keep cattle calm and moving.
- Cattle do not like to move towards bright light or shiny reflections so yard orientation should avoid situations where stock in the race, forcing pens, or on the loading ramp are moving directly into the sun or shadows and that the handler is not looking into the sun.

[193] Carey et. al., Chapter 14: Property Infrastructure: 22

- Cattle prefer to move back towards their paddock, so circular yards work better if the stock are moving back towards where they entered the yard.[194]

Key questions to ask of the design of a stockyard include:

- Are the yards large enough for the size of the herd to be handled in them?
- Do the yards have blind spots or areas where stock flow is restricted or cattle baulk?
- Do the drafting and forcing yards have a safe area or effective escape route for yard workers?
- Is the yard an appropriate size for the classes of stock being handled?
- Does the rail spacing allow safe access to animals for tasks to be undertaken such as vaccinating?
- Are all sliding gates sound, easily operated and capable of being secured so that they will not open if kicked or struck?
- Are watering points and troughs in sound order and positioned where they do not pose a trip, slip or fall hazard?
- Are there options for dust control, including water for sprinkler or irrigation systems?
- Are water pipes buried, or run overhead or along railing systems to avoid being damaged and so as not to create a trip hazard?[195]

Key elements of a cattle yard include:

- Holding yard - avoid corners so that the only place cattle will bunch is in the directions they need to move, such as towards forcing yards.
- Forcing yard - a half circle yard with gates that swing 300 degrees allow operators to push cattle up the race from behind the gate and at arms' length.
- The race - a curved race encourages cattle to move freely from one point to another but there are other race designs available. The ideal height is 1.5m and the recommended width between opposite posts is 675–700mm (plus the thickness of the rails).
- Loading ramp - ideally ramps should be 750mm wide between the rails. A ramp length of at least 3.5-4.6m will give the required rise to reach the ideal 1.2m loading height. A level section at least 0.8-1m long at the top of the ramp will encourage stock movement onto and off trucks.
- Ramp floors need to be non-slip and not cause a hollow noise. These can be stepped in concrete — allow a 450mm step length for every 100mm rise. Steel floors should not move or buckle under weight. Animals should not be able to see the ground below.

[194] DPIRD, 'Constructing Cattle Yards for Small Landholders', DPIRD Website https://www.agric.wa.gov.au/small-landholders-western-australia/constructing-cattle-yards-small-landholders Accessed 12 September 2019

[195] DPIRD, 'Constructing Cattle Yards for Small Landholders'

- Gate latches need to be positive bolt/ slam shut spring-loaded, especially in forcing yards. Chain and slot-style latches are more dangerous to operators but are a good addition in some parts of the yards to prevent cattle escapes. Latches should not protrude outside the boundary of the gate.
- Non-slip pressed steel or concrete catwalks beside forcing pens, races and loading ramps assist in animal husbandry operations.[196]

In smaller operations, some pastoral businesses establish trap yards. Trap yards encircle a water point and include a one-way entry point and a separate exit point, which is lockable. In these circumstances, livestock pass through the entry point to get a drink and, if required, can be trapped by locking the gate for a range of purposes, including:

- health checks / vaccinations
- pregnancy testing
- destocking for dry conditions
- sale of stock.

Figure 39: Cattle yard incorporating design elements for low-stress stock handling

Note: the curved, closed sides on the yards that prevent cattle from seeing out of the yard, facilitating smooth traffic of the cattle through the race and other areas

Source: Department of Primary Industries and Regional Development (DPIRD), 'Constructing Cattle Yards for Small Landholders', DPIRD Website https://www.agric.wa.gov.au/small-landholders-western-australia/constructing-cattle-yards-small-landholders Accessed 12 September 2019

[196] Department of Primary Industries and Regional Development (DPIRD), 'Constructing Cattle Yards for Small Landholders'

Trap yards are extremely efficient and much cheaper and easier than undertaking a muster. Trap yards can be as complicated or as simple as is required for the size of the business. A typical trap yard is designed as follows:

> The out trap for the yards is connected to the race, allowing the stock to either be placed in a simple crush, sent up the ramp onto trucks to market, or released if not transporting the animals.[197]

Benefits

- Quick and efficient handling of cattle in the yards, resulting in:
  - reduced stress on cattle
  - increased productivity
  - improved meat quality.
- Increased safety for handlers.[198]

Limitations

- Stockyards are significant investments and expensive up-front.
- A poorly designed stockyard will have the opposite effect to the intended benefits, so care must be taken when designing and building stockyards.

Figure 40: Example of trap yards on a pastoral station in the Southern Rangelands

Note: Left – the one-way gate; Right – Locked-in cattle have access to a water trough in the centre of the yard

Source: Rob Edwards 2019

[197] Rob Edwards, *20191111 File Note Bullseye Bulga Downs Field Days 6-7 November 2019*, Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10783245

[198] Ibid

Construction and Maintenance

Choice of material is essential for construction of stockyards. The yards must be sturdy enough to manage stock pressure, especially in areas such as gateways, forcing yard, and race. In the forcing areas and race, posts should be cemented into the ground, and, in some soils, cross-bracing may be required. The following are the minimum considerations for posts in these areas:

- Timber posts should be a minimum of 200mm diameter.
- Steel pipe should be a minimum of 75mm in diameter.

Resources

For more information about building stockyards, see the resources below.

Stockyards for cattle

- DPIRD, 'Constructing Cattle Yards for Small Landholders', DPIRD website https://www.agric.wa.gov.au/small-landholders-western-australia/constructing-cattle-yards-small-landholders?page=0%2C0
- https://futurebeef.com.au/wp-content/uploads/Cattle_yards_third_edition.pdf
- https://www.worksafe.qld.gov.au/safety-and-prevention/hazards/workplace-hazards/agriculture/stockyard-design
- https://futurebeef.com.au/wp-content/uploads/2019/04/Guide-for-safe-design-of-livestock-loading-ramps-and-forcing-yards.pdf
- Agriculture Victoria, 'Cattle Handling Facility 10-50', Agriculture Victoria website: https://agriculture.vic.gov.au/livestock-and-animals/beef/handling-and-management/cattle-handling-facility-10-to-50-head

This website provides blueprints for a basic cattle and effective yard design for between 10 and 50 head of cattle. Agriculture Victoria also has a guide to larger yards, designed for between 50 and 300 head:

https://agriculture.vic.gov.au/livestock-and-animals/beef/handling-and-management/cattle-handling-facility-50-to-300-head

Stockyards for sheep

- https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/286855/Circular-sheep-yard-design-and-construction.pdf
- https://www.worksafe.govt.nz/topic-and-industry/agriculture/working-with-animals/working-with-sheep/safe-sheep-handling-gpg

Good Pastoral Land Management
Guidelines

5 Grazing management

Contents

Grazing management entails the careful management of total grazing pressure on a pastoral lease, focusing on how livestock move and graze upon the natural vegetation in the landscape. The term also refers to how well land managers go about that task, and the methods they use. Managing grazing pressure is about ensuring pastures remain productive and are not overgrazed, thereby ensuring the sustainability of the resource upon which the pastoral business relies.

Overgrazing is a key contributing factor to land degradation. As noted in Chapter 3, when overgrazed, a pasture sees either an increase in unpalatable plants or loses its vegetation cover, becoming less productive and, ultimately, susceptible to erosion.

Figure 41: Bare ground due to overgrazing and severe gully erosion nearby, Kimberley Region, WA

Source: Rob Edwards 2019

This chapter provides information on how to manage grazing pressure and ensure that a pastoral property can remain productive, irrespective of the seasonal conditions. By managing grazing pressure and responding to seasonal conditions appropriately (and quickly), land condition can be maintained and/or improved.

There are many approaches to grazing management, some of which include:

- Set stocking, where stock levels remain constant, irrespective of seasons. Stocking rates should be set conservatively, meaning a rate not exceeding the carrying capacity for the property.
- Seasonal Tracking, where stock levels are adjusted depending on seasonal conditions and forage availability.
- Set utilisation, where stock levels are set by the forage available at the end of the growing season. Once livestock have been allocated to paddocks at the end of the growing season, they usually remain in place until the end of the next growing season (frequently used in tropical and sub-tropical savannah systems where there is a distinct summer growing season).
- Rotational grazing and spelling, where animals are moved from paddock to paddock, alternating between spelling and grazing.
- Opportunistic grazing, which is a less formal rotational system of opportunistic spelling, with forced destocking in drought, or rotation of stock between water points, as required.
- Tactical grazing, where stock numbers are adjusted in accordance with changes in seasonal and climatic conditions and plant growth, with a particular focus on the importance of perennial plants. Decisions are made based on plant and pasture condition scores.[199]
- Destocking is another option that must be considered, particularly in areas where a succession of bad seasons have occurred. The PLB allows for destocking a pastoral lease for up to five years to enable land to recover from drought, or in order for regeneration and rehabilitation works to be undertaken. Any period longer than five years must be approved by the PLB, in order to ensure that the land under the lease is being utilised for pastoral purposes.[200]

Some of these strategies are discussed in detail here, including methods of controlling grazing that have proven to be beneficial, or that are currently being tested with good results. Some of these may be higher-cost, such as rotational grazing, due of the level of investment in fencing that may be required, while others may be less so, such as rangelands self-herding, which operates mostly on animal behaviour rather than fences.

[199] Australian Wool Innovation Ltd., 'Making More from heep, Module 12: Efficient Pastoral Production', http://www.makingmorefromsheep.com.au/efficient-pastoral-production/procedure_12.4.html Accessed 21 May 2019

[200] For more details, see the PLB policy, Pastoral Lease Stocking Policy at: https://www.dplh.wa.gov.au/getmedia/a2c46f03-66af-4de8-b0dd-bb2701717548/POL-PLB-7-Stocking-of-a-Pastoral-Lease

Before implementing a grazing system, however, a business plan should be developed, and management objectives set. As noted in Chapter 3, having a clear understanding of the land systems, pasture types, water points, climate, hydrology, and geology of the pastoral lease being managed is essential.
A better understanding of the land under the lease will help inform the type of grazing management regime, and the infrastructure required to implement that regime.
Knowledge of the land will:

- Show where you can or cannot graze.
- Enable land to be fenced according to land type (see chapter 4 above).
- Enable the assessment of carrying capacity by determining the area available for grazing.
- Show the limitations of the land for other enterprises.[201]

Once an understanding of the land has been developed, a land manager should establish management objectives for the land. Since grazing areas controlled by waters or fences are the basic management units on pastoral properties, objectives need to be set for each.

> Objectives will generally focus on the pasture type that has the potential to contribute most to the pastoral productivity of the paddock. Only two broad objectives are possible: **maintenance** or **restoration**. If the main pasture type is already close to its potential for long-term animal production, or is in a condition from which it is unlikely to be able to change readily in response to grazing management, the appropriate objective would be to maintain it in its present condition. If the pasture is not close to its potential long-term productivity but has the capacity to respond to management, then restoration is the appropriate objective.[202]

In determining a strategy for achieving the objectives for a property and, consequently each paddock or grazing area, some common factors should be considered, including:

- the effect of defoliation on plants' ability to withstand drought
- the effect of soil cover on the rate of accelerated soil erosion
- the need for seeding opportunities to replenish the soil seed bank
- the likely benefit of plant species diversity for drought tolerance and recovery of pasture production;
- the effect of burning on woody shrubs of various ages
- the effect of heavy grazing on the competitive balance among plant species.[203]

[201] Department of Environment, Water and Natural Resources, *A Practical Guide to Rural Land Management: Course Booklet*, third edition. Adelaide: Government of South Australia, 2016: 4

[202] Ron Hacker, Luke Beange, Geoff Casburn, Greg Curran, Peter Gray, and Judy Warner, *Best Management Practices for Extensive Grazing Enterprises*, Orange: Department of Primary Industries NSW, 2005: 21

[203] Ibid

Even when factoring in these issues, remember that the semi-arid rangelands environment is highly variable, meaning grazing management 'cannot be based on simple recipes or implemented on calendar-based schedules'. Variable climatic conditions present pastoralists with both

> opportunities to progress towards the objective (for example, good seasons that favour germination or seed set of desirable species) and hazards that may push the pasture away from the objective (for example, drought, which may kill desirable species, or intense rainfall, which may cause excessive run-off and erosion). Strategies need to include the management principles that will allow both the exploitation of opportunities and the avoidance of hazards.[204]

Even in areas of more reliable and regular rainfall, such as the Kimberley, clear objectives and strategies should be established. For example, the 2018/19 wet season failed, meaning pastoralists in that region were required to implement contingency strategies to ensure stock were cared for and land condition preserved. The other key element to good land management, which is not the focus of this Guideline, is animal welfare. Good pastures, well-managed, lead to better animal welfare outcomes as well as a sustainable and profitable pastoral enterprise.

This chapter does not discuss management of feral or native herbivores that often increase grazing pressure. The previous chapter provides information on exclusion fencing, which can by keeping unwanted herbivores out of pastures, while other strategies for management of herbivores are analysed in Chapter 6.

[204] Ibid

Stocking rates in variable climates

The Western Australian Rangelands are characterised by variable climates, uneven rainfall and, in many areas these climates are semi-arid to arid. As a result, pastoral lessees must work with the climate, the productivity levels of the land systems and pastures on their leases, and seasonal conditions to determine the appropriate number of stock to run on their land. As shown below, there are different ways of determining the stocking rate on a pastoral lease, ranging from 'what dad used to do' to detailed scientific analysis of land system productivity, of feed on offer, response to rainfall, and computer modelling.

First, the methodology advocated by DPIRD for determining stocking rates is detailed, as this is the most widely utilised and accepted method in the State and is based on many decades of scientific research and analysis. Second, trigger points for adjusting stocking rates are discussed, with examples of the key indicators that inform stocking rate decisions from experienced pastoralists in different regions. Third, an alternative to the DPIRD system of determining stocking rates is proffered. Finally, a series of different grazing strategies are provided, each of which requires a varying degree of active management.

Understanding potential and present carrying capacity

Setting stock numbers is probably the most crucial decision a manager has to make. Often that decision will be guided by some very simplistic intelligence - 'what Dad did', 'what the previous owner suggested' or 'we've always used these numbers'. However, there are times when more objective guidance may be needed. The lessee may be opening up new land, moving on to a new property or just questioning what Dad did. Neighbours or previous owners are not always reliable. The number of stock on a property when offered for sale may be quite different to the long term sustainable stocking rate.

What resources are available and how can they be used to determine the stocking rate of a pastoral property or part thereof?

DPIRD has documented the Potential Carrying Capacity (PCC) of all pastoral leases in WA. The PCC is the theoretical number of stock the lease could carry in an average season if all the pastures on the property were in good condition and the lease was fully watered and accessible to stock, which is never the case. Therefore, the PCC is an overestimate of the actual carrying capacity of a lease. The PCC is determined by mapping the land systems on each lease and assigning a carrying capacity for each land system. The land system data is contained in the Land System Survey for the area.

To determine the actual carrying capacity of the lease, first the PCC must be discounted because pasture condition will not be good across the whole lease. Pasture condition was assessed and documented during the Land System Survey, and updated by regular Range Condition Assessments (RCAs). The latest RCA is available to the lessee by contacting the PLB, the Office of the Soil and Land Conservation Commissioner, or DPIRD.

These data define the pasture condition status of each land system on the lease and in that report, discounts are applied to each land system's carrying capacity to calculate Present Carrying Capacity (PrCC). The PrCC is the number of stock that can be carried in an average season with the pasture in its current condition and the property is fully watered and accessible to stock (i.e. a theoretical value). However, this does not provide the lessee with a realistic appraisal of the appropriate stocking rate for the property.

In the next step, a discount is applied for the degree of access stock have over the property – how well watered is the property – and the pastoralist should follow this process:

- Request a land system map of the property from DPIRD and identify working waters, including natural waters.
- Around each water, draw a 5-km circle (7850 ha) to indicate the watered componen.
- Then estimate the area of each Land System that is watered and apply the suggested stocking rate for each Land system.
- Remember to include the discounts for the surveyed pasture condition.

DPIRD can assist in this process by providing mapping information with associated areas by land systems. Lessees will need to provide up to date information on active water points and other infrastructure that may influence stock distribution, such as fences.

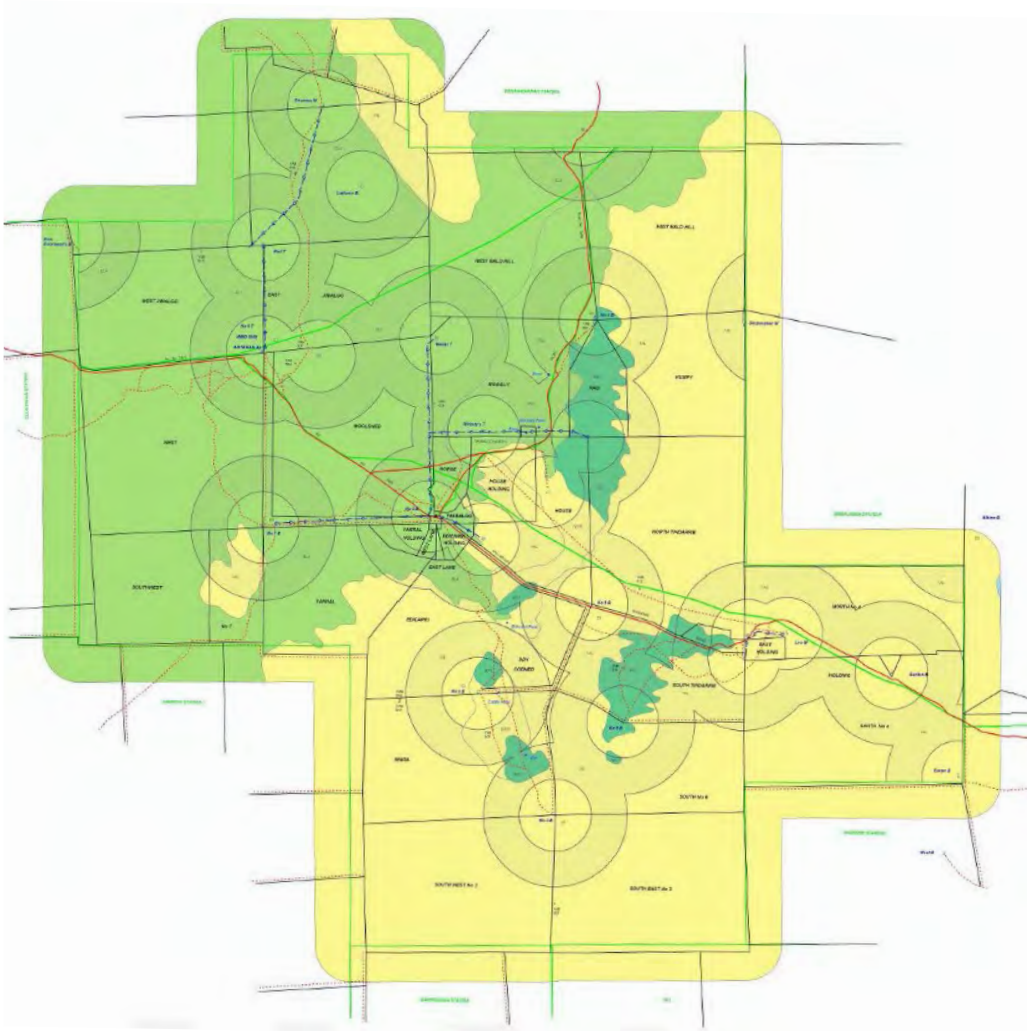
Figure 42 below is an example of a station map displaying land systems. The map provides details of the carrying capacity of each land system type, shows the average grazing radius for each water point (5 km), fences and other station infrastructure, including tracks and yards. The land system data for the map below includes:

- The dark green land system has very high carrying capacity, at less than or equal to 5ha/DSE or 35ha/CU.
- The light green land system has high carrying capacity, at 6 to 9ha/DSE or 42 to 63ha/CU.
- The yellow land system has low carrying capacity, at 20 to 29ha/DSE or 140 to 203ha/CU.

Table 10: Contact Information for RCAs and other Pastoral Lease Inquiries

Contact information for RCAs and other pastoral lease enquiries	
Pastoral Lands Board	plb@plb.wa.gov.au
Office of the Soil and Land Conservation Commissioner	08 9368 3282; commsoil@agric.wa.gov.au
DPIRD	08 9368 3333 enquiries@dpird.wa.gov.au

Figure 42: Pastoral lease map with land systems and grazing radii



Note: The different colours represent different land systems, and the rings on the map are grazing radii around water points

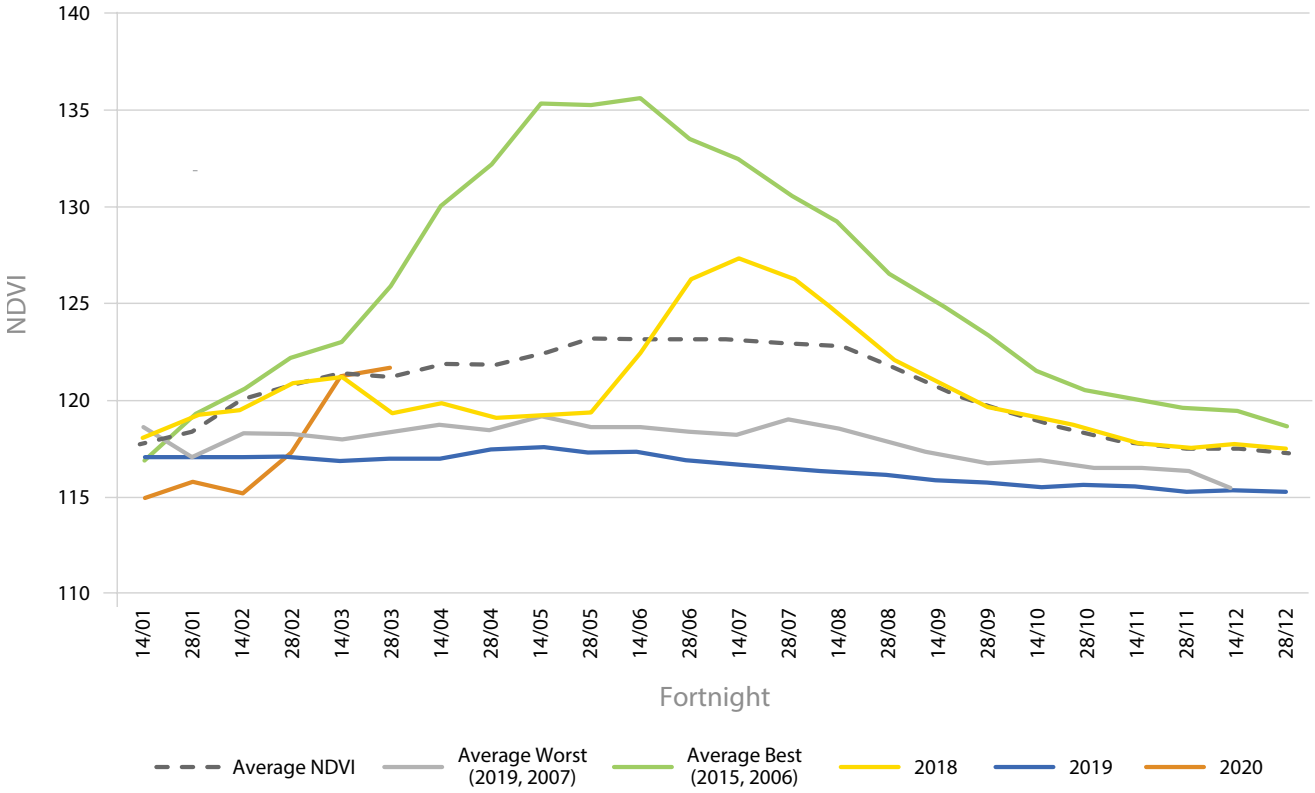
Source: Department of Primary Industries and Regional Development (DPIRD)

As can be seen, the data contained in the map will greatly assist in understanding the carrying capacity of the areas able to be grazed (i.e. those areas close to water), and where to focus efforts in terms of developing infrastructure to graze more of the land under the lease. For example, the map shows significant areas of the light green land system (high carrying capacity) that could support grazing with the development of new waters.

Once the stock number that can be carried in an average season has been calculated, the following factors must be considered in determining an appropriate stocking rate:

- seasonal conditions
- recent past, current and likelihood of rain in the near future based on seasonality or probability (i.e. no good hoping for rain in May in the Kimberley, it is highly unlikely) and long-range forecasts.

Figure 43: NDVI plot for a West Pilbara pastoral lease from 2004 to 2020



Source: Department of Primary Industries and Regional Development (DPIRD) Rangelands Team

A useful and readily accessible tool to put your current seasonal conditions into perspective is the NDVI (normalised difference vegetation index) plot for your property. The NDVI is a measure of greenness, which can be closely correlated with forage production. All you really need to know is where on the gradient from poor to good the current seasonal conditions sit.

Consider the following NDVI plot for a West Pilbara property (Figure 43).

The graph uses data from 2004 to 2020 and averages the NDVI value across all of the points (pixels) within the lease boundary, plotted every fortnight throughout the year. Lines on the graph show, over the year, the average of all years (black dotted line), the two best years (green line), the two worst years (grey line), the plot for the previous two years (2018 yellow and 2019 blue) and the current year to date (orange line).

Based on the previous 17 years, the plot tells us that for this property, the peak forage production is likely to be early winter, forage production does not really start until February, and highlights what an exceptionally poor year was 2019 with virtually no forage production. In 2018, a failed summer season was helped by effective winter rains for latter part of the year. Due to a poor 2019, 2020 has started from a low base, with little forage production until early March. Forage production has then climbed to an average value for the end of March.

Knowing where the land is on this plot, relative to other years, combined with other local parameters – how many stock on the land, their condition, the probability of rain – will allow seasonal adjustments to stocking rates and other management decisions to be made as the season progresses.

While NDVI gives an indication of current forage available, pasture condition is another important measure of pasture health. Pastures in better condition will produce forage of a higher nutritional quality. A good way to assess pasture condition change and evaluate your longer-term stocking rates, is to use monitoring sites, as discussed in Chapter 3. Regular monitoring of pasture condition will assist in determining whether stocking rates are appropriate, or whether adjustments are required. Determining whether and when to adjust stocking rates is discussed below.

Trigger points and stocking rates in variable climates

A number of Western Australian pastoralists and others, including a research scientist with the Northern Territory Government, have shared their decision points and considerations in respect of responding to seasonal conditions and feed on offer. Some general points emerged, which are summarised in the box below.

Key lessons about stocking rates and seasonal variability

1. **Hard-headed decisions are required.**
   While it is difficult, even heartbreaking, to destock or sell off your herd, doing so may be the only way to save your property for the long term. Hoping for rain is not a sound business strategy. Feed on Offer and seasonal conditions are key factors in these decisions.
2. **Land condition is key to improved production and resilience to climate variability.**
   Overgrazing is a recipe for long-term problems and declining productivity.
3. **Forward planning is vital to success.**
   Establish a plan and stick to it.

Case Study 1

At a forum in Karratha in late 2019, two pastoralists were discussing dry season responses. Both currently work in the Pilbara, while one of them owns a cattle property in Northern NSW, which was shut down due to the recent Eastern States drought. The New South Welshman noted the following:

> He noticed two years ago that the long-range forecast was not looking good, and that started a series of triggers for him. He has three fundamental triggers:
>
> 1. budget
> 2. long-range weather forecasting
> 3. cattle score.
>
> His process, below, is robust and focussed, leaving little room for sentiment in decision-making.
>
> **1. Budget**
>
> a. Feed is very expensive, and you can go broke if feeding the cattle to maintain them. Buying in feed means you can end up 'buying the cattle 2-3 times over', making it uneconomical.
>
> b. A major problem is the ongoing cost of vermin and weed management.
>
> c. In this drought, he was fortunate that the price of cattle has meant they have been able to make money on selling their cattle.
>
> **2. Long-range weather forecasting**
>
> a. When it was clear the seasons were not turning in his favour, he sold all the cows, withdrew the farm management deposits and shut down the farm.
>
> b. When good seasons return, the property will be used as an agistment block before rebuilding the herd.
>
> **3. Cattle score**
>
> a. The property will not be restocked until one full year of good pasture growth is received.
>
> b. The business model is to maintain the herd at score 3,[205] and he ensured the cattle were at score 3 before he sold them. The business plan was adhered to.[206]

[205] For information on cattle score, see: https://futurebeef.com.au/knowledge-centre/body-condition-score-for-beef-cattle/

[206] Rob Edwards, *20191122 File Note: Mardie Station Tour and Pilbara Land Managers Group Meeting 18-19 November 2019*, Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10793685

Case Study 2

The Northern Territory Government research scientist from Old Man Plains research station, near Alice Springs, notes that grazing budgets are essential to the success of any grazing enterprise. Indeed, the main takeaways from his presentation to producers at a field day were:

1. **Land capability must match to feed requirements**

   Stock feed requirements and the lands ability to feed them must be well-balanced, otherwise land condition will decline and stock condition will decline, leading to adverse outcomes for the business.

2. **Land condition is key to improved beef production and climate variability resilience.**

   Good land condition is vital to ensure point 1 is realised, while also ensuring that pastoral businesses are able to endure the regular periods of low or no rainfall (followed, often, by floods) typical of most parts of the pastoral estate. Good land condition enables water to be absorbed efficiently into the soil, leading to rapid response from plants, growth in pasture, and, ultimately, well-fed and healthy stock.

3. **Land condition improvement can coexist with livestock production.**

   Careful management of stock numbers (grazing pressure) and grazing regimes can lead to improvements in land condition, while ensuring that the business returns a profit.[207]

In addition to these perspectives, the box below provides a series of ten questions that Ashley Dowden, Pastoral Lands Board member and Lessee of Challa Station, asks when considering how to respond to variable rainfall and pasture growth.

[207] Rob Edwards, *20191111 File Note: Bullseye Bulga Downs Field Days 6-7 November 2019*, Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10783245: 3-4

Forage budgeting and carrying capacity: Ten questions

1. What time of the year is it and when are you expecting your main rainfall season, e.g.; in your area you may expect a predominantly winter season and you may be mustering at the end of winter when stock are at their best. If you are not expecting any significant summer rain you should have a pretty good idea how much feed you have on offer and thus how many you should carry through. If practical, it can be useful to adjust your mustering times to suit your seasons.
2. What was your season like last year? How much rain did you have, and did you have any carry over feed or not? Also, you may need to consider preceding years.
3. How many stock did you carry through last year and in preceding years, in relation to your current carrying capacity and recommended carrying capacity? You may only have 60% of your carrying capacity on the property.
4. What condition is your stock in now and how many are you expecting to sell off in your normal production system. If animals are light but still good enough to transport and you are not expecting any significant rain, then remove stock now. Either sell, agist or finish elsewhere.
5. How well watered is your property and are all your water points operating to full potential?
6. What percentage of the land can be utilised from operating water points? If water is limited, then you may only be able to utilise 50% of your property.
7. Do you have options to remove stock outside of your normal production cycle, e.g.; if you normally muster over winter, can you trap over summer to reduce numbers quickly if required?
8. Do you have options of where to send stock if not suitable for market but need to be removed from your property, e.g.; too poor or not heavy enough to meet specific markets?
9. Will you have an option of buying in or producing fodder at a realistic price, to feed out or finish stock so they can be either kept or sold?
10. Have you got hay on hand? If you use 100 bales of hay a year in your normal production system, then buy it in the hay season when it is available or at its cheapest. Don't wait until the week before you need it and find that none is available or it costs a fortune.[207]

[207] Ashley Dowden, 'Southern Rangelands Stock Numbers in Dry Times', Challa Station, 2019. Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – ***Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)***, document no: A10717416

For more information on this issue, Meat and Livestock Australia (MLA) has a training module for pastoralists, entitled Drought Management Decision Points, which contains information to assist pastoralists in making decisions on what actions to take, including financial considerations. See the link to the module below:

- https://mbfp-pastoral.mla.com.au/setting-directions/tools/tool-1.06-drought-management-decision-points/

Understanding forage budgets and carrying capacity

While DPIRD can provide a good guide to the carrying capacity of a lease, pastoralists still need to understand how to calculate the amount of forage available in the areas within the grazing radius of a water point, particularly given the need to calculate the 'discount' for land not in optimal condition. Forage budgeting, or matching available feed to livestock dietary requirements, demands land managers understand the amount of feed livestock consume, which differs depending on a range of factors, including:

- gender
- age
- pregnancy/lactation status
- condition and body weight
- quality of feed
- density and quantity of feed
- water supply and quality
- seasonal conditions.[209]

Table 11: Animal Type and Daily Feed Consumption Rates

Animal type	Rating (Cattle Unit*)	Average weight	Kg/day feed consumed
Dry cow/steer	1	450kg	10
Weaner	0.5	200kg	5
Bull or camel	1.5	650+kg	15
Pregnant cow/ cow with Calf	1.5		15
Horse	1.25		12.5
10 kangaroos	1		10

* Note: Original rating (Adult Equivalent) was altered to reflect the Western Australian standard measure, Cattle Unit. Measuring units are equivalent, even if estimated grazing impact differs (see table below)

Source: McClelland Rural Services, *Managing Indigenous Pastoral Lands, Module Five: Grazing Land Management*. Rural Industries Research and Development Corporation, 2014: 8

[209] DPIRD, 'Livestock Comparisons for Estimating Grazing Pressure in the Rangelands', DPIRD Website https://www.agric.wa.gov.au/rangelands/livestock-comparisons-estimating-grazing-pressure-rangelands Accessed 14 August 2019

Feed requirements of livestock

For a basic calculation of the amount of forage consumed by livestock, the table below provides information on cattle. Authorised stock in Western Australia are measured according to two main measures: Dry Sheep Equivalent (DSE); and Cattle Units (CU). DSE is utilised for small livestock (sheep and goats), and CU for cattle. In general, 7 DSE is the equivalent of 1 CU, although DPIRD cautions against using that formula at all times, because 'Brahman and European breeds of cattle have quite different energy requirements, and a single conversion is not accurate', and can lead to errors.[210]

For detailed information on consumption rates for sheep and cattle, see the DPIRD Website:

https://www.agric.wa.gov.au/rangelands/livestock-comparisons-estimating-grazing-pressure-rangelands.

DPIRD's analysis of sheep and cattle provides additional, and more detailed, information on livestock weights, but does not provide an estimate of the average amount of feed consumed in kilograms. Rather, it discusses megajoules of metabolisable energy, which requires detailed understanding of the energy provided by different pasture types.[211] While this is a more accurate and provable formulation, it does create greater complexity for the producer who is seeking to determine the amount of feed available on the land under the lease. As a result of a desire to reduce complexity, the industry standard animal used for an adult equivalent or cattle unit is 'a 2.25 year old, 450kg Bos Taurus steer at maintenance, grazing a 7.75 MJ ME/KG DM diet and walking 7.0 km per day',[212] where ME/KG DM means metabolisable energy per kilogram of dry matter. The assumption of 'maintenance' means the animal neither gains nor loses weight.

For more information on determining the feed requirements of livestock, see the MLA website:

https://www.mla.com.au/research-and-development/Grazing-pasture-management/

This information is particularly relevant for the land manager who has implemented or is contemplating implementing a rotational grazing system. This data is required to estimate the number of days or weeks a herd should be kept in a given paddock, or determining whether a reduction in stock numbers or complete destocking is required. DPIRD also provides more detailed estimates of the equivalent grazing impact of native and feral herbivores, which are just as vital as estimates for livestock. The table below refers:

Calculating the amount of Feed on Offer (FOO)

Calculations of the amount of feed available are also instrumental in determining an appropriate stocking rate. This can be undertaken in a variety of ways, including:

[210] DPIRD, 'Livestock Comparisons for Estimating Grazing Pressure in the Rangelands'

[211] DPIRD, 'Livestock Comparisons for Estimating Grazing Pressure in the Rangelands'

[212] Ian McLean and Shane Blakeley (Bush Agribusiness Pty. Ltd.), *Adult Equivalent Methodology: A methodology to accurately and consistently calculate cattle grazing loads in northern Australia* – Final Report. North Sydney: Meat & Livestock Australia, 2014: 10

Table 12: Livestock Equivalents for other Grazers and Browser

Livestock equivalents for other grazers and browsers		
Other Grazers	Annualised DSE	Annualised CU
Horses and Camels: small (450kg)	11.0	1.6
Horses and Camels: large (635kg)	14.0	2.0
Donkey	7.0	1.0
Kangaroo	0.7	0.1

Source: Department of Primary Industries and Regional Development (DPIRD), 'Livestock Comparisons for Estimating Grazing Pressure in the Rangelands', DPIRD Website https://www.agric.wa.gov.au/rangelands/livestock-comparisons-estimating-grazing-pressure-rangelands Accessed 14 August 2019

- by eye (experienced land managers)
- understanding the land systems, pasture types, their pastoral potential, and the condition of those pastures (see chapter 3 and the DPIRD Methodology section above)
- by using satellite analysis tools, such as NDVI and VegMachine to provide information on bulk feed and land condition
- by seeking the assistance of an independent Rangeland Consultant.[213]

The key elements of a forage budgeting process include:

- calculate how much edible forage exists in the paddock
- decide how much needs to remain after the animals are taken out in order to maintain pasture condition and ground cover
- nominate the proportion of the pasture that is to be consumed in that time period
- work out how much each animal will eat per day
- decide how long the animals are to stay in the paddock
- calculate how many animals can be safely run for that period.[214]

Further, pastoralists should monitor their pastures closely when determining a response to seasons, rather than focus on livestock condition. The MLA observes,

[213] McClelland Rural Services, *Managing Indigenous Pastoral Lands, Module Five: Grazing Land Management*. Rural Industries Research and Development Corporation, 2014: 6-7

[214] Department of Environment and Resource Management, *Managing Grazing Lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 8

> If you wait until your livestock begin to deteriorate there may be a greater investment in time and energy to get the stock back into condition. Further, the time lag in stock displaying a loss of condition and a decline in vegetation condition means that the paddock should have been spelled much earlier.[215]

The focus on monitoring pastures has two vital purposes, relating to decision points and forage budgeting:

- feed on offer at any given time
- land condition.

If a pastoralist is aware of the amount of feed available on the land at any given time, good decisions about responding to seasons can be made, leading to better land condition and land management outcomes.

There are a number of methods for determining Feed on Offer (FOO), but the most accessible, low-technology solutions are either the cut and measure method, outlined below or the use of a ruler, such as those described on the Future Beef Website (https://futurebeef.com.au/knowledge-centre/dry-season-pasture-budget-a-guide-for-stocking-rates/) or the MLA website (https://www.mla.com.au/research-and-development/Environment-sustainability/Sustainable-grazing-a-producer-resource/grazing-management/Pasture-utilisation/).

[215] MLA, 'More Beef from Pastures – Pastoral: 2 – Managing your feedbase'. MLA Website: https://mbfp-pastoral.mla.com.au/managing-your-feedbase/ Accessed 16 September 2019

Table 13: Determining Feed on Offer – Cut and Measure Methodology

Determining Feed on Offer – cut and measure methodology	
1	Find an area that is representative of an average area of grass in the paddock and, using a calibration ring or similar device that measures 0.1m^2 in area, cut all the grass within the calibration ring as close as possible to the ground (See Figure 44 below).
2	The harvested sample is collected in a bag and can then be weighted, before being oven dried at 100oC and re-weighed once dry to determine Feed on Offer (kg DM/ha). A good set of kitchen scales, accurate to 1g, with a tare function is required to ensure all measurements are accurately recorded
3	Using the entire sample acquired, chop the sample down into 3-4cm pieces using scissors or secateurs
4	Place an empty takeaway food container (or similar) on the scales, allow it to settle until the weight appears on the display. Hit the tare or zero button and record the weight (A)
5	Place the chopped-up sample into the container and then record the weight on the scales (B)
6	Place the sample into the oven as described at 2 above, preferably on a baking tray with baking paper to prevent sticking
7	Stir sample and dry for a little longer to ensure the whole sample is completely dry
8	Using the same process as in b. and c., weigh the sample and record the weight (C)
9	To calculate Food on Offer: Empty container (A): 25g Container + dry sample (B): 40g **B – A = 15g.** **15g of dry matter/0.1m2 = 150g/m^2.** **Dry matter/ha (10,000 m^2 in 1 ha) = 1500kg DM/ha (0.15kg x 10,000 m^2).**[216]

[216] Dynamic Ag Consultancy, 'Estimating Food on Offer (FOO)', http://www.dynamicag.com.au/wp-content/uploads/2015/12/FOO-fact-sheet-v2.pdf

Figure 44: Calibration ring on green grass and trimmings of green feed for determining FOO

Source: Left – Steve Cotton, Dynamic Ag Consultancy; Right – Australian Wool Innovation Limited. 'Estimating Food on Offer (FOO)', http://www.dynamicag.com.au/wp-content/uploads/2015/12/FOO-fact-sheet-v2.pdf

Depending on growing conditions and climate in the region in which a lease is situated, as well as the grazing regime being implemented on a given pastoral lease, the process of calculating feed on offer may need to be repeated on an annual or half-yearly basis, or perhaps more frequently.

Other methods, such as photographs of sites within a paddock or determining FOO by use of an experienced eye, may be utilised, but these invariably will require occasional verification via weighing dry matter, using the methodology outlined above.

There are several remote sensing tools available to calculate feed on offer and, consequently, determine current carrying capacity on a pastoral lease, such as VegMachine, NDVI, and GRASP. Most of these tools cannot be used in the Southern Rangelands, due to a range of difficulties in determining dry matter/hectare where shrubs and mulga predominate; nor are they calibrated for all pasture types found in the Western Australian pastoral rangelands. Some pastures in the tropical savannahs of the Kimberley have been calibrated for these tools,[217] while the grasslands of the Pilbara, particularly the Buffel grass pastures, are obvious candidates for calibration.

However, other pasture areas have received scant attention, as David Blood, a Rangelands Scientist and ex-DPIRD employee notes:

> The fact is there are perhaps less than 50 sites across the entire rangelands where average and peak pasture biomass production has been measured reliably….

[217] See, for example, R Dyer, L Cafe, and A. Craig, *The AussieGRASS Northern Territory and Kimberley Rangelands sub-project Final Report*. Brisbane: Queensland Department of Natural Resources and Mines, 2001g

What data exists is also highly skewed towards the most productive landscapes rather than representative pasture types – i.e. there are no sites in stony hill/ plains pastures which occupy 60% of the Gascoyne, 40% Ashburton etc. etc. Until we have reliable benchmarks for all grazed landscapes, there is no way you can extrapolate from GRASP to these highly heterogonous landscapes.[218]

Therefore, a significant research and analysis agenda would be required to take advantage of existing remote sensing tools. However, much of the data likely already exists in the comprehensive surveys of the pastoral estate undertaken by DPIRD scientists over the last 40 or more years, the pasture identification field guides, and other documents, which could be aggregated with climatic data, per the GRASP model.[219] See the text box below for more details on GRASP.

GRASP: An example of a detailed pasture growth modelling system

GRASP is a simulation model for soil-water, pasture-growth developed for northern Australia and rangelands pastures. The GRASP modelling program operates through a user-friendly interface known as the GRASP Calibrator, which includes a number of critical features required by users, including:

- The capacity to easily run simulations for different land-types and climate stations
- Graphical display of all variables simulated by the model, including soil water, hydrological components, pasture growth, dry matter flow, nitrogen uptake and concentration, tree water use and other tree attributes, stocking rate and other grazing variables, and aspects of degradation risk (utilisation and soil loss)
- Conditional probability analysis of simulated variables especially pasture growth
- Graphical comparison of observed and simulated variables with statistical analysis, which are particularly important for analysis of pasture growth and grazing trial data
- Growth analysis in which measured pasture growth is graphically compared to a range of variables (such as 'simulated growth index'), hence facilitating parameterisation of the data set.

A key limitation of the usefulness of GRASP, assuming the data becomes available for the entire WA pastoral estate, is likely to be the need for a pasture or rangelands scientist to interpret the data.

[218] David Blood, Personal Correspondence (email) to ob Edwards, 5 February 2020

[219] Queensland Department of Environment and Resource Management. *Improving Grazing Management Using the GRASP Model*, Final Report. North Sydney: Meat and Livestock Australia, 2010

However, a program based in Queensland, Aussie Grass (https://www.longpaddock.qld.gov.au/aussiegrass/) can provide information on projected pasture growth, based on seasonal conditions, across the Western Australian pastoral estate. While this may not provide detailed analysis of the actual or projected growth of pasture in respect of the nutritional data that GRASP can provide, it does give an indication to pastoralists of the likely rate of growth for their pastures in response to a particular season.

Due to the difficulty in interpreting data produced by GRASP, the Queensland Government developed a tool called FORAGE, which provides Pasture Growth Alert Reports at the property level. A Property Growth Alert Report can be used to assist in stock and property management decisions to increase property resilience to drought and help to identify pasture recovery opportunities by assessing the property's:

- last 12 months pasture growth
- pasture growth forecast for the next 6 months
- the monthly total cover percentile.[220]

Pasture Growth Alert Reports include:

- background information for current and historical property context
- a pasture growth and resilience indicator showing the risk level of reduced pasture growth and pasture resilience for the next 6 months
- a summary of factors contributing to the risk level of reduced pasture growth and pasture resilience
- modelled pasture growth graphs for last 12 months and next 6 months
- a monthly percentile cover map showing how the property compares with the historical cover record for the same month
- 12-month regional rainfall and modelled pasture growth percentile maps (i.e. relative to history) to provide spatial context of the property to the local and surrounding shires
- suggested management considerations to support each different level of risk.[221]

This type of data, at the property scale, could prove invaluable to a pastoralist developing a grazing management plan, determining whether to increase or reduce herd size. Below is a link to the Queensland Government website, containing detailed information about FORAGE and an example of a Pasture Growth Alert Report:

https://www.longpaddock.qld.gov.au/forage/report-information/pasture-growth-alert/

Detailed information on rainfall and pasture growth response can assist in determining how to handle stocking rates on a pastoral lease. However, given the lack of detailed data on pasture growth rates in response to seasons in the Western Australian context

[220] Queensland Government, 'Pasture Growth Alert Report', The Long Paddock Website: https://www.longpaddock.qld.gov.au/forage/report-information/pasture-growth-alert/ Accessed 19 February 2020

[221] Ibid

that might be used in a FORAGE-style program, the best method at present to determine the amount of Feed on Offer is the manual method described above. Determining stocking rates, as will be shown below, can occur either by utilising the FOO methodologies, or by engaging with the DPIRD Rangelands Team.

Determining the stocking rate

To determine stocking rates, you need to know how many cattle units you have on your lease, what their feed requirements are for the objectives you have set for your business and how much feed is available to them. This may seem easy, but it is not as simple as it sounds.

The current leading methodology for determining stocking rates, or grazing load, is the MLA's Adult Equivalent Methodology. The methodology provides for a series of scenarios to assist the pastoralist in determining the amount of feed required for the specific requirements of an animal at various stages of the production cycle, ranging from maintenance to growth, pregnancy to lactation, and calf feeding requirements.[222]

At its core, Adult Equivalent calculations are about determining how much food livestock require either to maintain their current condition or gain condition, based on their weight and/or phase of life cycle (pregnant, calf, etc.). Therefore, knowing how much food is required for your goals for livestock is one of two key factors for successful and sustainable pastoral businesses, alongside knowing how much feed is available for stock (see above).

As seen in the Feed Requirements of Livestock section above, the Adult Equivalent model uses a fixed diet quality of 7.75 MJ ME/KG DM at maintenance per Cattle Unit, and each Cattle Unit requires 72.6 MJ ME/day, or 9.36KG of dry matter per day to maintain condition.[223] The Adult Equivalent Methodology provides equations for measuring energy requirements for growth, pregnancy, and lactation as well.[224] However, the standard measure for determining the carrying capacity of a block of land is Cattle Units at maintenance.

Therefore, if a Cattle Unit requires 9.3KG of dry matter per day at maintenance, calculations of carrying capacity will follow thus:

[222] Ian McLean and Shane Blakeley (Bush Agribusiness Pty. Ltd.), *Adult Equivalent Methodology: A methodology to accurately and consistently calculate cattle grazing loads in northern Australia* – Final Report. North Sydney: Meat & Livestock Australia, 2014

[223] Ibid.: 3

[224] Ibid.: 7-10

Figure 45: Calculating feed on offer and grazing time in paddock

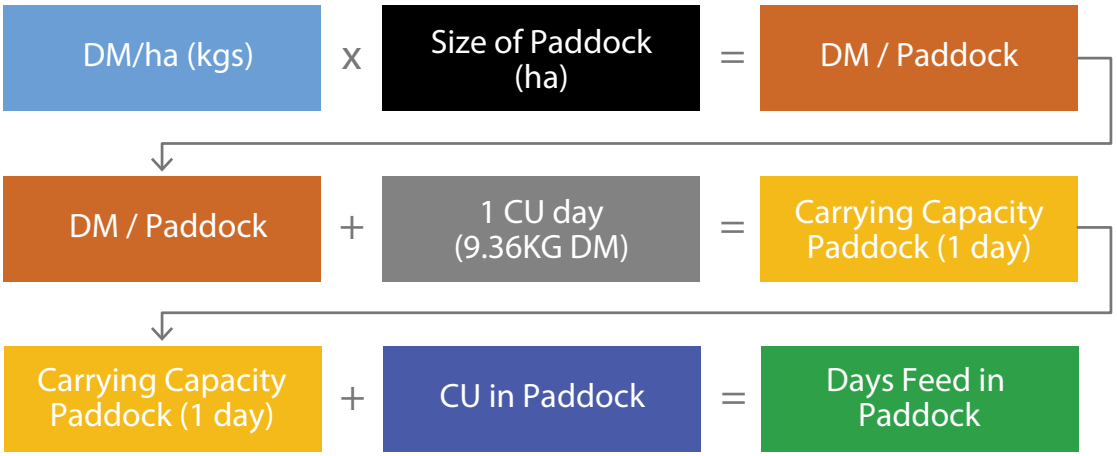
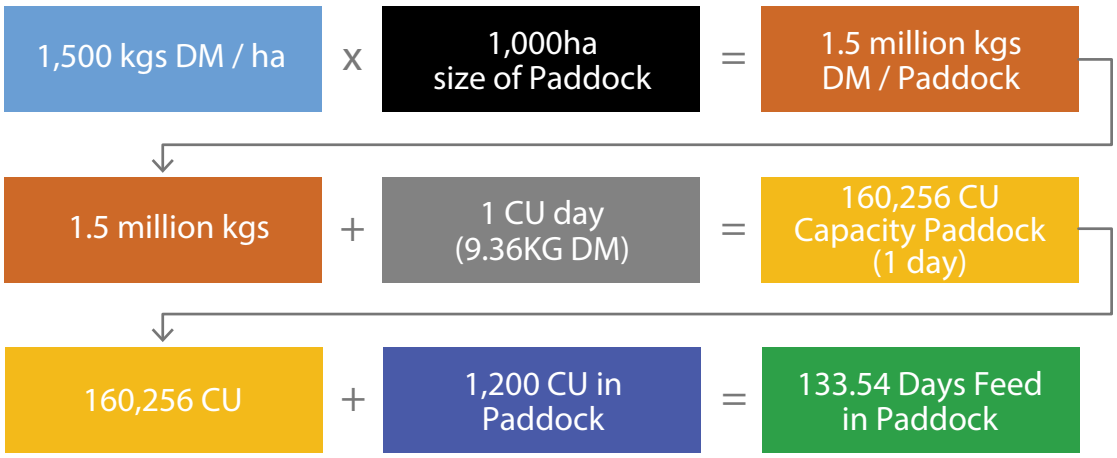


Figure 46, below, provides an example of how the calculations shown above is made. In the example, the following numbers are used:

- DM/ha = 1500kg
- Size of Paddock = 1000ha
- 1 CU daily feed requirements = 9.36kg DM
- CU in Paddock = 1200

The DM/ha amount was derived from the example in the Calculating Feed on Offer section above, while the size of the paddock was determined for ease of calculation. The CU daily feed requirements were derived from the MLA's Adult Equivalent Methodology.

Figure 46: Example of calculating feed on offer and grazing time in paddock



This process can then be replicated across the lease, or at least the paddocks that a lessee is planning to use for whichever grazing regime is intended, or for the 5-km radius around a water point, per the DPIRD Methodology.

Note that the final number of days of feed in a paddock is the **maximum amount of days feed**, at which time the feed would have been **completely eaten out**. Therefore, when calculating the number of days to leave cattle in a paddock, pastoralists should consider moving cattle out of a paddock well before the maximum number of days is reached. This will ensure the health of the pasture and allow it the best chance to recover and grow again for future use. For further discussion of the benefits of grazing management planning and implementation, including the importance of forage budgeting, see the next section.

Responding to seasons: conservative stocking, spelling pastures, rotational grazing, and managing stock numbers

A key element of good grazing management is the ability to respond quickly to seasonal changes, good rainfall or long periods of dry weather or drought. Having a strategy for grazing management, stocking rates, and utilising the Feed on Offer will greatly assist in achieving the twin goals of profitability and sustainability for any pastoral business. Any grazing management strategy or plan must account for seasonal conditions, which are beyond a land manager's control. However, land managers can manipulate grazing pressure to capitalise on the natural ecological processes within pastures on a paddock scale, while also minimising damage to the landscape. Land managers should consider careful management of grazing pressure as part of the way they respond to seasonal conditions.

Conservative stocking

Conservative stocking is a strategy that has been tried and proven in a range of different environments. Conservative stocking means running fewer cattle than the recommended carrying capacity (in WA, DPIRD has produced potential carrying capacity numbers for every pastoral station – see above), or fewer than the capacity that a pastoralist has determined, based on the formula and process shown above.

Evidence for the benefits of a conservative stocking strategy can be found in the MLA Final Report on the Wambiana Grazing Trial Phase 3, which analysed stocking strategies for improving carrying capacity, land condition and biodiversity outcomes over a 20-year period. The trial also compared the financial benefits of several stocking strategies, all of which demonstrated that good financial outcomes and good land condition outcomes go hand in hand.[225]

The key stocking strategies trialled were:

- **Constant moderate stocking –** continuously stocked at the estimated long term carrying capacity of the site to achieve an average of around 20-25 per cent utilisation of expected pasture growth. Initially the areas utilising this methodology were stocked at an average of 10ha/adult equivalent, increased to 8ha/animal equivalent.
- **Rotational wet season spelling –** paddocks divided into three equal subsections with one sub-section spelled each year for the full wet season. Initially stocked at 6.5ha/adult equivalent, this was later reduced to 8ha/adult equivalent as a result of a fire and subsequent drought.
- **Heavy stocking rate –** continuously stocked at about twice the long term carrying capacity to achieve an average of 40-50% utilisation of

[225] Peter O'Reagain, John Bushell, Lester Pahl and Joe Scanlan (Queensland Department of Agriculture and Fisheries), *Wambiana Grazing Trial Phase 3: Stocking Strategies for Improving Carrying Capacity, Land Condition and Biodiversity Outcomes*. Final Report. North Sydney: MLA 2018

expected pasture growth. Initially stocked at 5ha/adult equivalent, but this was increased to 4ha/adult equivalent for 5 years, before being reduced to 6ha/adult equivalent for three years due to low rainfall and extreme scarcity of forage.[226]

The key lessons from the Wambiana grazing trial in respect of profitability include:

- The most consistently profitable and sustainable methodologies were those for constant moderate stocking and rotational wet season spelling, both of which ran at long term carrying capacity.
- The least profitable and sustainable methodology was heavy stocking rates, where individual weight gains and carcass values were substantially lower than the two methodologies discussed above.
- Total weight gains per hectare were highest in heavy stocking rate, however, this required expensive drought feeding in six of the 20 years of the trial
  - partial drought feeding was required only once in 20 years in the other strategies.
- Average gross margin in the heavy stocking rate trial was by far the lowest ($5/ha/yr) and barely half of that in the other strategies ($10-13/ha/yr).
  - this was a direct result of higher costs due to drought feeding and other factors.
- Variability of annual income was by far the greatest in the heavy stocking rate trial with negative gross margins in nine of the 20 years:
  - Accumulated gross margins over 20 years for heavy stocking rates was $106/ha
  - Accumulated gross margins over 20 years for other strategies was $250-260/ha
  - Scaled to a 25,000ha property, this is around a $3 million advantage to the other strategies.[227]

Regarding land condition, the following lessons were drawn:

- Wet season spelling and constant moderate stocking were both sustainable, maintaining a high proportion of palatable, productive, perennial (3P) grasses.
- Heavy stocking rates was not sustainable, with the proportion of 3P grasses declining and the proportion of 2P species increasing significantly with time.
- Flexible stocking was proven to be advantageous over fixed stocking during the most recent drought, with both the wet season spelling and constant moderate grazing areas requiring destocking in January 2018.[228]

[226] Ibid.: 12

[227] Ibid.: 3

[228] Ibid: 3-4

For a copy of the report, and all the other research undertaken at Wambiana over the length of the study (20 years or more), see the Future Beef website: https://futurebeef.com.au/projects/wambiana-grazing-trial/.

Modelling, based on and together with the detailed long-term research under this trial demonstrates that 'profitability and land condition will … be maximised with flexible stocking around long term carrying capacity with stocking rates adjusted in a risk-averse manner, coupled with wet season spelling'.[229]

The success of continuous moderate stocking in maintaining land condition is borne out in a Western Australian context by the grazing strategy employed by a lessee near Meekatharra. They have been running fixed stocking numbers below those recommended by DPIRD, and have never had any concerns relating to rangeland condition in the 30 years they have held the lease. As the pastoralist noted, the DPIRD recommendations are effectively at the limit of what is sustainable. In his view, 'long-term sustainability of the lease requires conservative stocking and a concentration of the quality of the animals produced, rather than quantity'. One crucial observation he made, of relevance to all pastoralists, was that he 'cannot control the rangelands' but he does control the number of stock they run on the land.[230]

Pastoralists cannot control the rangelands, but they can control the number of stock they run on the land

Spelling pastures

Spelling pastures is a proven strategy for grazing management. Resting paddocks may even be a key strategy for specific seasons, regardless of the amount of rain received. Increasingly, scientific literature is demonstrating significant benefits to resting land, particularly during the growing season for perennial grasses.

Design

Shulke provides examples of two separate types of spelling programs:

- Large paddocks being spelled for a significant period of the growing season, such as a four-paddock rotational spelling program, where each paddock gets spelled for a full wet season once every four years.
- Smaller paddocks can be spelled for shorter periods by rotation, provided livestock do not return to those paddocks for around six to eight weeks.[231]

Benefits of spelling pastures

- perennial grass root stock recovery when spelled

[229] Ibid.: 4

[230] 20190315 File Note Fact Finding Field Trip 1 – Gascoyne-Murchison-Pilbara – Good Pastoral Land Management Guidelines 11-15 March 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019: 9; 13

[231] Bill Schulke, 'Pasture Management for Drought ecovery', Future Beef https://futurebeef.com.au/knowledge-centre/pasture-management-for-drought-recovery/ Accessed 21 May 2019

- reduction in the rate of pasture decline in prolonged dry seasons
- quicker recovery in good seasons in rested pastures when compared to continuously grazed pastures.

Mark Alchin argues that resting paddocks in the semi-arid shrublands of the Murchison region during the summer allows perennial grasses to recover or, in particularly difficult seasons, reduces the rate of decline. In his doctorate, Alchin found that seasonal conditions and grazing are 'two key factors which determine the position of an ecosystem along the gradient of functionality and dysfunctionality'. Grazing 'had a significant influence on perennial grass mortality over and above that imposed by seasonal conditions'. Further, he argues that the 'management implication of this finding is that grazing management must be applied in a judicious manner and pastoralists must seek to align stocking rates with the seasonal carrying capacity'.[232]

Much of the literature on grazing management in North Queensland likewise advocates spelling pastures, particularly during the wet season. For example, Bill Schulke refers to grazing management techniques that assist pastures to recover after prolonged drought or a series of poor growing seasons, with techniques including pasture spelling, deferred restocking, continued drought feeding and prompt weed management. He advocates for wet season spelling in tropical pastures that includes 'pasture spelling during the early phases of growth', which ensures that 3P grasses (productive, palatable, and perennial grasses) 'have time to replenish their root reserves'.[233] Schulke argues this is particularly important during drought recovery.

Spelling, as advocated by Alchin and Schulke, is well suited to responding to seasons in an appropriate manner. Indeed, Alchin's results clearly indicated that paddocks not protected from grazing over the summer experienced 'greater losses of perennial grass plants compared to the protected exclosure sites. Furthermore, higher stocking rates appeared to result in greater losses of mature plants and reduced recruitment'.[234] Therefore, seasonal or other forms of spelling and management of total grazing pressure can contribute to the long-term health of pastures and, therefore, improve land condition and the viability of a pastoral enterprise.

Limitations

Shulke also argues against restocking immediately following useful rain:

> Where stock numbers have been reduced due to drought, delaying restocking allows pastures time to recover. If the 'break' to the season turns out to be a false one, you are not left with the problem of trying to feed expensive stores on pastures that continue to be stressed.
>
> Continue drought feeding for a few weeks in smaller paddocks if possible as this will allow larger paddocks to be wet season

[232] Mark Alchin, *A Test of Landscape Function Theory in the Semi-Arid Shrublands of Western Australia*, Unpublished PhD Thesis, Perth: Curtin University of Technology, 2011: 152

[233] Schulke, 'Pasture Management for Drought Recovery'

[234] Mark Alchin, *A Test of Landscape Function Theory in the Semi-Arid Shrublands of Western Australia*, Unpublished PhD Thesis, Perth: Curtin University of Technology, 2011: 114

spelled. It never rains grass and cattle can lose weight quickly chasing green pick. Maintaining an adequate plane of nutrition through supplementary feeding can offset this problem. The added benefit is that the grazing pressure on the pasture is reduced.[235]

Sheep and cattle also require time to adjust to green feed after a prolonged period of drought, meaning the animals cannot simply be let loose into a freshly green paddock immediately. Even if the new greenery is normally consumed by livestock, if there is not enough perennial grass to go with the fast-growing annual plants and herbage, there is a risk of poisoning.[236] As a result, pastoralists need to restock paddocks carefully in order to avoid unintended consequences.

Implementation

At a macro level, land managers should consider spelling pastures during plants' growth seasons where possible.
For example, in large areas of the southern rangelands, pastures tend to be C3, which means they grow in cooler temperatures (i.e. during winter). In the northern rangelands, pastures tend to be C4, which means they grow in summer. As a result, spelling in the southern rangelands may be rotated through the winter, while in the northern rangelands, during the summer, should Schulke's recommendations be followed. However, Alchin's research also demonstrates the value of spelling pastures in the Southern Rangelands during summer. This means that a strategy of regular rotation of stock grazing and spelling paddocks may provide good results.

The table below provides a brief summary of the features and potential management issues associated with a rotational grazing program.

[235] Schulke, 'Pasture Management for Drought Recovery'

[236] Amy McCosker, 'Queensland Graziers Face a "Green Drought" as Dams Run Dry and Disease Threatens Stock', *ABC News Online*, 23 May 2019. https://www.abc.net.au/news/rural/2019-05-23/queensland-graziers-face-a-green-drought/11139320?WT.ac=statenews_qld Accessed 23 May 2019

Table 14: Rotational Grazing and Spelling

Rotational grazing and spelling	
Features	**Management issues**
• Rotational grazing and spelling systems take many forms but usually involve multiple paddock systems. • Many rotational grazing systems use regular spelling (or grazing) on a calendar basis or on the basis of the number of days grazing or spelling. • Numerous systems are in use in the rangelands in the United States but few have been tested in Australian Rangelands – some principles might be relevant.	• There is growing interest in this system in recognition that most native pasture species are not well adapted to continuous grazing, and some form of pasture resting/spelling is needed to let plants recover from grazing and complete their life cycle processes. • There is little objective information to support or challenge the claimed benefits of rotational grazing, or the pros and cons of alternative rotational grazing schemes, so their value remains unproven. • In systems where rainfall and plant growth are unreliable and unpredictable this approach may not offer any benefits. • These systems (including cell grazing) can operate on recommendations that we consider inappropriate, such as the use of very high stock densities, often well above usually accepted limits. Despite a lack of explicit scientific evidence with which to refute them, they are contrary to normally accepted practice for protecting the soil surface and limiting plant defoliation.

Note: Features and management issues in respect of rotational grazing and spelling systems

Source: Australian Wool Innovation and Meat & Livestock Australia, 'Making More From Sheep, Module 12: Efficient Pastoral Production', http://www.makingmorefromsheep.com.au/efficient-pastoral-production/procedure_12.4.html Accessed 21 May 2019

Rotational grazing is best described as a period of grazing followed by a period of rest, and is viewed as an efficient way to utilise pasture throughout the year. Strip grazing and cell grazing are both forms of rotational grazing, which aim

> to enable the plants to recover quickly from being grazed, after which they grow to a height suitable to be grazed again. This will keep the plants in a productive vegetative state. Plants which are continuously grazed often struggle to recover and may die in hot dry conditions during summer (assuming a dry summer). If plants are allowed to grow too tall, the lower leaves can become shaded, brown off and rot with a loss of productivity.[237]

However, in areas of variable rainfall, plans and strategies to achieve objectives need to be flexible, in order to respond to opportunities and hazards. Management will need to respond tactically to changing conditions in order to implement the strategy. This continuous response to changing conditions, guided by a well-thought-out strategy, is the essence of

[237] Department of Environment, Water and Natural Resources, *A Practical Guide to Rural Land Management: Course Booklet*, third edition. Adelaide: Government of South Australia, 2016: 25

tactical management.[238] The table below provides a summary of the features and management issues of tactical grazing management.

Table 15: Tactical Grazing

Tactical grazing	
Features	**Management issues**
• Tactical grazing involves adjusting stock numbers in accordance with changes in seasonal and climatic conditions and plant growth. The key principle underpinning tactical grazing is the need for grazing to be managed in a way that recognises the critical importance of perennial plants. These species must be able to complete all life cycle stages to ensure the persistence of plant populations. • Decisions are made, based on plant condition scores, to alter stock numbers or destock. For example, in the semi-arid woodlands of New South Wales, or wherever seasonal conditions are unpredictable, minimum stubble height (grazing residue) for perennial grasses is 10cm. The mortality of the grasses increases dramatically during drought by grazing beyond this limit.	• For regions where the climate (and rainfall in particular) is erratic and unreliable, tactical grazing is recommended. • An important part of applying tactical grazing is the identification and definition of objectives and strategies on a paddock-by-paddock basis (Campbell and Hacker 2000). • Tactical grazing acknowledges the potential for plants to be killed by grazing and for recruitment to be limited because grazing can limit growth, flowering and seed production. • Regions with an erratic and unreliable climate are most likely to benefit from tactical grazing since many plants do not complete life cycle processes on a regular or annual basis.

Note: Features and management issues in respect of tactical grazing

Source: Australian Wool Innovation Limited, 'Making More from Sheep, Module 12: Efficient Pastoral Production', http://www.makingmorefromsheep.com.au/efficient-pastoral-production/procedure_12.4.htm Accessed 21 May 2019

[238] Ron Hacker, Luke Beange, Geoff Casburn, Greg Curran, Peter Gray, and Judy Warner, *Best Management Practices for Extensive Grazing Enterprises*, Orange: Department of Primary Industries NSW, 2005: 21

A key element of any grazing system, including tactical grazing, is monitoring. Constant monitoring will ensure that progress towards the objectives of the grazing system can be tracked, and grazing management can be adjusted to meet change those objectives, if necessary.[239] Chapter 3 also argues for regular monitoring of the land as a management tool.

Self-herding, including herd monitoring

Rangelands Self-Herding is an approach to grazing management that encourages animals to graze in particular areas by guiding the animals to make decisions about their grazing habitats and diet selection.[240] This approach deviates from convention by guiding animals via choice rather than exclusion or restriction so as to 'establish new grazing patterns to achieve a form of rotational grazing that does not rely on permanent fencing'.[241]

Livestock tend to graze in a pattern that is habitual in nature, often returning to the same pastures time and again. This can mean certain pastures are overgrazed while others remain relatively untouched. Additionally, the standard approach to supplements, or attractants, has been to deploy them in areas the livestock currently graze, ensuring easy access.

Consequently, livestock 'continue to congregate and heavily graze areas around nutrient and water supplies, even when abundant forage is available in other areas'. Employing a more strategic approach to nutrient licks and other attractants, including visual, audible and olfactory signals can help change livestock behaviour, leading to more even patterns of grazing and better nutritional outcomes for livestock.[242]

The seven principles of Rangelands Self-Herding are:

1. *Human-animal interactions shape outcomes.* In adaptive systems, the relationship between humans and livestock is critical in achieving favourable results in a timely fashion.
2. *Internal feedback sets behaviours.* Animals start an eating behaviour if they expect a reward; sight, sound and smell cues, both natural and contrived, can be used to influence that behaviour. They continue the behaviour if they receive the reward because it provides positive feedback that reinforces the initial behaviour.
3. *Experience reinforces behaviour.* Past experience is a major factor in determining current behaviours, including dietary choices and habitat selection. However, unwanted behaviours can be replaced by encouraging new behaviours that establish a new set of experiences.

[239] Ibid

[240] Dean Revell and Bruce Maynard, 'Self Herding and Self Shepherding', http://selfherding.com/index.html accessed 17 May 2019

[241] Meat and Livestock Australia (Northern Territory), 'Self-Herding for Landscapes and Profits Update', 15 November 2018, https://www.mla.com.au/news-and-events/industry-news/self-herding-for-landscapes-and-profits-update/ Accessed 16 May 2019

[242] Dean Revell, Bruce Maynard, and Dean Thomas, *Managing Feed Supply and Groundcover in Rangelands Through Nutritional Shepherding: 'Rangelands Self Herding'*, Perth: Rangelands NRM, 2016: 6

4. *Animals seek diet diversity.* Different plants bring different nutrients from different soil depths at different times. Livestock perform better when there is diversity, but they must learn how to use this diversity.

5. *Adaptability is required to face change.* A wide range of experiences prepares animals for a range of future circumstances. Exposure to different feeds and forages in utero and pre-weaning can have important long-lasting consequences. Continued learning from experienced peer animals, with low levels of stress, can help animals manage further changes.

6. *Individuals and groups influence each other.* Individuals need to experiment with, and learn about, all the resources where they live. Individuals shape the behaviour of a group, but so too does group behaviour influence individual responses; it's a dynamic relationship that acts continuously in both directions.

7. *Consequences are broad as everything is connected.* Livestock behaviours affect other parts of the system: soil, plant communities, predator behaviour, and other animals in the landscape. Being aware and observant to this can create opportunities for multiple benefits.[243]

Design

To achieve this, self-herding draws on animal behaviour, nutrition, physiology and ecology. Detailed research from around the world, including Australia, has led to a set of practices that are simple and cheap to apply. Self-herding can be tightly focussed around a particular issue, such as encouraging animals to use a new area, or broadened to encompass the way livestock, wildlife, plants and people interact over time and space.[244]

As noted above, an important element of self-herding techniques is the strategic deployment of attractants, including audio, visual, and olfactory tools to entice cattle to move to different areas to graze. Some of the attractants can be:

- a whistle (blown by a land manager as a signal that a food attractant is around – this is something the cattle are trained to do in a yard before being released again)
- a coat hanger with a mix of things they can see, touch, and hear (a bell, a CD that shines in the sun, and hanging metal things the animals can pass under and touch with their heads or backs)
- bells paired with a mobile lick feeder
- diluted strawberry flavour – used as an olfactory signal, among other things.

[243] Dean Revell, Bruce Maynard, and Dean Thomas, Managing Feed Supply and Groundcover in *Rangelands Through Nutritional Shepherding: 'Rangelands Self Herding'*, Perth: Rangelands NRM, 2016: 12

[244] Dean Revell and Bruce Maynard, 'Self Herding and Self Shepherding', http://selfherding.com/index.html accessed 17 May 2019

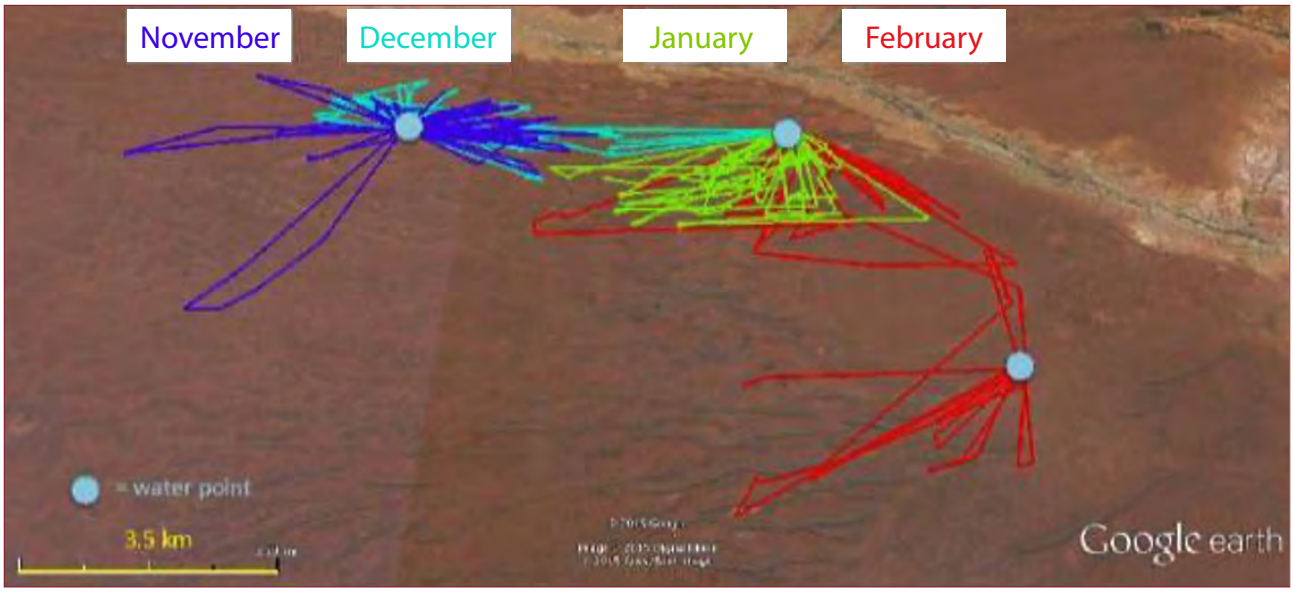
To understand the movements of cattle, and to track whether self-herding techniques are having the desired effect, some animals in the herd are fitted with GPS or radio collars or ear tags. The data maps the effect of self-herding on animal behaviour, and enables the refinement of techniques, should that be required. For example, see the map of a cow's movement over a four-month period in Figure 47 below.

Benefits

A key element of Rangelands Self-Herding is the strategic use of nutrients as attractants that, in turn, increase the capacity of livestock to obtain the nutrient balance they require from the broader landscape. Behavioural insights, such as combining nutritional attractants with clear signals (i.e. behavioural cues), allows many new opportunities to influence and manage grazing distribution and patterns. This then helps to minimise damage to vegetation and reduce risk of erosion, whilst improving livestock productivity and adaptability, and increasing the efficiency of gathering livestock by mustering or by trapping.

A trial of the self-herding methodology at the Northern Territory Government's Victoria River Research Station (Kidman Springs) has shown positive results. Observations at week 16 of the trial 'indicate that the techniques have been able to draw cattle

Figure 47: Rangelands self-herding – GPS tracking of cow over 4 month period, Gascoyne Trial



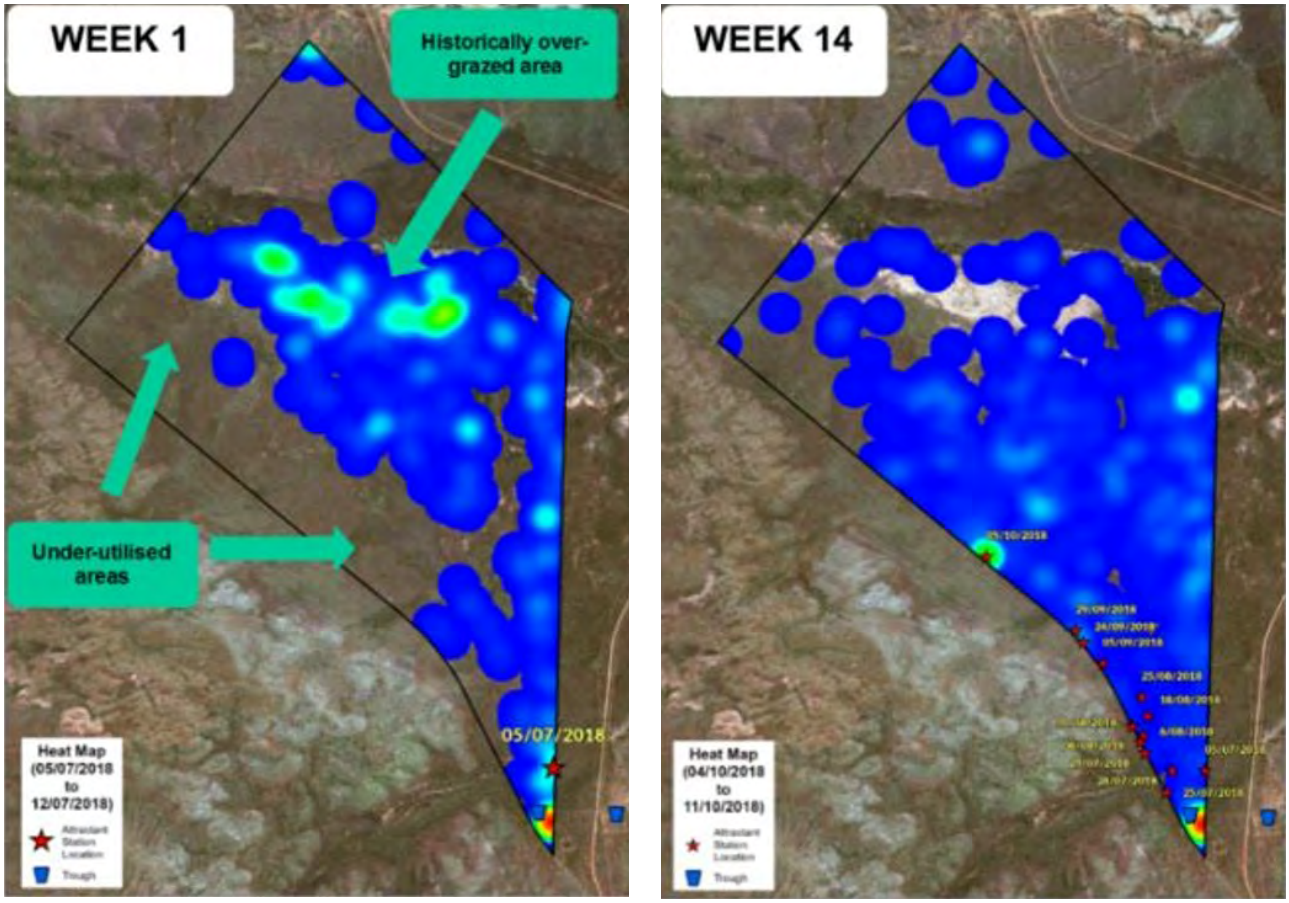
Note: Each colour represents a different month, and shows the cow's movements between water points, which were encouraged by self-herding techniques. Over time, she ceased returning to the previous water point (during December she moved to a new water point, but returned to the previous water point. When she moved to a new water point in February, she did not return to the previous one).

Source: Dean Revell, Bruce Maynard, and Dean Thomas, *Managing Feed Supply and Groundcover in Rangelands Through Nutritional Shepherding: 'Rangelands Self Herding'*, Rangelands NRM, 2016: 20

into areas that they have traditionally not used very much'. The trial has demonstrated the self-herding techniques are 'very flexible and can be integrated into normal cattle station management'.[245]

The Northern Territory trial demonstrates that grazing behaviours do change with self-herding techniques. The images in Figure 48, below, demonstrate shifting grazing patterns using self-herding, in which cattle moved away from an historically over-grazed area into generally under-utilised areas of a paddock. Note the significant change in the grazing pattern from week 1 to week 14. Reducing grazing pressure on overgrazed pastures is the first step in rehabilitation of the land. With self-herding, this can occur without large expenditure on fences.

Figure 48: Rangelands self-herding – Northern Territory Trial



Source: Future Beef, 'Grazing with Self Herding to improve performance of pastoral cattle', Future Beef Website, 13 February 2019: https://futurebeef.com.au/projects/self-herding-kidman-springs/

[245] Meat and Livestock Australia (Northern Territory), 'Self-Herding for Landscapes and Profits Update', 15 November 2018, https://www.mla.com.au/news-and-events/industry-news/self-herding-for-landscapes-and-profits-update/ Accessed 16 May 2019

These results appear to confirm those from trials in the Western Australian pastoral estate.

In Western Australia, trials were undertaken in the Gascoyne, Murchison, Pilbara, and Kimberley regions. The findings suggest Rangelands self-herding offers possibilities to address issues often classed as too difficult or too costly, such as redistributing livestock grazing pressure, or flexible options to adjust stocking rates through successful relocation or movement of stock. Self-herding provides a range of positive outcomes, including:

Table 16: Benefits of Self-Herding Methodology to Landholders and Landscape

Benefits to landholders	Benefits to landscape
Stocking rate adjustments within a production year	As carry capacity fluctuates, livestock impact can be adjusted to mitigate damage
Broader use of the areas within paddocks	Fewer over-grazed patches
More plant growth by enabling rest and recovery periods	Fragile area protection without large financial investment
Adjusting stocking rate to carrying capacity at any time	Erosion reduction
Increased joining percentage by concentrating animals together	Retaining plant diversity by more even grazing
More efficient mustering & removal of cleanskin animals	Responsiveness to variable conditions
Reduced risk of fire removing large areas of vegetation	Doubling the number of landscape mosaics by managing using fire *and* grazing
Easier and more frequent gathering of livestock to meet market opportunities	Near real-time adjustment of stocking rates to matching feed supply and demand
Increasing animal performance when relocated to new areas, including regional relocation from rangelands to farm land	Flexible grazing pressure when required

Source: Dean Revell, Bruce Maynard, and Dean Thomas, *Managing Feed Supply and Groundcover in Rangelands Through Nutritional Shepherding: 'Rangelands Self Herding'*, Rangelands NRM, 2016: 37

As the table suggests, there are immediate benefits for pastoral enterprises, including those associated with more controlled and intensive grazing without increasing management intensity or infrastructure, improved monitoring and flexibility, and livestock that initiate more exploratory grazing behaviours. Rangelands self-herding is practical, low-cost and adaptable to local conditions and the landholder's needs and can lead to less over- and under-utilisation of pastures because the animals are influenced to occupy and graze in areas that the land manager chooses. Self-herding also offers ways to implement year-round musters, so that land managers can adjust stocking rates in response to seasons and feed availability in the highly variable environments of the rangelands. This enables flexible responses to changes in weather, ecosystems, markets, animal welfare and business factors that are normally not possible in pastoral areas.[246]

Some lessees have embraced self-herding, including some who were not involved in the trials that were run by Rangelands NRM in 2014-15.[247] One lessee stated that he manages the land using self-herding and was aware of the study undertaken by Rangelands NRM. He was using similar methods, including nutrient licks and other incentives to move cattle around the lease. He found the method reduced overgrazing of the most desirable plant species, allowing more spelling time for pastures, while reducing the prevalence of less desirable species. He added that the lick program puts more back into the cattle, in terms of condition. He noted that fencing, while good, is very expensive, and the licks and other incentives do a good job of drawing the grazing pressure around the property.[248]

For more information on Rangelands Self-Herding, including more detail on techniques, go to the link below:

- http://selfherding.com/index.html

[246] Revell, Maynard, and Thomas, *'Rangelands Self Herding'*: 34

[247] Results of that trial are found in Dean Revell, Bruce Maynard, and Dean Thomas, *Managing Feed Supply and Groundcover in Rangelands Through Nutritional Shepherding: 'Rangelands Self Herding'*, Perth: Rangelands NRM, 2016

[248] M20190412 File Note Fact Finding Trip 2 Kimberley – Good Pastoral Land Management Guidelines 8-11 April 2019. Perth: Department of Planning, Lands and Heritage, Lands File 50246/2004 – *Crown Land Administration – Policy – Pastoral Lands Board – Guidelines for the Environmental Management of Pastoral Leases in Western Australia (WA)*, document no: A10483937

Good Pastoral Land Management
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6 Fire, weeds and feral animals

Contents

Management of fire, weeds, and feral animals is essential. Each of these elements represents a risk to the economic, environmental, and social success of a pastoral lease. Fire can destroy infrastructure, stock, and even cost people's lives, while at the same time can regenerate and revitalise pastures if managed correctly. Weeds can choke waterways, infest and destroy productive pastures, and some cases injure and/or poison stock. Feral animals, such as camels, horses and donkeys can compete with livestock for feed, as can native animals such as kangaroos. Additionally, some feral animals, especially wild dogs, present a predatory and disease risk. Feral pigs present a disease risk and degrade waterways and riparian vegetation, leading to erosion, decreased water quality, increased sedimentation and nutrient levels.

Pastoral lessees have an obligation under the LAA to control declared pests (including weeds and feral animals) on the land under the lease. Section 111(3) of the LAA states:

> A pastoral lessee must control declared pests on the land under the lease in compliance with the *Biosecurity and Agriculture Management Act 2007* and to the satisfaction of the Board.

This provision reinforces the requirements a land manager has under the BAM Act by making it a requirement of the lessee under the LAA. As such, the PLB has powers to enforce compliance with the BAM Act beyond the BAM Act requirements. BAM Act provisions as they relate to managing declared pests are found in the sections on weed and feral animal management below. Land manager obligations in respect of fire management are discussed in the section below.

Fire management

What is fire management and why does it matter?

Good fire management practices have a material effect on the economic, environmental, and social wellbeing of the pastoral estate and broader Western Australian community. Therefore, fire management is vital to good land management. There is a long association between climate, vegetation, and the bushfire environment, which pre-dates the arrival of humans by thousands of years. Most rangelands landscapes are 'prone to bushfires at varying intervals and seasons, so can be considered as fire maintained or fire dependent. These include some of the most fire-prone landscapes on Earth, such as the tropical savannahs of the north Kimberley, which have the potential to burn every year'.[249]

Fire management in pastoral areas can have a range of positive effects. Fire can promote pasture regeneration and regrowth, benefitting land management and animal production.[250] For example, spinifex pastures are of most value to pastoralists in the early stages of regeneration after a fire (around 1-2 years).[251] Knowing which pastures to burn and when, which to protect from fire, and how to do it, will

[249] Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*, Perth: Rangelands NRM, 2015: 5

[250] Department of Agriculture and Food, Western Australia, *Fire Management Guidelines for Kimberley Pastoral Rangelands: Best Management Practice Guidelines*, Perth: DAFWA, 2006: 1

[251] Department of Agriculture and Food Western Australia, *Fire Management Guidelines for Southern Shrubland and Pilbara Pastoral Rangelands: Best Management Practice Guidelines*, Perth: DAFWA 2006: 3

ensure productive pastures and reduce the risk of destructive, uncontrolled bushfires, providing a wide range of benefits across the rangelands.

Further, recently burned pastures that are regenerating have 'relatively high productivity, diversity and palatability that is important for many native flora and fauna species. Long-unburnt areas are important for providing breeding and shelter requirements of native fauna and for species with long life cycles, such as mature tree parasites, saprophytes and fungi'.[252]

Good fire management can significantly reduce the risks of fires to people's lives, property – whether towns, homesteads, livestock, station infrastructure – and environmentally sensitive areas. Of course, bushfire risks are not limited to pastoral infrastructure, although that is the focus of these Guidelines. Bushfires also threaten homes, lives and infrastructure in remote Aboriginal communities, national parks, and mining camps.

Managing the bushfire threat, for pastoralists, also means using planned fire to enhance ecosystem resilience, to manage pastures, and for other economic benefits. Careful planning of fire management is important because, as a growing body of evidence demonstrates,

> intense bushfires are implicated in the recent decline of some plant and animal species, are a significant source of greenhouse gas emissions and degrade populations of long-lived woody plants such as mulga (*Acacia Aneura*), which serve important ecological, environmental and cultural functions.[253]

Furthermore, replacing intense (hot) fires with low intensity (cool) fires, which are typically fires lit while vegetation is still uncured (green), rather than cured (dry), provides benefits to a range of different pasture types across the pastoral rangelands. This section discusses fire management and provides a series of links to sources that give region- and pasture-specific information on how to manage fire.

Regulation

The principle legislation governing fire in WA is the *Bush Fires Act 1954* (Bush Fires Act). This Act provides local governments with powers in respect of fire management within their shire boundaries, such as the ability to prohibit burning during certain times of the year, require a permit for other times, and, where appropriate, allow burning without a permit. Additionally, local governments may to compel land holders or occupants to build firebreaks around the boundaries of their properties, and specify the minimum width of such firebreaks.

Section 34 of the Bush Fires Act provides specifically for burning on Crown land, particularly where an owner or occupier's land abuts UCL or unmanaged reserves (UMR), except where a Government agency has responsibility for managing a reserve, and has established a fire management

[252] DPIRD, 'Arid Zone Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

[253] Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*, Perth: Rangelands NRM, 2015: 3

plan. Despite UMR's 'unmanaged' status, DBCA is often contracted to manage fire, feral animal, and weed risks. DBCA also undertakes similar management activities on UCL.

Should an owner or occupier wish to create fire-breaks on UCL and/or UMR as set out in section 34(1), a permit to burn must be obtained from a bush fire control officer in the relevant local government authority. The bush fire control officer will determine the width to which a fire-break may be burnt – up to a maximum of 200 metres in width from the boundary of the land.

For more detailed information about requirements for prescribed burns, firebreaks, and any other fire-related matters, please contact your local government or check their website. In addition, pastoralists looking to undertaken fire control measures such as these should liaise with DBCA, who may have fire control activities planned in the relevant area.

For further information on the legislation governing local government powers in relation to fires, the Bush Fires Act can be found at:

- https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_43477.htm/$FILE/Bush%20Fires%20Act%201954%20-%20%5B09-i0-01%5D.html?OpenElement

Most pastoral leases will contain bush fire prone areas designated by the Fire and Emergency Services Commissioner under section 18P of the *Fire and Emergency Services Act 1998*. Additional planning and building requirements may apply to developments within designated bush fire prone areas including any tourism development sites that occur on pastoral lands. The Map of Bush Fire Prone Areas is available online through the Department of Fire and Emergency Services website. The website address is:

- https://www.dfes.wa.gov.au/bushfire/bushfireproneareas/

Under the *Environmental Protection Act 1986*, and the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (Clearing Regulations), burning is considered 'clearing'. However, according to the Clearing Regulations, clearing that is for the purpose of fire hazard reduction burning is permitted, provided such clearing is undertaken in accordance with declarations pursuant to the Bush Fires Act and is 'done in such a way as to minimise long term damage to the environmental values of the vegetation'.[254]

Additionally, clearing of land that was lawfully cleared within the past 10 years for the purposes of a fire risk reduction area for a building may be cleared again for the same purpose. In the case of a building, the area around the building may be cleared up to 20 metres.[255] For more information about clearing of native vegetation in relation to buildings and other infrastructure, see Chapter 4: Infrastructure.

[254] Environmental Protection (Clearing of Native Vegetation) Regulations 2004, Regulation 5, Table Item 3 Clearing for fire hazard reduction

[255] Ibid.: Table item 15 Clearing to maintain existing cleared areas around infrastructure, etc

Regional differences and imperatives

Just as the Rangelands climate and vegetation are varied across the pastoral estate, so too is the bushfire environment. Differences between regions require tailored fire management regimes and techniques. The map at Figure 49 shows the pastoral estate and the different regions of the State.

The arid interior and agricultural regions are not part of the pastoral estate, although the environment and pastures of the arid interior hold many similarities with parts of the Pilbara, southern Kimberley, and northern Goldfields. Rangelands NRM proposed that the WA Rangelands be divided into six fire regions, one of which,

Figure 49: Map of the WA Rangelands – DPIRD fire regions

Source: Department of Primary Industries and Regional Development (DPIRD), 'Arid Zone Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

the 'Desert' fire region, includes the Pilbara and large portions of the Kimberley. Those six fire regions of the Western Australian rangelands are:

1. North Kimberley (North Kimberley, Central Kimberley, Victoria Bonaparte bioregions)
2. West Kimberley (Dampierland bioregion)
3. Desert (Pilbara, Great Sandy Desert, Little Sandy Desert, Gibson Desert, Great Victoria Desert, Ord Victoria Plain, Tanami bioregions)
4. Gascoyne Murchison (Carnarvon, Gascoyne bioregions, Murchison, Yalgoo bioregions)
5. Goldfields (Coolgardie bioregion)
6. Nullarbor (Nullarbor bioregion)

Rangelands NRM argues that the amalgamation of the Pilbara and many northern and southern desert bioregions to form a single desert bushfire region is

> justifiable on the grounds that while there are soil and landform differences, and a north-south climate gradient (north predominantly summer rainfall, south predominantly winter rainfall), spinifex (Triodia Spp.) grasslands form the dominant fuel and the region is arid, experiencing unreliable rainfall and long periods of hot dry weather.[256]

Indeed, while the DPIRD map above shows the arid interior as being outside the pastoral zone, DPIRD acknowledges that much of the pastoral estate is contained within the arid zone, which DPIRD defines as 'areas which receive an average rainfall of 250 millimetres (mm) or less'.[257] Pastoral areas contained within the arid zone include the Nullarbor, Goldfields, Murchison, areas of the Gascoyne, and the Pilbara.[258]

While much of the pastoral estate is contained within the arid zone, the Rangelands NRM fire regions also point to different vegetation types as key to understanding fire regimes and the importance of good fire management. From fire region to fire region, pastures shift from spinifex to chenopod to tussock grasslands to mulga woodlands, and for each of these a different fire regime is required. Spinifex requires fire to regenerate and become palatable to livestock after a period of time, while chenopods are fire sensitive (fire will kill them) but won't burn unless other types of fuel have invaded a chenopod pasture (e.g. grasses invading, usually due to overgrazing of chenopods).

The Kimberley is a very different proposition, with most of the region receiving large amounts of wet season rain (December-March/April) and receiving little to no rain during the dry season (May-November). As a result, the vegetation types and climate are very different to elsewhere in WA. Therefore, fire management plans will differ substantially from the southern fire regions.

[256] Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 7

[257] Department of Primary Industries and Regional Development, 'Rangelands Glossary: Arid', DPIRD Website https://www.agric.wa.gov.au/rangelands/rangelands-glossary#rangeglossA Accessed 28 June 2019

[258] DPIRD, 'Arid Zone Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

These guidelines detail the fire regimes and fire management treatments that should be utilised on a region-by-region basis; a number of excellent guides to fire management in the various regions already exist. Rather, general information is provided, alongside links to guides on fire management for specific regions.

Table 17: Regional Pastures and Appropriate Fire Regimes – a Summary

Region	Dominant vegetation	Fire sensitivity	Appropriate fire regime
Kimberley	Pasture Grasses (Ribbon Grass, Birdwood Grass, Mitchell Grass, Buffel grass, etc)	Low	Early Dry Season (March – June) Low Intensity Fires[1]
	Hard Spinifex	Low	0-3 years since last burn: Early Dry Season (March-June)[2]
			3+ years since last burn: Late Wet/Early Dry Season (February – March)[3]
Pilbara	Spinifex	Low	• Just before or just after opening rains late in the winter dry season. • Moderate- to high-intensity rotational burning to encourage fresh growth • (this is a risk, but there are pasture production advantages)[4]
	Tussock Grasslands and river floodplain pastures	High	• Fire should be avoided, due to increased post-fire erosion risk • Fuel reduction burning permissible in localised areas – no wholesale burning • Early winter burns while there is still moisture in the soil • Low-intensity[5]
Murchison Gascoyne	Spinifex	Low	See Pilbara Spinifex above.
	Chenopod, samphire and forblands pastures	High	• Seek to exclude fire from these pastures where possible, generally by maintaining chenopod biomass – plants are non-flammable • If burnt, exclude stock to enable recovery[6]
	Mallee	High	• Do not promote fire in mallee shrublands • Mallee shrublands burn at aprox. 30-year intervals • Control grass understory via grazing to reduce fuel loads[7]

Table 17: Regional Pastures and Appropriate Fire Regimes – a Summary (cont.)

Murchison Gascoyne (cont.)	Mulga Hardpan Pastures	High	• Fire should be avoided as much as possible, but due to grazing patterns and regrowth, impossible. • Low Intensity Cool Season (winter) burns • Fine-grain mosaic burning is recommended, with patches of post-fire regrowth at various stages, including some areas that are long-unburnt[8]
Goldfields	Eucalypt Woodlands	High	• Infrequent fire intervals (decades / centuries) • Fuel for fires sparse[9]
	Shrublands	Low	• Dense vegetation, highly flammable • Low Intensity, Cool Season (winter) burns • Install strategic low fuel buffers between shrublands and eucalypt woodlands[10]
Nullarbor	Chenopod Shrublands	High	• Fire management should aim to exclude fire or reduce risks of large damaging fires • Chenopod pastures are not flammable in the absence of invasive grasses, weeds, and herbs • Treat fuel in flammable parts of landscape by prescribed burning or mechanical means • Install strategic low fuel buffers[11]

1 Kimberley Land Council, "Fire Management in the Kimberley", Broome: Kimberley Land Council 2017. https://www.klc.org.au/indigenous-fire-management Accessed 17 June 2019; Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 10

2 Fire and Emergency Services Authority of Western Australia, *Kimberley Bush Fire Guidelines: Burning Guidelines and Firebreak Location, Construction and Maintenance Guidelines*, Perth: FESA 2007: 3

3 Ibid.

4 Department of Primary Industries and Regional Development, "Spinifex Rangeland Pastures and Fire", DPIRD Website https://www.agric.wa.gov.au/rangelands/spinifex-rangeland-pastures-and-fire Accessed 2 July 2019; Department of Agriculture, *Abydos-Woodstock Pastoral Research Station 1946-1976*, Perth: Western Australia Department of Agriculture [n.d.]: 10

5 DPIRD, "Pilbara Rangeland Pastures and Fire", DPIRD Website.

6 DPIRD, "Arid Zone Rangeland Pastures and Fire", DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

7 Ibid.

8 Ibid.

9 Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 13

10 Ibid.

11 Ibid.: 17

Rangelands-wide fire management principles

While each region has its own particular fire regime and, consequently, fire management principles, there are commonalities across regions and land systems. These principles relate to the protection of station assets, including fences, waters, yards, and homesteads, as well as protecting environmental and cultural assets.

Vegetation should be:

- 'kept away from homesteads, yards, bores and fences (electric fencing being particularly susceptible), and poly-pipe carrying water across country should be run in a trench and covered with soil'
- damaging fires should be kept out of environmentally sensitive areas, because, beyond their conservation value, these areas 'may be of particular significance to Aboriginal people and are increasingly the focus of tourism activities contributing to [pastoral] enterprise income'.[259]

Some general guidance for managing fire includes:

In general, early dry-season burns:

- are less intense (cooler) and less likely to kill trees and shrubs
- reduce overall pasture production in the year of the burn
- reduce production by perennials (grasses, shrubs and trees, especially if grazing resumes soon after fire)
- increase the proportion of production by annuals
- produce less greenhouse gas emissions than from late dry-season burns
- reduce the risk of wildfires later in the season.[260]

In general, late dry-season burns:

- are more intense (hotter) and more likely to kill trees and shrubs
- have less of an impact on total annual yield
- have higher greenhouse gas emissions than from early dry-season burns
- can increase the risk of high impact wildfires late in the season.

Additionally, DPIRD recommends that:

(1) pastoral stations do not use prescribed burning at any time in areas under grazing because of the unreliability of soil moisture available for pasture growth

(2) pastoral stations include wildfire mitigation in their property management plan

[259] Department of Agriculture and Food, Western Australia, Fire Management Guidelines for Kimberley Pastoral Rangelands: Best Management Practice Guidelines, Perth: DAFWA, 2006: 1

[260] DPIRD, 'Pilbara Rangeland Pastures and Fire: General principles for managing fire', DPIRD Website https://www.agric.wa.gov.au/climate-land-water/pilbara-rangeland-pastures-and-fire#Pilbfireprinc Accessed 1 July 2019

(3) pastoral stations in arid zone landscapes under other uses consult DFES and other resources for fire advice.[261]

Broad principles for fire management across the Rangelands:

- Rangelands NRM, Guiding Principles for Fire Management in the WA Rangelands, Perth: Rangelands NRM, 2015. https://rangelandswa.com.au/new-guiding-principles-for-fire-management-in-the-wa-rangelands/
- DPIRD, 'Fire in the Western Australian Rangelands', DPIRD Website: https://www.agric.wa.gov.au/rangelands/fire-western-australian-rangelands

Kimberley

The Rangelands NRM *Guiding Principles for Fire Management in the WA Rangelands* separates the north and West Kimberley into separate bushfire regions. However, they note that the fire regimes for both are similar. They suggest the fire regime for both regions of the Kimberley should both acknowledge that the 'climate and vegetation ensure that fires will occur every year in this region' and also look to 'increase the area burnt by early dry season fires' and aim to 'reduce the total area burnt per annum'.[262] They propose that the fire regime more closely reflect the pre-European settlement fire regime, in which Aboriginal people lit fires early in the dry season, which

> resulted in better control of fires, which were mostly low intensity and patchy. Fire sensitive communities … were able to escape being frequently burnt, or were able to survive low intensity fires at this time of year. Fires also burnt during the dry season with the coincidence of lightning storms and dry vegetation, but the scale and intensity of these fires was probably constrained by earlier burning and rain associated with the storms.[263]

The Kimberley Land Council (KLC) notes they are increasingly involved in fire management activities that reflect the traditional methods of their people. They observe, 'with the introduction of native title and the recognition that Western fire prevention methods have not been working effectively,' Aboriginal fire management methods have become more prominent.[264]

The KLC explains that Aboriginal fire management involves the lighting of 'cool' fires in targeted areas during the early dry season between March and July. Further, the KLC observes, as Rangelands NRM did, such cooler fires burn slowly, reducing fire loads and creating fire breaks, reducing the amount of fuel and therefore risk for later season fires.[265] Fire can be used, therefore, as a tool for land management.

[261] DPIRD, 'Arid Zone Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

[262] Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 10

[263] Ibid

[264] Kimberley Land Council, 'Fire Management in the Kimberley', Broome: Kimberley Land Council 2017. https://www.klc.org.au/indigenous-fire-management Accessed 17 June 2019

[265] Ibid.; Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 10

However, before undertaking a fire management action, **land managers should contact their local shire council and DFES**.

The key guide to fire management in the Kimberley is:

- Department of Agriculture and Food, Western Australia, *Fire Management Guidelines for Kimberley Pastoral Rangelands: Best Management Practice Guidelines*, Perth: DAFWA, 2006 https://researchlibrary.agric.wa.gov.au/lr_best/2/

Contacts for DFES in the Kimberley:

Broome:

Street Address	Cnr Carnarvon and Frederick Streets BROOME WA 6725
Postal Address	Locked bag 2743 BROOME WA 6725
Telephone	+61 8 9158 3200
Fax	+61 8 9193 6744

Kununurra:

Street Address	32 Poincettia Way KUNUNURRA WA 6743
Postal Address	PO Box 1094 KUNUNURRA WA 6743
Telephone	+61 8 9142 4010
Fax	+61 8 9142 4004

Pilbara

As noted above, Rangelands NRM has classified the Pilbara as part of the desert bushfire region, due to the low, unreliable rainfall and the similarity of the vegetation grown across this large bushfire region. Rangelands NRM notes, 'spinifex grassland on a variety of substrates and landforms (sand plains, dunefields, stony plains, stony hills) form the dominant ground cover and fuel, and is the common characteristic of this region'. Scattered shrubs, low trees and mallees often grow in association with spinifex and are found across the region.[266] However, given the specific climate in the Pilbara, and the importance of the Pilbara as a pastoral region, these Guidelines treat the region separately.

The Pilbara is a fire-prone environment that experiences regular fire.[267] Most managers in the northern Pilbara plan to burn just before or just after the first rains, late in the winter 'dry' season 'to reduce fuel loads and rejuvenate rank pastures'. Planned fires in the Pilbara have generally moved from early or middle dry season to late dry season. While these burns are generally hotter, have greater risk, and need to be managed in an environmentally appropriate way, they have pasture production advantages:

> Moderate- to high-intensity fires are used to manage the balance between trees and shrubs versus grasses, and remove unpalatable and low-digestibility mature plant material, allowing new growth.[268]

[266] Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 12

[267] Department of Primary Industries and Regional Development, 'Pilbara Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/climate-land-water/pilbara-rangeland-pastures-and-fire Accessed 2 July 2019

[268] Ibid

Long-term experiments have demonstrated that 'burning shortly before summer rains is to be preferred to winter burning' for pastoral purposes on spinifex pastures.[269] However, great care is needed to ensure these types of fires do not get out of control. This research has informed DPIRD Guidelines, and, consequently, land managers across the Pilbara, Ashburton and northern Gascoyne who 'use large-scale rotational burning to encourage fresh growth: livestock find fresh growth of spinifex is more palatable and digestible than mature spinifex. Long-term burning plans are required to maintain productivity'.[270]

However, on tussock grassland and extensive river floodplain pastures, fire should be avoided where possible, because of the 'unacceptably high risk of post-fire erosion and reduced available feed'. Fire may be used to reduce fuel in localised areas, but this burn should occur 'prior to winter when there is still some soil moisture for perennial grass regrowth'.[271] Where fire is used on tussock grasslands, there needs to be significant post-fire livestock control to allow groundcover plants to regenerate.

The southern Pilbara also contains areas in which mallee shrubland, sandplain and mixed acacia woodland pastures dominate, as well as some chenopod shrublands, samphire and forbland pastures. These are discussed below in the guide 'Arid Zone Rangeland Pastures and Fire', and in the Southern Rangelands section that follows.

For a summary of fire management approaches in the Pilbara, see the table in the Regional Differences section above. Key guides to fire management in the Pilbara:

- Department of Primary Industries and Regional Development, 'Pilbara Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/climate-land-water/pilbara-rangeland-pastures-and-fire
- Department of Primary Industries and Regional Development, 'Arid Zone Rangeland Pastures and Fire' https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands

Specific guide for spinifex:

- Department of Primary Industries and Regional Development, 'Spinifex Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/rangelands/spinifex-rangeland-pastures-and-fire

[269] Western Australia Department of Agriculture, *Abydos-Woodstock Pastoral Research Station 1946-1976*, Perth: Western Australia Department of Agriculture [n.d.]: 10

[270] Department of Primary Industries and Regional Development, 'Spinifex Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/rangelands/spinifex-rangeland-pastures-and-fire Accessed 2 July 2019

[271] DPIRD, 'Pilbara Rangeland Pastures and Fire', DPIRD Website

Contacts for DFES in the Pilbara:

Karratha:

Street Address	16 De Grey Place Karratha WA 6714
Postal Address	PO Box 1627 KARRATHA WA 6714
Telephone	+61 8 9159 1400
Fax	+61 8 9143 1236

Port Hedland:

Street Address	Cnr Anderson & McKay Streets PORT HEDLAND
Postal Address	PO Box 1627 KARRATHA WA 6714
Telephone	+61 8 9158 1300
Fax	+61 8 9173 2170

Southern Rangelands

Across the geographically diverse Southern Rangelands, vegetation differs markedly, leading to different fire regimes. For example, in the north, spinifex grasslands predominate, while further south, chenopod, samphire and forblands, as well as mallee, sandplain, and mixed acacia woodlands exist. Some of these pastures require fire, while others are fire sensitive. Many of the pasture types of the Southern Rangelands are fire sensitive, including chenopod, samphire and forblands, as well as mallee, sandplain, and mixed acacia woodlands.

Gascoyne and Murchison

In the northern sections of the Gascoyne and Murchison, spinifex pastures predominate. Fire regimes for these areas are similar to the spinifex regimes of the Pilbara. Further south, where chenopod, samphire and forbland pastures are dominant, DPIRD recommends that pastoralists actively exclude fire.

These pasture types are extensive on the lower, saline soil areas of the semi-arid and arid rangelands. The high salt content and relatively succulent character of chenopod shrub leaves renders them less flammable than other vegetation. However,

> the risk of fire damage increases with overgrazing which reduces shrub cover and increases the biomass of grasses and forbs, especially after better than average seasons. Grasses and herbs occur as a ground layer and are highly flammable.[272]

Plants such as the bladder saltbush will be killed if exposed to fire, while bluebushes will suffer from a loss of stored seed and desirable shrubs following a fire. Chenopods only regenerate post-fire via seed germination, so grazing pressure must be reduced to allow post-fire recovery and to preserve the seedbank. The risk of soil erosion is elevated when fires burn these pasture types. The most effective way to prevent fire in chenopod, samphire and forbland pastures is to manage grazing pressure to retain the dominant chenopod shrub biomass. If overgrazing starts,

[272] DPIRD, 'Arid Zone Rangeland Pastures and Fire', DPIRD Website https://www.agric.wa.gov.au/fire-management-southern-shrublands-and-pilbara-pastoral-rangelands Accessed 17 June 2019

total grazing pressure should be reduced immediately, so that the shrubs have an opportunity to recover.[273]

In the Mallee shrubland, sandplain and mixed acacia woodland pastures, DPIRD recommends that pastoral managers **do not** promote fire. These pastures tend to burn once every 30 years or more, so even though they are adapted to some fire, regular fire is not ideal. Surface fuel sufficient to sustain a large-area fire only occurs after extensive periods of above-average rain. Grazing livestock reduces the fuel load and therefore the fire risk, especially around water points. However, should a fire burn these pastures, DPIRD advises land managers to keep livestock off freshly burnt areas 'until there is effective regrowth. Temporary closure of water points close to newly burnt pastures will help keep livestock and some feral grazers off freshly burnt areas, and native grazers may need to be controlled'.[274]

Mulga and many associated shrubs are fire-sensitive, although these pastures generally will not carry a fire. However in good seasons, grasses and herbs supply sufficient fine fuel to carry a fire. DPIRD notes that the

> palatable shrubs of the mulga hardpan pastures of the southern rangelands have been substantially reduced by heavy grazing and subsequent wildfire. The increase of fine grassy fuels as a result of reduced competition by perennial low shrubs has contributed to an increased frequency of fire in these pastures. Palatable perennial grasses are now rare on mulga hardpan intergroves. Unpalatable large shrubs, such as turpentine bush and royal poverty bush, have increased in these pastures because they are not grazed and are less fire-sensitive than the desirable low shrubs.[275]

To help manage fire risks in the mulga pastures, Rangelands NRM recommends the establishment of a fine grain mosaic of patches of vegetation representing a range of growth (post-fire) stages, including patches of long unburnt vegetation. This mosaic will assist biodiversity by providing diverse habitats, whilst also buffering these landscapes from large wildfires following periods of above average rain. Therefore, land managers should undertake cool season burning regimes, soon after rain when fuels are moist. Such fires are likely to result in smaller, low intensity fires that are less likely to damage fire sensitive species and communities such as mulga.[276]

Goldfields

In the Goldfields bushfire region, vegetation is more varied than other parts of the Southern Rangelands. As a result, the fire regime is different. The vegetation of the Goldfields region is a

> rich mosaic of eucalypt woodlands on low hills and heavy soils interspersed with dense shrublands on yellow sand plains. These broad, often interlinked vegetation types have contrasting fuel properties, hence fire regime potentials and responses to fire.[277]

[273] Ibid

[274] Ibid

[275] Ibid

[276] Rangelands NRM, *Guiding Principles for Fire Management in the WA Rangelands*: 13

[277] Ibid.: 15

In undisturbed eucalypt woodlands, fuel for fires is comprised of sparse, usually discontinuous leaf litter and a 'low open understory of small shrubs, making these fuels of low flammability'. However, these woodlands are often in disturbed state, where regrowth can lead to vegetation becoming more fire prone.

The shrublands, however, are often dense and, under dry and windy conditions, highly flammable. While fire intervals in the woodlands can be many decades, even centuries, much shorter fire intervals are possible in the more flammable shrublands.[278]

For a summary of fire management approaches in the Southern Rangelands, see the table in the Regional Differences section above. Contacts for DFES in the Southern Rangelands:

Midwest/Gascoyne:

Street Address	1 Vulcan Way GERALDTON WA 6530
Postal Address	As above
Telephone	+61 8 9956 6000
Fax	+61 8 9964 4617

Goldfields:

Street Address	31-33 Dugan Street KALGOORLIE WA 6430
Postal Address	PO Box 10401 KALGOORLIE WA 6430
Telephone	+61 8 9026 4100
Fax	+61 8 9021 5577

[278] Ibid

What is a fire management plan?

A fire management plan is a risk management instrument utilised to prepare for and manage the bushfire threat on a pastoral station or within specified areas of the station.[279] The plan will illustrate the 'risks to life, property and environmental values' in a given location.[280]

However, in a pastoral context, a fire management plan is about more than protecting pastoral infrastructure and stock from bushfires. Proactive pastoral fire management can regenerate pastures and reduce woody weeds, while protecting fire sensitive ecosystems, which hold intrinsic value and may contain extrinsic value as Aboriginal heritage sites or locations for potential tourism activities, among other things.

Therefore, a fire management plan should be considered 'a key aspect of the overall property management plan', incorporating planned burns for pastoral benefits, bushfire mitigation, and bushfire control activities.[281]

[279] Fire and Emergency Services Authority of Western Australia, *Kimberley Bush Fire Guidelines: Burning Guidelines and Firebreak Location, Construction and Maintenance Guidelines*, Perth: FESA 2007: 48; Department of Environment, Water and Natural Resources, South Australia, *DEWNR Fire Policy and Procedure Manual: 3.2 Risk Assessment in Fire Management Planning*, Adelaide: DEWNR, 2013: 55

[280] DEWNR, *DEWNR Fire Policy and Procedure Manual: 3.2*: 55

[281] IDepartment of Agriculture and Food, Western Australia, *Fire Management Guidelines for Kimberley Pastoral Rangelands: Best Management Practice Guidelines*, Perth: DAFWA, 2006: 5

Design

A fire management plan for a pastoral lease should generally include the following:

- A list of objectives, such as those listed in the Benefits section above. The plan should be map-based.
- Maps required – to assist with the development of a fire management plan, a number of maps will be required, and may include:
  - stock carrying capacity
  - vegetation type (know your fuels)
  - soil type
  - topography
  - infrastructure
  - cultural heritage
  - environmental issues in the area such as declared rare flora, priority species and threatened ecological habitats
  - fire history of the property (fire footprint)[282]
- Identify plan components based on the information contained within the maps, the objectives set for the burn, values / risks / options
- Implementation Plan:
  - Phase 1 – development and training
  - Phase 2 – operational implementation / mentoring / review / adaptation.[283]

While there will be several objectives, as DFES identifies in their *Guidelines for Pastoral Stations Fire Management Plans*, there are two main objectives – protection burning and burning for pasture management.

For protection burning, the following elements are required as part of a fire management plan:

Protection burning

1. Identify the key assets or values requiring protection:
   a. infrastructure
   b. high value pasture (carrying capacity)
   c. cultural heritage
   d. environmental protection.
2. Analyse vegetation map and fuel age map.
3. Apply fire management principles for the hard spinifex and pasture grasses (tussock grass) buffers.
4. Pasture grasses (tussock grasses) burn plan.
5. Analyse primary risk of ignition.
6. Set objectives for a strategic fire break (300 m–1000 m).[284]

[282] Department of Fire and Emergency Services, ' Rural and Farm Fire', DFES Website: https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/ruralandfarmfire.aspx Accessed 3 July 2019

[283] Fire and Emergency Services Authority, *Guidelines for the development of Pastoral Station Bush Fire Management Planning*, Perth: FESA, 2010: 2-3

[284] Ibid.: 3

When burning for pasture management, the following applies:

Burning for pasture management

1. Pasture growth rates / senescence rates.
2. Regeneration requirements.
3. Methods of regeneration.[285]

Benefits

Well-planned fire management can reduce bushfire risk, increase pasture productivity, and reduce the incidence of weeds and woody shrubs, while safeguarding pastoral infrastructure. A full list of potential benefits includes:

- asset protection - utilise fire to protect assets (houses, sheds, equipment, water reticulation systems and fences)
- grass management- use fire to improve diversity and quantity of pasture available to livestock.
- woody shrub management - use fire to reduce prevalence of woody shrub
- weeds- use fire to assist in control of weed infestations minimising germination and reducing spread for some species
- access- remove vegetation to improve safety, ease of mustering and access to water sources.
- hazard reduction - utilise fire to manage fuel loads and install burnt area fire breaks in the landscape to reduce the extent and frequency of bushfires
- time management- ability to remove potential bushfire risks when time is available and conditions are suitable rather than when conditions are less suitable and other priorities prevail
- avoid response- conduct burning when conditions are more suitable to avoid responding later in the year also not burning early so can focus on ensuring cattle utilise all available pasture
- preparedness- removing amount of fuel by burning to limit suppression work later in the year
- safety- manage fuel load decreasing fires potential intensity, improving safety for firefighters and visitors.[286]

Limitations

Burning at the wrong time or in the wrong conditions contains risks. Without proper safeguards, planned burns can get out of control, potentially leading to destruction of fire-sensitive plants and ecosystems, adverse outcomes for pasture (such as cool burning for spinifex, which does not regenerate the pasture as required), and damage to infrastructure.

Fire-breaks

A fire management plan must include fire-breaks. A fire-break is a strip of land that has been cleared of all trees, shrubs, grass and other combustible material, providing a 'fuel free' area. Fire-breaks allow access for firefighting vehicles and can provide a

[285] Ibid

[286] Bushfires NT, Department of Environment and Natural Resources, *Savanna Regional Bushfire Management Plan 2018*, Katherine: DENR, 2018: 22

fuel free area from which prescribed burning can be undertaken. They may slow or stop the spread of a low-intensity bushfire. However, they should not be relied upon to prevent the spread of a fire.[287] Some fire-breaks are designed to prevent the escape of fires associated with high risk activities, such as a hot burn of spinifex.

Two different types of fire-breaks are required:

1. Boundary fire-breaks, which need to be quite wide – between 10 and 15 metres wide.
2. Internal paddock fire-breaks, which tend to be narrower – between 6 and 10 metres.[288]

Often, firebreaks are built into other essential infrastructure, such as fence lines and roads, which also serve as access points for firefighting purposes. Therefore, when building a fire-break, the requirements for road building outlined in Chapter 4 should be followed. However, firebreaks are often required to be much wider than a road or fence line, depending on its position in the landscape, the fuel load, and the type of fire the fire-break is intended to contain.[289]

Conducting mitigation treatments

A bushfire management plan should include some prioritisation of mitigation treatments, such as planned burns. This allows for a schedule of works to be developed that considers the proposed mitigation treatment, approximate timing for planned burning, and the environmental conditions for the treatment to be conducted.

For bushfire mitigation to be effective, it needs to reduce the risk of bushfire across the landscape regardless of land tenure. This requires partnerships between the key stakeholders in the planning and implementation of targeted and coordinated mitigation activities. Neighbouring pastoralists are encouraged to coordinate their bushfire mitigation activities to complement those activities of other landowners and land managers, including traditional landowners and DBCA.

[287] Department of Fire and Emergency Services, *A Guide to Constructing and Maintaining Fire-breaks*. Perth: DFES Rural Fire Division, 2018: 2

[288] Fire and Emergency Services Authority of Western Australia, *Kimberley Bush Fire Guidelines: Burning Guidelines and Firebreak Location, Construction and Maintenance Guidelines*, Perth: FESA 2007:18

[289] Fire and Emergency Services Authority of Western Australia, *Kimberley Bush Fire Guidelines: Burning Guidelines and Firebreak Location, Construction and Maintenance Guidelines*, Perth: FESA 2007:17

Useful links

For information in relation to fire management plans, see:

- Department of Fire and Emergency Services, Kimberley Burning Guidelines, Perth: DFES 2014 https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireProtectionPlanningPublications/DFES_Kimberley_Burning_Guidelines.pdf

- Fire and Emergency Services Authority, *Guidelines for the development of Pastoral Station Bush Fire Management Planning*, Perth: FESA, 2010 https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireProtectionPlanningPublications/FESA-Guidelines_for_Pastoral_Station_Fire_Management_Plans.pdf

- Department of Fire and Emergency Services, 'Rural Farm and Fire: Pastoral Land Management', DFES Website https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/ruralandfarmfire.aspx

- DFES, 'Bushfire Prone Areas Map', DFES Website https://www.dfes.wa.gov.au/regulationandcompliance/bushfireproneareas/Pages/default.aspx

- Department of Fire and Emergency Services, *A Guide to Constructing and Maintaining Fire-breaks*. Perth: DFES Rural Fire Division, 2018 https://www.dfes.wa.gov.au/regulationandcompliance/buildingplanassessment/Special%20Operations%20Guidenance%20Notices/DFE40125_Constructing_Firebreaks_Brochure.pdf

Biosecurity and pest control on pastoral leases

Biosecurity is a key element of good pastoral land management. Weeds and feral animals can affect the productivity of a pastoral business in a number of ways, including:

- weeds infesting land and reducing available pasture, blocking access to rivers and other water sources
- weeds poisoning stock
- feral animals competing with livestock for available pasture
- feral animals carrying and transmitting diseases to livestock
- feral animals damaging water points and waterways, contributing to erosion and other land management issues
- predatory animals, such as wild dogs and foxes, taking livestock.

The DPIRD website is an excellent first point of contact for information on biosecurity

For specific biosecurity information, see: https://www.agric.wa.gov.au/biosecurity-quarantine

For Pest Control, see: https://www.agric.wa.gov.au/pests-weeds-diseases

The Biosecurity and Agriculture Management Act 2007

Pastoralists are required to manage biosecurity threats in accordance with the *Biosecurity and Agriculture Management Act 2007* (BAM Act), as outlined in the Legislative Context section in Chapter 1. The BAM Act regulates the introduction of plants and animals into the State, the control of declared plants and animals, and provides effective biosecurity and agricultural management for WA. It does this by controlling the entry, establishment, spread and impact of organisms that may have an adverse impact on other organisms, humans, the environment or agricultural, fishing or pearling activities carried out in WA.

Plants and animals declared under the BAM Act are controlled through regulation of movement and the requirement for landholders to control them, including the eradication of certain species and preventing them from spreading to uninfected areas.

Under section 12 of the BAM Act:

(1) The Minister may declare that an organism of a kind specified or described in the declaration is a prohibited organism if there are reasonable grounds for believing that the organism —

(a) has or may have an adverse effect on —

(i) another organism; or

(ii) human beings; or

(iii) the environment or part of the environment; or

(iv) agricultural activities, fishing or pearling activities, or related commercial activities, carried on, or intended to be carried on, in the State or part of the State; or

(b) may have an adverse effect on any of those things if it were present in the State or part of the State, or if it were present in the State or the part in greater numbers or to a greater extent.

Further, section 22 of the BAM Act establishes that a prohibited organism under section 12 is a 'declared pest for the whole of Western Australia'. Section 22 reads as follows:

(1) A prohibited organism is a declared pest for the whole of Western Australia.

(2) The Minister may declare that any other organism of a kind specified or described in the declaration is a declared pest for an area if there are reasonable grounds for believing that the organism —

(a) has or may have an adverse effect on —

(i) another organism in the area; or

(ii) human beings in the area; or

(iii) the environment, or part of the environment, in the area; or

(iv) agricultural activities, fishing or pearling activities, or related commercial activities, carried on, or intended to be carried on, in the area; or

(b) may have an adverse effect on any of those things if it were present in the area, or if it were present in the area in greater numbers or to a greater extent.

(3) A declaration under this section may assign the declared pest to a category designated by the regulations.

(4) Before making a declaration under this section the Minister must consult with —

(a) any other Minister who in the opinion of the Minister has a relevant interest; and

(b) if the Minister is of the opinion that such consultation is necessary for the purpose of properly informing himself or herself as to whether or not the declaration should be made, the Biosecurity Council.

(5) The area for which an organism is declared to be a declared pest may be the whole or part of the State.

(6) The declaration may set out or identify a management plan that must be followed by a person who has a duty under section 30 to control the declared pest.

Of particular interest are paragraphs (5) and (6), underlined above. A declared pest may only be declared for a part of the state, or for the whole, depending on the type of pest and any assessment of its invasiveness. Further, a declaration may set out a management plan, and that management plan must be followed by a person who has a duty under section 30 to control the declared pest.

Section 30 requires that:

(1) In this section — prescribed control measures, in relation to a declared pest, means the measures to control that declared pest required under the regulations or a management plan.

(2) The owner or other person in control, in an area for which an organism is a declared pest, of an organism or thing infected or infested with the declared pest must take the prescribed control measures to control the declared pest. Penalty: a fine of $20 000.

(3) The owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take the prescribed control measures to control the declared pest if it is present on the land, or has infected or infested an organism or thing on the land, or is likely to be present on the land or to infect or infest an organism or thing on the land. Penalty: a fine of $20 000.

Therefore, the onus is on the owner or occupier of the land on which a declared pest is located to take the appropriate control measures outlined in a declaration by the Minister. The BAM Act includes significant penalties if that person does not act on the Minister's declaration. The table below explains the declared pest control categories, which will be referenced in the discussion below of specific weeds. Note that the categories below are relevant to animals and all other organisms, not just plants.

Table 18: Declared Pest Control Categories – Biosecurity and Agriculture Management Regulations 2013

Declared pests control categories – Biosecurity and Agriculture Management Regulations 2013		
C1	Exclusion	Pests (plants, animals, and other organisms) which should be excluded from part or all of Western Australia.
C2	Eradication	Pests (plants, animals, and other organisms) which should be eradicated from part or all of Western Australia.
C3	Management	Pests (plants, animals, and other organisms) that should have some form of management applied that will alleviate the harmful impact of the pest, reduce the numbers or distribution of the pest or prevent or contain the spread of the pest.

Source: Regulation 7, Biosecurity and Agriculture Management Regulations 2013

Further, there is a range of requirements for land managers in respect of C1 or C2 organisms. These are:

Table 19: Requirements for Land Owners / Occupiers in respect of C1 and C2 Organisms

Requirements for land owners / occupiers in respect of C1 or C2 organisms	
Requirement	**Recommendations**
Introduction of the pest into, or movement within this area is prohibited.	Mark the location of the pest in such a way that it can be found again.
Report the presence or suspected presence of this pest in this area.	C1 and C2 category pests are of high importance to WA and must be reported as a priority. Please report sightings to the **Pest and Disease Information Service** (08 9368 3080).
Supply or advertising supply of this pest into this area is prohibited.	Sale and Supply of a declared pest is not permitted for C1 and C2 organisms.
If the declared pest is found in this area control measures must be taken to destroy, prevent or eradicate it.	Treat to destroy all pests, whether animals, plants, or other organisms, including prevent seed set and prevent the spread of seed or plant parts within and from the area on or in livestock, fodder, grain, vehicles and/or machinery. Treat prior to seed set each year.
Ensure that any person conducting an activity on the land is aware that measures are required to be taken to control the declared pest.	Erect a biosecurity sign for persons conducting an activity on the land.

Source: Biosecurity and Agriculture Management Regulations 2013, Part 3

For more information, see: Department of Primary Industries and Regional Development (DPIRD), 'Declared Plant Requirements', DPIRD Website https://www.agric.wa.gov.au/declared-plants/declared-plant-requirements Accessed 1 August 2019

With respect for C3 organisms, the following requirements are in place:

Table 20: Requirements for Land Owners / Occupiers in respect of C3 Organisms

Requirements for land owners / occupiers in respect of C3 organisms	
Requirement	**Recommendations**
Introduction of the pest into, or movement within this area is prohibited.	The plant or its seeds must not be moved within the C3 area.
Supply or advertising supply of this pest into this area is prohibited.	Sale and Supply of a declared pest is not permitted for C3 organisms.
The infested area must be managed in such a way that alleviates the impact, reduces the number or distribution or prevents or contains the spread of the declared pest in this area.	Treat to destroy all pests, whether animals, plants, or other organisms, including prevent seed set and prevent the spread of seed or plant parts within and from the area on or in livestock, fodder, grain, vehicles and/or machinery. Treat prior to seed set each year.
Ensure that any person conducting an activity on the land is aware that measures are required to be taken to control the declared pest.	Erect a biosecurity sign for persons conducting an activity on the land.

Source: Biosecurity and Agriculture Management Regulations 2013, Part 3

For more information, see: Department of Primary Industries and Regional Development (DPIRD), 'Declared Plant Requirements', DPIRD Website https://www.agric.wa.gov.au/declared-plants/declared-plant-requirements

Recognised biosecurity groups (Rangelands) and other biosecurity organisations

In order to assist landholders, including pastoralists, the BAM Act provides a mechanism by which the Minister could recognise biosecurity groups established to control declared pests in an area. These groups are known as Recognised Biosecurity Groups (RBGs). RBGs support and complement activities that individual landholders and managers are required to do to meet their legal obligations to control declared pests on their land and provide a framework to foster efficiency through arrangements that make the best use of skills, funds, capacities, incentives and regulations.

RBGs have been established to provide a community-coordinated approach for the management and control of widespread and established pests that are of particular interests and concern to their community. DPIRD Biosecurity Officers support RBGs by providing training workshops and knowledge on how best to control particular declared pests or, in some cases, are engaged by the RBGs to undertake control work on pests such as Camels, horses and donkeys (LFH). The key is that the RBG is community-driven working on the right-hand side of the invasion curve (controlling existing or established pests) while the Departments focus is on the left hand side of the invasion curve (controlling new incursions or those species populations that can be eradicated).

RBG activities are funded through the declared pest rate (DPR) paid annually by landholders and matched dollar-for-dollar by the State Government. The RBGs allocate funding yearly to manage high priority animal and plant pests within their area of operation. RBGs may also receive funds from other sources including national, state and local government funds, and grants from regional NRM and private conservation organisations.[290]

As a result, in the pastoral areas, RBGs determine where and how the DPR is spent, whether wild dogs, invasive plant species, or large feral herbivores.

Therefore, it is imperative that pastoral lessees not only pay their rates, but become involved in their local RBG.

The RBGs in the Rangelands are:

- Goldfields-Nullarbor Rangelands Biosecurity Association
- Meekatharra Rangelands Biosecurity Association
- Carnarvon Rangelands Biosecurity Association
- Pilbara Regional Biosecurity Group
- Kimberley Rangelands Biosecurity Association.

The RBGs are excellent sources of knowledge and expertise, and should be a first port of call for pastoralists seeking to learn how to deal with any biosecurity issues on their leases.

[290] Don Burnside and Bruce Howard, *Sustainable Land Use and Economic Development Opportunities in the Western Australian Rangelands: Final Report*. Perth: URS Australia for the Department of Agriculture and Food, Western Australia: 2013: 13; DPIRD, 'Recognised Biosecurity Groups', DPIRD Website https://www.agric.wa.gov.au/bam/recognised-biosecurity-groups Accessed 25 July 2019

Contact details for the Rangelands RBGs are:

Goldfields-Nullarbor Rangelands Biosecurity Association

Chair: Trevor Hodshon

Executive Officer: Michelle Donaldson

Email: CEO@gnrba.com.au

Mob: 0439 918 492

Website: http://www.gnrba.com.au/index.html

GNRBA area LGAs: Coolgardie, Dundas, Kalgoorlie-Boulder, Laverton, Leonara, Menzies, Ngaanyatjarraku, Sandstone and Wiluna.

Carnarvon Rangelands Biosecurity Association

Chair: Justin Steadman

Executive Officer: Krystie Bremer

Email: crba_eo@iinet.net.au

Mob: 0417 183 705

CRBA area LGAs: Carnarvon, Exmouth, Murchison, Upper Gascoyne and Shark Bay.

Kimberley Rangelands Biosecurity Association

Chair: Mike Shaw

Executive Officer: Dick Pasfield

Email: krbg@westnet.com.au

Mob: 0418 959 832

KRBA area LGAs: Broome, Derby-West Kimberley, Halls Creek and Wyndham-East Kimberley.

Meekatharra Rangelands Biosecurity Association

Chair: Ashley Dowden

Executive Officer: Geoff Brooks

Email: gpbrooks2000@yahoo.com.au

Mob: 0499 343 828

MRBA area LGAs: Cue, Meekatharra, Mount Magnet and Yalgoo.

Pilbara Regional Biosecurity Group

Chair: Jamie Richardson

Executive Officer: Bill Currans

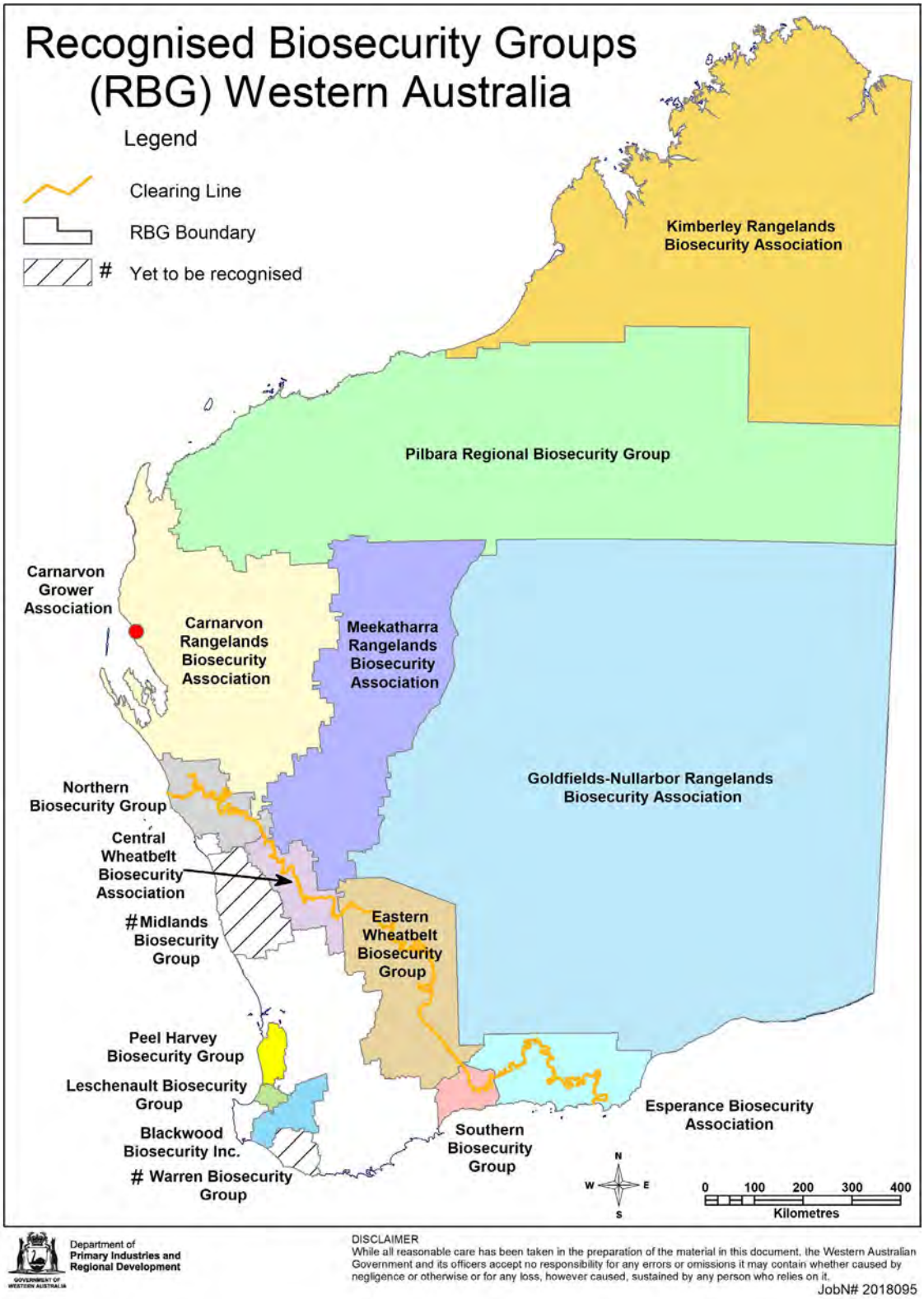
Email: bill@billcurrans.com

Mob: 0488 383 449

PRBG area LGAs: Ashburton, East Pilbara, Karratha and Port Hedland.

Figure 50 is a map of the areas covered by each of the RBGs in the Rangelands.

Figure 50: Western Australia's recognised biosecurity groups



Source: Department of Primary Industries and Regional Development (DPIRD), 'Recognised Biosecurity Groups', DPIRD Website https://www.agric.wa.gov.au/bam/recognised-biosecurity-groups Accessed 25 July 2019

In addition to the Rangelands RBGs, there are a range of other groups that perform biosecurity work in the Rangelands. For example, the Pilbara Mesquite Management Committee (PMMC), which was formed, as the name would indicate, to manage Mesquite infestations in the Pilbara. However, the PMMC is now a significant biosecurity organisation in the Pilbara, working to control not only Mesquite but other Weeds of National Significance, such as parkinsonia and noogoora burr.[291]

The PMMC has undertaken research into best-practice mesquite control, and has a wide range of resources on its website, which are recommended for anyone seeking to control weeds in the Pilbara, which may also be of use to pastoralists in other areas. A series of documents and links, including some from the PMMC website, are referenced towards the end of this section.

For pastoralists in the Pilbara, the PMMC is a vital resource. Their contact details are as follows:

Pilbara Mesquite Management Committee

Address:	DBCA Offices Lot 3 Corner Anderson and Mardie Roads Karratha Industrial Estate Postal PO Box 867 Karratha WA 6711844
Email:	info@pilbaramesquite.com.au
Website:	https://pilbaramesquite.com.au

Introduced weeds

Introduced plants are a significant issue in the Rangelands. The CRC for Australian Weed Management notes there are some 622 'non-native naturalised species that are known to occur in the [Australian] rangelands', of which 160 were considered to be threatening rangeland biodiversity.[292] These weeds, if unchecked, can create significant problems for pastoralists, including:

- reduction in pasture available for grazing – infestations of some weeds, such as mesquite and cacti, can cause impenetrable thickets
- reduction in stock access to natural waters – riverbanks can become infested with impenetrable thickets, causing stock to roam further to find water access, and increasing grazing pressure in those areas with accessible water, leading to increased risks of erosion
- some weeds, such as rubber vine, can be poisonous to stock.

Biosecurity protocols help prevent weeds

Practice good biosecurity to keep weeds away. The following are appropriate and reasonable prevention measures that should be implemented immediately if they are not already in place:

[291] Pilbara Mesquite Management Committee, 'About us', PMMC Website https://pilbaramesquite.com.au/about-us/ accessed 31 July 2019

[292] A.C. Grice, S. Campbell, R. Breaden, F. Bebawi, and W. Vogler, *Habitat management guide—Rangelands: Ecological principles for the strategic management of weeds in rangeland habitats*. Adelaide: CRC for Australian Weed Management, 2008: 9

Prevention is cheaper than control

- Ensure vehicles, machinery, livestock and produce do not carry weed seeds or propagules (vegetative material that is capable of reproduction).
- Report sales of declared plants to your local DPIRD office or biosecurity officer.

Find weeds early

- Get to know plants in your area/on your property and quickly identify and deal with new threats.

Prevent weed spread

- Take measures to contain weed infestations and prevent further weed dispersal.

Plan your control approach

- Obtain information about managing your target weed.
- Map infestations.
- Treat weeds when they are young.
- Use the recommended control method.
- Minimise damage to non-target plants.
- Establish and promote competing vegetation.

Undertake follow-up control

- Continue follow-up treatments over a number of years as per current guidelines for the species.

  Some plants may have been missed, some may not have died and new seedlings may emerge.[293]

Additional measures include:

- Ensure contractors entering your property have clean equipment to avoid the introduction of new weeds.
- Establish a clean-down/ inspection point.

  Using a property map, determine the edge of the infested area and establish an inspection point. This will help prevent spread to clean areas. If possible, choose an open, clear site that is less likely to be frequented by stock or wildlife. Ensure the site is away from watercourses and drains and consider the site's run-off. This will help prevent the spread of weeds. Ensure the site can be easily identified, as it will need to be monitored for outbreaks in the following seasons. Use a fence post, distinguishing landmark or GPS coordinate to identify the site.
- It is an offence to sell or transport produce or other material contaminated with declared plants
  - all offences regarding declared plants should be reported to the nearest DPIRD office.

  For advice on how to reduce the risk of weed contamination from fodder, see: MJ Laidlaw, MA Louden, AR Bean and EJ Thompson, *Reducing Weed Risks from Fodder*, Toowong: Queensland Herbarium, 2017

[293] M.R. Sheehan and S Potter, *Managing Opuntioid acti in Australia: Best practice control manual for Austrocylindropuntia, Cylindropuntia and Opuntia species*. Perth: DPIRD, 2017: 78

- Prompt action is necessary to eradicate new and/or isolated patches of invasive weeds, especially Weeds of National Significance (WoNS), and to prevent the weed becoming established in new areas.
- Report suspected WoNS or other unusual weeds as soon as possible. Contact DPIRD or the Pest and Disease Information Service (1800 084 881).

Where weeds are established, seek best practice control advice from DPIRD officers, the DPIRD website, of the Pest and Disease Information Service.

Pest and Disease Information Service

Phone: (08) 9368 3083080

Email: padis@dpird.wa.gov.au

WoNS and the Western Australian Rangelands

The table below lists the 32 Weeds of National Significance (WoNS), ranked according to their impact on the Rangelands. Of these, 14 are considered a priority for the Rangelands. The WoNS list was compiled as a component of Australia's National Weeds Strategy in the year 2000. An initial list of 71 weeds was developed, with 20 of those being given priority as warranting 'long-term, strategically coordinated action at the national level in order to minimise their economic, social and environmental costs'. In 2012, 12 additional weeds were given WoNS status.[294] The 32 currently recognised as WoNS were prioritised based on their 'invasiveness, impacts, potential for spread and the socio-economic and environmental consequences of their invasions'.[295]

[294] Department of Environment, 'Weeds of National Significance', Department of the Environment (Commonwealth) Website https://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html Accessed 6 August 2019

[295] Ibid

Table 21: Australia's Weeds of National Significance

WoNS that are very important in Australian Rangelands		
Common name		**Scientific name**
1	Athel pine	*Tamarix aphylla*
2	Chilean needle grass	*Nassella neesiana*
3	Gamba Grass	*Andropogon gayanus*
4	Lantana	*Lantana camara*
5	Mesquite	*Prosopis spp.*
6	Prickly Pears	*Opuntia spp.*
7	Parkinsonia	*Parkinsonia aculeata*
8	Parthenium	*Parthenium hysterophorus*
9	Prickly acacia	*Acacia nilotica*
10	Rubber vine	*Cryptostegia grandiflora*
11	African Boxthorn	*Lycium ferocissimum*
12	Fireweed	*Senecio madagascariensis*
WoNS that occur in Rangelands but only in wetlands		
13	Alligator weed	*Alternanthera philoxeroides*
14	Cabomba	*Cabomba caroliniana*
15	Hymenachne	*Hymenachne amplexicaulis*
16	Mimosa	*Mimosa pigra*
17	Pond apple	*Annona glabra*
18	Salvinia	*Salvinia molesta*

Table 21: Australia's Weeds of National Significance (cont.)

WoNS that are of minimal importance to the Rangelands		
19	Blackberry	*Rubus fruticosus*
20	Serrated tussock	*Nassella trichotoma*
21	Gorse	*Ulex europaeus*
22	Bitou bush / boneseed	*Chrysanthemoides monilifera / C. monilifera ssp. monilifera*
23	Willows	*Salix spp.*
24	Bridal creeper	*Asparagus asparagoides*
25	Madeira Vine	*Anredera cordifolia*
26	Cat's Claw Creeper	*Dolichandra unguis-cati*
27	Water Hyacinth, Water Orchid, Nile Lily	*Eichhornia crassipes*
28	Delta Arrowhead, Arrowhead, Slender Arrowhead	*Sagittaria platyphylla*
29	Salvinnia	*Salvinnia Molesta*
30	Silver-leaved Nightshade	*Solanum elaeagnifolium*
31	Flax-leaf Broom / Cape Broom	*Genista linfolia / Genista monspessulana*
32	Broom	*Cytisus scoparius*

Source: A.C. Grice, S. Campbell, R. Breaden, F. Bebawi, and W. Vogler, Habitat management guide—Rangelands: Ecological principles for the strategic management of weeds in rangeland habitats. Adelaide: CRC for Australian Weed Management, 2008: 9; Department of the Environment, 'Weeds of National Significance', Department of the Environment (Commonwealth) Website https://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html Accessed 6 August 2019

Alongside the list of WoNS are lists of so-called 'sleeper weeds' and the National Environment Alert List. Sleeper weeds are those plant species with the potential to increase rapidly and cause nationally significant impacts on Australian agricultural industries. They were selected on the basis that they were thought to occupy less than 100 hectares in total, and thus may be containable.

The National Environment Alert List is different to the sleeper weeds list, inasmuch as it is a list of 28 plant species that are considered to be

> in the early stages of establishment but have the potential to become a significant threat to biodiversity if they are not managed. Those of concern to rangeland environments include cutch tree (*Acacia catechu*), Karroo thorn (*Acacia karroo*), barleria (*Barleria prioritis*), kochia (*Bassia scoparia*), Siam weed (*Chromolaena odorata*), Senegal tea plant (*Gymnocoronis spilanthoides*), horsetails (*Equisetum spp.*), leaf cactus (*Pereskia aculeata*), praxelis (*Praxelis clematidea*), cane needle grass (*Nassella hyalina*) and lobed needle grass (*Nassella charruana*). Management guides for each of the 28 alert list species have been produced by the Weeds CRC.[296]

The above Commonwealth guidance aside, the States and Territories are primarily responsible for pest plants and animals (see above). Each State and Territory has enacted legislation that specifies which plant species are most problematic and should become declared weeds. They all recognise several classes of declared weeds, largely based on a weed's current and potential impacts. These classes prescribe the actions required under the legislation to remove the plants or minimise their effects.

Major Weeds Present in the WA Rangelands

As indicated in the table above, there are several WoNS of particular importance to the Rangelands. In Western Australia, some of these weeds have a greater presence and therefore impact on the Rangelands than others. Given climatic differences, certain weeds are more prevalent in the Northern Rangelands than the Southern Rangelands. Therefore, this section will discuss these regions and their specific weeds separately.

Given the large number of weeds present in the pastoral estate, this section will only discuss examples of weeds in the respective regions. Pastoralists are encouraged to engage with DPIRD, whether on their website or by contacting the DPIRD regional offices. Contact details are provided in the biosecurity section above.

Weeds in the Northern Rangelands

The CSIRO and CRC for Australian Weed Management proposed the highest priority weeds for the pastoral industry as being Noogoora burr, Bellyache bush, Parkinsonia, and Mesquite in 2002. Since then, DPIRD has acknowledged that these weeds have become established and widespread in specific regions.

Mesquite is widespread in the Pilbara and parts of the Gascoyne, while Noogoora burr has infested large parts of the Kimberley. Parkinsonia is one of the two most serious weeds in the Kimberley, while smaller infestations exist in the Pilbara.
The Bellyache bush is mostly confined to the East Kimberley. They are categorised as C3 species and management plans are in place, which are listed as follows:

[296] Ibid.: 10

Table 22: Management Plans for Priority Weeds in Northern WA – C2/C3 Plants

Management plans for priority weeds in Northern WA – C2/C3 plants	
Name	**Management plan**
Noogoora burr (*Xanthium occidentale*) [C3 in the Kimberley; C2 in the rest of WA]	• Detailed information on treatment options for Noogoora burr are found on the DPIRD website: https://www.agric.wa.gov.au/herbicides/noogoora-burr-control • DPIRD, *Factsheet: Noogoora Burr* (Xanthium Strumarium), Perth: DPIRD 2017, DPIRD Website https://www.agric.wa.gov.au/sites/gateway/files/FactSheet%20Noogoora%20burr%20May%202017.pdf
Bellyache bush (*Jatropha gossypiifolia*)	• Detailed information on treatment options for Bellyache bush are found on the DPIRD website: https://www.agric.wa.gov.au/herbicides/bellyache-bush-control • Information on how to identify Bellyache Bush: https://www.agric.wa.gov.au/declared-plants/bellyache-bush-declared-pest
Parkinsonia, Jerusalem thorn (*Parkinsonia aculeate*)	• DPIRD, Parkinsonia: Declared Pest, DPIRD Website https://www.agric.wa.gov.au/declared-plants/parkinsonia-declared-pest • Details of recommended herbicides are on the DPIRD website: https://www.agric.wa.gov.au/herbicides/parkinsonia-control
Mesquite (*Prosopis spp.*) [C3 for Mardie and Karratha Stations; C2 in rest of WA]	• Commonwealth Department of the Environment and Heritage, *Weeds of National Significance Weed Management Guide: Mesquite* – Prosopis Species, Canberra: Dept. Environment and Heritage, 2002 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/prosopis.pdf • Department of Agriculture and Fisheries, Biosecurity Queensland, Mesquite Prosopis spp., Brisbane: DAF 2016 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/prosopis.pdf • Department of Land Resource Management, *Weed Management Plan for Mesquite (Prosopis spp.)* 2015, Palmerston, NT: Rangelands Division, Department of Land Resource Management NT: 2015 https://nt.gov.au/__data/assets/pdf_file/0018/231426/mesquite-management-plan.pdf - chapter 6 in particular • Linda Anderson, *Effective Control of Mesquite – a Pilbara Approach*, Karratha: Pilbara Mesquite Management Committee, 2012 https://pilbaramesquite.com.au/wp-content/uploads/2013/04/Effective-control-of-mesquite-a-Pilbara-approach-v1-2.pdf

Source: Mic Julien and Rieks van Klinken, 'Weeds of Significance to the Grazing Industries of Northern Western Australia', *Weeds of Significance to the Grazing Industries of Australia*, compiled by Tony Grice, Adelaide: CRC for Australian Weed Management; and North Sydney: Meat and Livestock Australia, 2002: 34

Table 23: Four Highest priority weeds in Northern WA – C2 Plants

Four highest priority weeds in Northern WA – C2 plants	
Common name	**Scientific name**
Gamba Grass	*Andropogon gayanus*
Rubber Vine	*Cryptostegia grandiflora*
Mimosa Pigra	*Mimosa Pigra*
Prickly Acacia	*Acacia nilotica*

Focus in these Guidelines is on weeds that have been categorised as C2, which means that not only must land managers catalogue and report their locations, but all efforts must be used to eradicate those weeds. However, due to certain of the C3 plants, namely Noogoora Burr, Parkinsonia, and Mesquite being significant weeds with major footprints, land managers should be aware of them. For example, Noogoora Burr is a C3 plant in the Kimberley, but C2 elsewhere in the state. It was recently found at the De Grey rest area in the Pilbara, where it is being treated by landholders, the PMMC, and Main Roads WA, to ensure it is eradicated.

For this reason, these Guidelines will include additional information about these three plants, from a Pilbara and, where mesquite is concerned, Gascoyne and Pilbara perspective. Information on these three plants follows the discussion of C2 plants. The C2 WoNS of most concern in the northern rangelands are:

Gamba Grass (*Andropogon gayanus*) is an invasive weed that was brought to Australia from Africa as a pasture species. Gamba grass is a significant problem in the Northern Territory and is established on the Cape York Peninsula in Queensland. It is regarded as a serious threat to the tropical savannas of northern Australia, including the Kimberley. DPIRD notes there is 'only one known infestation in WA – a cattle station in the East Kimberley. It has been under an eradication program for a number of years to reduce its spread and impact'.[297]

Gamba Grass has a high biomass that can fuel intense bushfires, damaging ecosystems and threatening the safety of people and property. According to the Queensland Government, Gamba Grass significantly alters soil-nutrient cycles, water cycles and fire regimes in the following ways:

- gamba grass-infested landscapes carry up to eight times higher fuel loads than native forest and pastures

[297] DPIRD, 'Gamba Grass: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/gamba-grass-declared-pest Accessed 11 October 2019

- bushfires are extensive with increased intensity and heat, which affects the tree canopy, transforming woodlands to grasslands. This also poses a serious threat to people and property
- the changing demands for nutrients and water over a large area can alter catchment hydrology and downstream wetlands and watercourses.[298]

Gamba grass can grow over four metres high, forming dense patches that can burn at high intensity, while out-competing native plants, reducing natural biodiversity. Seed is spread by wind and water, as well as by vehicles and machinery in mud and on radiators.

Figure 51: Gamba Grass

Note: Clockwise from top left – Tall stands of Gamba Grass; Gamba Grass Leaves; Stems and Branches (covered in fine hair); and Seed Heads

Source: Images courtesy of the Weed Management Branch, Northern Territory Government

[298] Biosecurity Queensland, *Gamba Grass: Restricted Invasive Plant*, Brisbane: Department of Agriculture and Fisheries, 2016: 1

Gamba Grass has robust stems covered in soft hairs, leaves 30-60 centimetres long and up to three centimetres wide, often with a white midrib and covered in soft hairs. The root system spreads up to one metre from the tussock, close to the soil surface. The flowers are a typical grass seed head, with terminal paired racemes that spread to a V-shape. Seed heads mature brown and the plant typically flowers in April. The seeds are contained in a fluffy V-shaped seed head consisting of up to six groups of branches, each containing 2-18 primary branches. Each plant can produce up to 250 000 seeds with a 65% viability.[299]

Good management practice for Gamba Grass

There are three main methods of control for Gamba grass – physical, mechanical, and chemical. These are summarised in the gamba grass control methods table:

[299] Ibid.: 2

Table 24: Gamba Grass Control Methods

Gamba Grass control methods	
Physical	For small infestations, removal by hand: • By pulling or grubbing out with a mattock or hoe. • Do so after rain when the soil is moist. • Removing by hand minimises soil disturbance and therefore further gamba seed germination. • In the wet season, any gamba plants removed must not be left in contact with the soil – they will easily re-root, even if the dirt has been shaken off the plant.
Mechanical	• Gamba grass must be slashed or mowed before it sets seed in April/May. • Slashing gamba grass before it sets seed will reduce seed production but will not kill the roots. • Slashing after seed is set only helps spread Gamba grass. • Regular slashing at appropriate times will encourage smaller, early seeding native grass species.
Chemical	• Generally, the herbicide **glyphosate** is used. • Very effective for large infestations. • Care of use is important it is a non-selective herbicide and may kill native vegetation. • To apply glyphosate, the plants must be actively growing and apply the herbicide to the entire plant. • To reduce the amount of herbicide needed, spray at the beginning of the wet season when plants are actively re-sprouting but are still fairly small, or burn and slash the gamba grass and then spray the re-sprouting grass.
	• Alternatively, use **Roundup Bioactive**, which is safer to apply around water. • Application should follow as for glyphosate.
Grazing[300]	• Gamba Grass being used as a pasture should be grazed with enough stock to keep grass height below 90cm. • Above this height, tussocks may be avoided by stock and be allowed to produce vast quantities of seed. • After lightly grazing in the early wet, a stocking density of four to five head per hectare is required to control growth for the remainder of the wet season. • Increase grazing pressure if grass height nears 90cm.

Source: Department of Primary Industries and Regional Development (DPIRD), 'Gamba Grass Control', DPIRD Website https://www.agric.wa.gov.au/herbicides/gamba-grass-control Accessed 11 October 2019

[300] Grazing as a management tool for Gamba grass is only recommended where it is endemic. This is the case in Queensland and the Northern Territory, where discussion of grazing management is included in guides to gamba grass control. Of greater importance is good pasture management and maintaining good land condition, which will provide some resistance against gamba grass invasion. For more details on grazing management of gamba grass see: Northern Territory Government, 'Gamba Grass', NT Government Website https://nt.gov.au/environment/weeds/weeds-in-the-nt/A-Z-list-of-weeds-in-the-NT/gamba Accessed 11 October 2019; Biosecurity Queensland, Gamba Grass: Restricted Invasive Plant, Brisbane: Department of Agriculture and Fisheries, 2016: 3

For more information about Gamba Grass control, see:

- https://www.agric.wa.gov.au/herbicides/gamba-grass-control
- Biosecurity Queensland, Gamba Grass: Restricted Invasive Plant, Brisbane: Department of Agriculture and Fisheries, 2016 https://www.daf.qld.gov.au/__data/assets/pdf_file/0011/67466/gamba-grass.pdf
- Northern Territory Government, 'Gamba Grass', NT Government Website https://nt.gov.au/environment/weeds/weeds-in-the-nt/A-Z-list-of-weeds-in-the-NT/gamba
- Australian Government, Department of the Environment and Energy, 'Invasive Pasture Grasses in Northern Australia – gamba grass, para grass, olive hymenachne, perennial mission grass and annual mission grass – Gamba Grass', Department of the Environment and Energy website https://www.environment.gov.au/biodiversity/threatened/threat-abatement-advices/invasive-pasture-grasses-gamba-grass

Rubber Vine (*Cryptostegia grandiflora*) is an invasive weed that was first cultivated in the 1860s in the gardens of mining towns in northern Queensland. It is native to southwestern Madagascar and has become a weedy species in several countries and continents around the world.[301] Rubber vine has serious weed potential in the Kimberley region of WA, where two infestations are known, around the lower Fitzroy River and Lake Argyle.

Rubber vine is able to spread quickly and colonise areas, making it a significant threat to many areas of northern Australia. The Queensland Government notes, 'Rubber vine generally invades waterways first, where the seeds germinate in moist silt layers after rain. The plant smothers riparian vegetation and forms dense, sometimes impenetrable, thickets'.[302]

Rubber vine is a woody climbing plant. Its rampant growth permits it to climb over trees up to 15 metres high. In the open it forms loose many-stemmed shrubs from one to two metres high. Rubber vine is poisonous; it contains cardiac glucosides that interfere with heart function. When eaten it also causes severe stomach and intestinal upset. Stock find it unpalatable but may eat it when feed is scarce and dry. The impenetrable thickets that rubber vine may produce can then limit stock access to water.[303]

Rubber vine has fleshy, shiny, dark green leaves ranging from 6-10 centimetres long and up to five centimetres wide. They are arranged in pairs opposite each other on long smooth succulent stems. When broken the stems exude a milky sap. The rubber vine's flowers are large, showy, white to lilac in colour, with a broad funnel-shaped tube and five spreading lobes. The tubular portion is sometimes

[301] Department of Primary Industries, NSW, 'Rubber Vine (Cryptostegia grandiflora)', NSW Department of Primary Industries Website https://weeds.dpi.nsw.gov.au/Weeds/Details/168 Accessed 11 October 2019

[302] Biosecurity Queensland, *Rubber Vine: Restricted Invasive Plant*, Brisbane: Department of Agriculture and Fisheries, 2017: 1

[303] DPIRD, 'Rubber Vine: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/rubber-vine-declared-pest Accessed 11 October 2019

tinged with red. Flowers are about 3-5 centimetres across. The seeds form in large pods about 15 centimetres long. Pods are often found in pairs, joined at the bases to form an angled wing-like shape on a short stalk. The pods distinguish it from similar native plants. Each pod contains numerous seeds, each with a tuft of long white silky hairs, which enable easy dispersal by wind and water. The plant produces a milky latex sap when leaves, unripe pods or stems are cut.[304]

Good management practice for Rubber Vine

Before undertaking any control activities in respect of rubber vine, the presence of this pest must be reported.

Figure 52: Rubber Vine

Note: Clockwise from top left – Colonising a Tree; Rubber Vine Flower; Smothering other Vegetation; and Seed Pods

Source: Colonising a Tree and seed pods © State of Queensland through the Department of Agriculture and Fisheries [2020]; Rubber Vine Flower 'Rubber Vine (Cryptostegia grandiflora)', NSW Department of Primary Industries Website https://weeds.dpi.nsw.gov.au/Weeds/Details/168; Smothering other vegetation - Department of Primary Industries, NSW

[304] Ibid.; Biosecurity Queensland, *Rubber Vine: Restricted Invasive Plant*, Brisbane: Department of Agriculture and Fisheries, 2017: 2

All control methods for rubber vine involve chemical controls, although the application of such controls may differ depending on the size and scale of the infestation.

Biosecurity Queensland has developed a table of suggested strategies for the control of rubber vine, which is reproduced below:

Table 25: Rubber Vine Control Methods

Situation	Initial treatment	Follow-up	Comment
Scattered infestations	Basal bark / cut stump	Follow-up with basal bark/ cut stump as necessary	Cut stump method preferred where possible
	Foliar spray	Follow-up basal bark/ cut stump/foliar spray as necessary	Only foliar spray when there is nil to little rust on the leaves of the plants
	Fire	Follow-up basal bark/ cut stump/foliar spray as necessary	For scattered infestations usually recommended only if herbicides not desired, or if have other weeds can be controlled by fire or if fire is utilised to improve pastures
	Repeated slashing		
Medium infestations	Foliar spray	Treat regrowth, seedlings with basal bark/cut stump/ foliar spray	
	Fire	Fire 1 year later and follow up basal bark/cut stump/ foliar spray as necessary	If fuel load is sufficient CAUTION: There are some native tree species which are susceptible to fire Check before burning
	Repeated slashing		
Dense infestations previously cleared areas	Stick rake or blade plough	Sow pasture – basal bark/ foliar spray – fire and basal bark/cut stump/foliar spray as necessary	First treatment clears bulk of rubber vine and kills roots; any regrowth or seedlings can then be treated; when grass growth allows fuel build up, fire used as control and individual plants later treated
	Fire	Fire one year later and follow-up basal bark/ cut stump/foliar spray as necessary	If fuel load is sufficient CAUTION: There are some native tree species which are susceptible to fire Check before burning
	Aerial Spray	Fire 1–2 years later or follow-up with basal bark spray	Bulk of rubber vine killed with aerial spray; allow build-up of fuel for fire or treat remaining plants with basal bark spray
	Graslan		Where situation and soil type are suitable
Dense infestations along creeks and rivers	Basal bark / cut stump	Fire or basal bark/cut stump/foliar spray	When bulk of rubber vine killed, allow fuel build up for fire or treat remaining plants individually
	Fire and sow pasture	Fire one year later and follow-up basal bark/ cut stump/foliar spray as necessary	If there is a sufficient fuel load to carry a fire, it can open up dense infestations CAUTION: There are some native tree species which are susceptible to fire. Check before burning

Source: Biosecurity Queensland, *Rubber Vine: Restricted Invasive Plant*, Brisbane: Department of Agriculture and Fisheries, 2017: 6

DPIRD provides a detailed list of the types of herbicides recommended for control of rubber vine, including the rates of dilution. These can be found at https://www.agric.wa.gov.au/herbicides/rubber-vine-control.

For more information about rubber vine control, see:

- DPIRD, 'Rubber Vine Control', DPIRD Website https://www.agric.wa.gov.au/herbicides/rubber-vine-control
- Biosecurity Queensland, *Rubber Vine: Restricted Invasive Plant*, Brisbane: Department of Agriculture and Fisheries, 2017 https://www.daf.qld.gov.au/__data/assets/pdf_file/0020/52544/IPA-Rubber-Vine-PP11.pdf
- Australian Government, Department of Environment and Energy, *Weed Management Guide: Rubber Vine* – Cryptostegia Grandiflora, Canberra: Department of Environment and Energy, 2003 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/c-grandiflora.pdf

Mimosa Pigra is an erect, much-branched prickly shrub, which can grow to a height of three to five metres. It is found in one location in Western Australia – the Shire of Wyndham-East Kimberley.[305] Eradication programs are underway in that location. **If found, please report immediately**.

Mimosa Pigra is capable of forming large, dense thickets, as seen in parts of the Northern Territory, most notably on the Adelaide River flood plain. The Northern Territory Government notes that Mimosa Pigra is particularly invasive on floodplains, where it can form vast monocultures, significantly impacting wetland ecosystems, affecting grazing production and restricting social and cultural land use.[306]

Mimosa pigra seeds may be spread by the following methods:

- water, through floods and along watercourses
- animals, such as kangaroos and livestock
- humans through clothing or vehicle / machinery movement.

[305] DBCA, 'Mimosa pigra L.', DBCA Florabase website: https://florabase.dpaw.wa.gov.au/browse/profile/36337 Accessed 5 March2020

[306] Weed Management Branch, Department of Land Resource Management, *Weed Management Plan for Mimosa* (Mimosa pigra), Palmerston: Northern Territory of Australia, 2013: 5

Mimosa Pigra has the following characteristics:

Table 26: Mimosa Pigra Appearance

Mimosa Pigra appearance	
Stems	Greenish at first becoming woody, to three metres long, initially covered with short stiffened hairs, and bearing randomly scattered hooked prickles 5-10 millimetres long.
Leaves	Bright green 20-25 centimetres long, bipinnate, consisting of about 15 pairs of opposite primary segments five centimetres long, each with numerous pairs of stalkless narrow leaflets that fold when touched or injured. Pairs of prickles sometimes occur between the branchlets on the main leaf stalk.
Flowers	Numerous, small pink or mauve flowers grouped into globular heads one to two centimetres diameter; heads borne on stalks two to three centimetres long, two in each leaf axil, petal tube four lobed with eight pink stamens.
Fruit	A thickly hairy flattened pod borne in groups in the leaf axils, each to 6.5-7.5 centimetres long and 7-10 millimetres wide each bearing 20-25 seeds, turning brown when ripe and breaking into one-seeded segments.
Seed	Brown or olive green, oblong, flattened four to six millimetres long and two millimetres wide.
Root	Branched woody tap root, to two metres long, bearing nitrogen-fixing nodules amongst the fine feeding roots.

Source: Department of Primary Industries and Regional Development (DPIRD), 'Mimosa: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/mimosa-declared-pest Accessed 11 October 2019

Good management practice for Mimosa Pigra

Given seeds can be spread by animals and humans, an initial approach would be to limit the ability for spread by contact, by creating a physical barrier around an infestation – fencing. A good fence will prevent accidental spread of seeds via vehicles and machinery, as well as controlling livestock, while deterring native animals.[307]

[307] DPIRD, *Management Plan for the Control of Mimosa Pigra Ivanhoe Station*, Perth: DAFWA 2010: 4

Figure 53: Mimosa Pigra

Note: Clockwise from top left – Mimosa Pigra invading a wetland; Mimosa Pigra Plant; Mimosa Pigra Seed Pods; and Leaves

Source: Mimosa invading Wetland – Australian Government, Department of Environment and Energy, *Weed Management Guide*: Mimosa Pigra, Canberra: Department of Environment and Energy, 2003: 1 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/m-pigra.pdf; all other photographs - Department of Primary Industries and Regional Development (DPIRD), 'Mimosa: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/mimosa-declared-pest Accessed 11 October 2019

The types of control best suited to managing outbreaks of Mimosa pigra include fire and herbicide. Fire is only suitable if used with herbicide control. The following notes were made by DAFWA staff when examining options in respect of an outbreak of Mimosa pigra on Ivanhoe Station in the northeast Kimberley:

Fire – suitable but not recommended alone. To be used with herbicide control.

- To be used after treatment with herbicide.
- Widespread use of fire as the only management tool to kill existing plants is not suitable at this site; however, if plants were burned after they have died from herbicide treatment, use of fire would be extremely useful to stimulate germination of the seed bank. Access to the site and detection of re-growth and seedlings would also be easier after burning (provided there is no dense re-growth of other plants, e.g. grasses).
- Spreading hay around the base of each of the nine stands after they have been killed by herbicide treatment using around 1 kg of dry hay per m^2 and burning it would raise the temperature to ~500 degrees for 2-3 minutes, followed by 5-10 minutes of ~250-300 degrees, before the fire burns down to ash.
- The area should then be treated with water to ensure that all burning material is extinguished.

This technique has been used by DAFWA staff in trials on other declared plants in WA and has proved effective in soil seed bank stimulation.[308]

In the Northern Territory, where infestations of Mimosa pigra are severe, they recommend the use of herbicide in the first instance, coupled with fire management and other, physical methods, such as stick raking and chaining. However, the key element in any control methods for Mimosa pigra is chemical control. The Northern Territory Government's Weed Management Branch also notes that there have been 15 biological agents released to assist in control of Mimosa pigra.[309]

For more information about Mimosa pigra control, see:

- DPIRD, 'Mimosa Control', DPIRD Website https://www.agric.wa.gov.au/herbicides/mimosa-control
- Weed Management Branch, Department of Land Resource Management, Weed Management Plan for Mimosa (Mimosa pigra), Palmerston: Northern Territory of Australia, 2013 https://denr.nt.gov.au/__data/assets/pdf_file/0016/400372/Final-Weed-Management-Plan-for-Mimosa-Dec-2013.pdf

[308] Ibid.: 5

[309] Weed Management Branch, Department of Land Resource Management, *Weed Management Plan for Mimosa (Mimosa pigra)*, Palmerston: Northern Territory of Australia, 2013: 14-20

- Australian Government, Department of Environment and Energy, Weed Management Guide: Mimosa Pigra, Canberra: Department of Environment and Energy, 2003 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/m-pigra.pdf

Prickly Acacia (*Acacia nilotica*) is a non-native acacia naturalised from India and Pakistan. Prickly acacia was first introduced to Queensland in the 1890s for use as shade, as ornamental trees, and for their protein-rich pods, which provided stock feed. Prickly acacia grows best on cracking clay soils that have a high water holding capacity, but can also grow on sandy soil in areas of higher rainfall. It grows best around waterways and on seasonally inundated floodplains receiving 350-1500mm of annual rainfall.[310]

Prickly acacia shares many characteristics with Mesquite, including:

- a thorny shrub or tree growing to 5-10 m in height
- capable of forming dense thorny infestations that invade and dominate tropical grasslands and grass-based pastures
- produces large numbers of distinctive flat, grey-green pods up to 25 cm long, each containing 8-15 hard-coated seeds and deeply constricted between each seed
- seeds are hard coated and relatively long lived (~7 years).

Dispersal of Prickly acacia is due to the movement of seeds, especially via ingestion of its palatable pods by cattle. Floodwaters and mud can also spread the seeds and pods long distances.[311]

At present, Prickly acacia is located within the East Kimberley, localised to one infestation that extends over some 15-17,000 hectares 40km south west of Wyndham. Otherwise, there have been localised single prickly acacia plants found on the roadside from the Northern Territory border to Kununurra.[312]

Good management practice for Prickly Acacia

As with the other Prickle bush weeds, several control methods are available for Prickly acacia. However, where an infestation is detected, the first course of action must be containment or limitation of the spread of the infestation.
The Queensland Department of Natural Resources and Mines developed eleven management strategies aimed at preventing the spread of prickly acacia, including:

[310] Australian Government, Department of Environment and Energy, Weed Management Guide: Prickly Acacia – Acacia Nilotica, Canberra: Department of Environment and Energy, 2003: 3 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/a-nilotica.pdf

[311] IJon Dodd, Andrew Reeves, Richard Watkins, and Linda Anderson, *Situation Statement: The 'Prickle Bush' Weeds (Mesquite, Parkinsonia and Prickly Acacia) in Western Australia*, Perth: DAFWA, 2012: 12 https://pilbaramesquite.com.au/wp-content/uploads/2013/04/Situation-Statement-the-prickle-bush-weeds-in-Western-Australia.pdf

[312] Ibid

- mapping infestations
- eliminating prickly acacia near waterways
- replacing open bore drains with piped water
- targeting small infestations and seeding trees for control first
- restricting grazing of seeding trees
- fencing to contain infestations
- running sheep instead of cattle in prickly acacia infested paddocks
- quarantining sheep and cattle before transport
- keeping infestations manageable
- not overgrazing
- providing feeding supplements after prickly acacia is removed.

Figure 54: Prickly Acacia

Note: Clockwise from top left – Prickly Acacia Infestation near Wyndham, East Kimberley; Seed Pods; Spines and Leaves; and Flowers

Source: Prickly Acacia Infestation near Wyndham, East Kimberley - Jon Dodd, Andrew Reeves, Richard Watkins, and Linda Anderson, *Situation Statement: The 'Prickle Bush' Weeds (Mesquite, Parkinsonia and Prickly Acacia) in Western Australia*, Perth: DAFWA, 2012; Rest of photos: Australian Government, Department of Environment and Energy, *Weed Management Guide: Prickly Acacia* – Acacia Nilotica, Canberra: Department of Environment and Energy, 2003 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/a-nilotica.pdf

Once these limitation initiatives are in place, where applicable (for example, running sheep is not an option in the Kimberley), developing an integrated control and eradication approach using mechanical, chemical, and biological methods is the most effective strategy. Fire and pasture management can complement these treatments in some instances. However, the three main methods are discussed in the table below.[313]

[313] Quoted in: Australian Government, Department of Environment and Energy, *Weed Management Guide: Prickly Acacia* – Acacia Nilotica, Canberra: Department of Environment and Energy, 2003: 4 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/a-nilotica.pdf

Table 27: Control Methods for Prickly Acacia

Control methods for Prickly Acacia	
Mechanical	**Timing / Benefits**
	Undertake treatment before seed pods are dropped
	Particularly effective in drought because seedling regrowth is minimised
	Costs of mechanical treatment can be partially offset if using cleared prickly acacia as fodder (especially helpful in drought conditions)
	Type of Treatment
	Grubbing – Large areas with scattered to medium density, cutting at least 300mm below surface to prevent regeneration
	Pushing and stickraking suited to large areas of prickly acacia at medium density
	Chaining, or double-chain pulling, especially for larger trees in established dense stands. Chaining is best suited to the second year of drought, or before the first seed pod drop following drought Not recommended for drainage channels or waterways due to the likelihood of seedling regrowth
Chemical	**Timing / Benefits**
	Most effective in growing season – after the Wet
	Type of Treatment
	Basal bark spray method suitable for stems up to 100mm in diameter. Stem to be sprayed up to a height of 300mm above ground, wetting bark to the point of run-off Larger trees can be contained by spraying to 1m above ground. Basal bark spraying most effective between April and August
	Cut stump technique – all year round. Stems cut horizontally as close as possible to ground, and immediately painted or sprayed with herbicide
	Folliar spraying is effective on seedlings and young plants up to 2m tall as a follow-up to other forms of control
	Soil-applied herbicides placed as close to the trunk as possible can be highly effective, especially before rainfall
Biological	One native insect – the root eating cicada *Cicadema oldfieldi* – is thought to be one of the causes of prickly acacia dieback observed during occasionally drought conditions
	Queensland Department of Natural Resources and Mines has released six insect species into prickly acacia infestations across the state. Only a few of these species have established, and their impacts have not been significant. Research is ongoing

Source: Australian Government, Department of Environment and Energy, *Weed Management Guide: Prickly Acacia* – Acacia Nilotica, Canberra: Department of Environment and Energy, 2003: 4-6 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/a-nilotica.pdf

For more information about prickly acacia control, see:

- DPIRD, 'Acacia: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/acacia-declared-pest
- Australian Government, Department of Environment and Energy, *Weed Management Guide: Prickly Acacia* – Acacia Nilotica, Canberra: Department of Environment and Energy, 2003 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/a-nilotica.pdf
- Jon Dodd, Andrew Reeves, Richard Watkins, and Linda Anderson, *Situation Statement: The 'Prickle Bush' Weeds (Mesquite, Parkinsonia and Prickly Acacia) in Western Australia*, Perth: DAFWA, 2012: 12 https://pilbaramesquite.com.au/wp-content/uploads/2013/04/Situation-Statement-the-prickle-bush-weeds-in-Western-Australia.pdf

Noogoora burr occupies at least 53,364 hectares on 16 properties in the Kimberley, including along the Ord and Fitzroy Rivers and on Gordon Downs and Nicholson Station. The most extensive infestation is on the Fitzroy River, while Noogoora burr is spreading and increasing in density in the Kimberley.[314] DPIRD notes that Noogoora burr is 'one of the most serious and widespread weeds in the world'. Noogoora burr mostly grows in high rainfall areas with a temperate climate, but may also persist in arid environments. Seeds may remain dormant for years and then sprout with occasional rainfall and reproduce. Noogoora burr is a declared plant for the whole of Western Australia with a control category of C3 in the Kimberley and C2 for the remainder.[315]

Noogoora burr spreads by seed located in the burrs. Burrs are spread by attaching to animals, clothing and bags. Burrs can also float on water. At the seedling stage, Noogoora burr is poisonous to stock, while the burrs tangle in wool, which negatively affects production costs and the value of wool at auction.[316] Poisoning of stock seldom occurs unless stock are starving, and Noogoora burr can cause contact dermatitis in humans and stock.[317] Some Noogoora burr infestations can become so thick as to prevent sheep and cattle from accessing water along riverbanks. Therefore, Noogoora burr is a significant problem in both cattle and sheep country.

A significant infestation was found in the Pilbara in 2018 at the De Grey River Rest Area, between Port Hedland and 80 Mile Beach. Quarantine protocols were instituted and eradication work started immediately after discovery. However, PMMC project manager Jo Williams notes that, despite the excellent work undertaken already by Main Roads, DPIRD, and particularly the PMMC, eradicating

[314] Mic Julien and Rieks van Klinken, 'Weeds of Significance to the Grazing Industries of Northern Western Australia', *Weeds of Significance to the Grazing Industries of Australia*, compiled by Tony Grice, Adelaide: CRC for Australian Weed Management; and North Sydney: Meat and Livestock Australia Ltd, 2002: 34

[315] DPIRD, *Factsheet: Noogoora Burr (Xanthium Strumarium)*, Perth: DPIRD 2017: 1

[316] Ibid.: 1-2

[317] DPIRD, 'Noogoora burr: declared pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/noogoora-burr-declared-pest accessed 1 August 2019

Noogoora Burr from the area will, realistically, be 'an ongoing program for the better part of a decade'.[318]

If a land manager encounters Noogoora burr on their lease, the **must report it to the Pest and Disease Information Service** (contact details above) or by using the MyWeedWatcher application on their smart device or the online reporting tool.

Good management practice for Noogoora burr

As noted above, since Noogoora burr is a C2 weed for most of the state, any presence of the pest **must be reported**, except in the Kimberley, where it is a C3 declared pest.

Figure 55: Noogoora Burr, a weed of national significance

Note: Clockwise from top left – Noogoora Burr in Flower; close up view of the burrs; and an infestation of Noogoora Burr

Source: Department of Primary Industries and Regional Development (DPIRD), *Factsheet: Noogoora Burr* (Xanthium Strumarium), Perth: DPIRD 2017, DPIRD Website https://www.agric.wa.gov.au/sites/gateway/files/FactSheet%20Noogoora%20burr%20May%202017.pdf Accessed 1 August 2019

[318] Shannon Beattie, 'Funds Boost Fight against Deadly Weed in the Pilbara', *Pilbara News*, 18 January 2019. Source: https://www.pilbaranews.com.au/news/pilbara-news/fund-boosts-fight-against-deadly-weed-ng-b881065395z accessed 5 March 2020

Prevention is the best form of defence against Noogoora burr. Implement good biosecurity protocols, such as those listed in the biosecurity section above, and ensure that any fodder purchased off-station comes from areas free of Noogoora burr. Treatment for Noogoora burr is via chemical control, utilising herbicides.

For information about Noogoora burr control, see:

- DPIRD, 'Noogoora Burr: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/noogoora-burr-declared-pest
- DPIRD, 'Noogoora Burr Control', DPIRD Website https://www.agric.wa.gov.au/herbicides/noogoora-burr-control

Parkinsonia is considered one of the most serious weeds in northern Australia. Parkinsonia, also known as Jerusalem thorn, was introduced into northern Australia from tropical America as an ornamental plant, because of its attractive foliage and drought tolerance. Parkinsonia grows best in moist conditions along river banks and flats where it forms dense thickets. It does particularly well on tropical black soils and, once established, withstands heat and drought. The plant produces long seed pods with marked constrictions between each seed, while the seed pods are five to ten centimetres long and straw-coloured when ripe. Several large seeds are housed in each pod, and many will germinate years later. Pods float and are spread by floods.[319]

DPIRD considers Parkinsonia to be one of the two most serious weeds in the Kimberley. Hundreds of kilometres of watercourses are infested in the east Kimberley and Pilbara regions. Although mainly riparian, some infestations are beginning to spread onto floodplains. It forms dense, thorny thickets that become virtually impenetrable. There is currently no cost-effective means for containing and managing parkinsonia. Data demonstrate that Parkinsonia infestations are particularly severe in the eastern Kimberley region, although the scale of the infestation means the total area infested has not been calculated. In the Pilbara, estimates suggest some 800ha have been infested, while approximately 785 kilometres of river frontage is also infested.[320]

Good management practice for Parkinsonia

DPIRD notes that biological control agents have been released for parkinsonia, including parkinsonia loopers. These are leaf-feeding moths that were released in the Kimberley and Pilbara between 2012 and 2014 by the CSIRO as part of an effort to control and limit the spread of Parkinsonia.[321]

Together with biological control agents, DPIRD recommends herbicides to reduce numbers.

[319] DPIRD, 'Parkinsonia: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/parkinsonia-declared-pest Accessed 1 August 2019

[320] Julien and van Klinken: 35

[321] See: S. Raghu, G. Fichera, and A. White (2016), *Release and evaluation of the parkinsonia loopers in WA*. Final report submitted to the Cattle Industry Funding Scheme, Department of Agriculture and Food Western Australia. Canberra: CSIRO, 2016

Figure 56: Parkinsonia, a weed of national significance

Note: Clockwise from top left – Parkinsonia bush; parkinsonia branches and leaves; and Parkinsonia flowers

Source: Department of Primary Industries and Regional Development (DPIRD), 'Parkinsonia Control' DPIRD Website https://www.agric.wa.gov.au/herbicides/parkinsonia-control Accessed 1 August 2019

For more information on Parkinsonia control, see:

- DPIRD, 'Parkinsonia: Declared Pest', DPIRD Website https://www.agric.wa.gov.au/declared-plants/parkinsonia-declared-pest.
- DPIRD, 'Parkinsonia Control', DPIRD Website https://www.agric.wa.gov.au/herbicides/parkinsonia-control.

Mesquite is a legume of the same group of plants as the wattles. It forms impenetrable thorn forests in upland habitats and is adapted to a large proportion of semi-arid and arid Australia. There are over 40 different species of mesquite and a range of hybrids; all members of the genus *Prosopis* are WoNS and declared plants in WA. The Prosopis species known to be present in WA are *P. glandulosa*, *P. glandulosa x*

velutina and *P. pallida*. Mesquite trees were planted in the north-west for shade, ornamental purposes, and their nutritious pods. They originally showed little tendency to spread. However, some trees reverted to wild types with spines and weedy tendencies.

In WA, the most extensive infestation is on Mardie station and surrounds, where there is an estimated 30,000 ha of dense hybrid mesquite and a further 120,000 ha of scattered mesquite. In the Murchison and Gascoyne Junction districts, over 200 km of watercourses have patches of hybrid mesquite, and isolated plants are found throughout. Mesquite infestations are present around Onslow (*P. pallida*) and in the Kimberley (hybrid mesquite and *P. glandulosa*). Hybrid infestations in the Pilbara and Gascoyne Regions are beyond any realistic eradication attempts. There is currently no method for sustainable containing and managing mesquite.[322]

Seedling Mesquite trees are often confused with prickly acacia. They may be differentiated by three features:

1. Prickly acacia twigs have small, grey, wart-like lumps, while mesquite twigs are smooth.
2. Prickly acacia has circular yellow flower heads about eight millimetres in diameter.
3. Prickly acacia flowers produce dark brown, woody pods which contain only one or two seeds each.

Mesquite is a long-lived perennial that propagates by seed. Shrubs begin to flower after two or more years of age, and flowering begins in April and peaks in early summer. It grows well on a variety of soils, including saline and highly alkaline areas, but grows best on alluvial soils associated with water courses. Mesquite has a deep tap root that enables it to draw water from deep in the soil profile.[323] Mesquite can be found either as densely branched shrubs about one metre high or as trees that can reach 15 metres or more in height.

Good management practice for Mesquite

As with many rangeland weeds, the high cost of control options for Mesquite can greatly exceed the value of the land and its productive capacity; however, their potential to infest much larger areas justifies intervention to eradicate or control current infestations. There are a large number of control methods available for Mesquite,[324] although not all those techniques are recommended for implementation against Mesquite in the Pilbara on account of the hybrid Mesquite's greater vigour and resilience, for example chain pulling and dozer pushing.[325]

[322] Julien and van Klinken: 35

[323] DPIRD, 'Mesquite: What you should know', DPIRD Website https://www.agric.wa.gov.au/declared-plants/mesquite-what-you-should-know Accessed 2 August 2019

[324] See, for example, the Northern Territory Government's comprehensive *Weed Management Plan for Mesquite* (Prosopis spp.)

[325] See Linda Anderson, *Effective Control of Mesquite – a Pilbara Approach*, Karratha: Pilbara Mesquite Management Committee, 2012

The PMMC has published a guide describing suitable Mesquite control techniques for the Pilbara. Recommended treatments include:

- Physical control
  - Blade ploughing
  - Stick raking
  - Fire
- Chemical control
  - Basal bark spraying
  - Cut stump treatment
- Biological control
  - Seed feeding bruchid beetles
  - Leaf tying moth.[326]

Granular herbicides are applied aerially in the West Kimberley to control populations of Mesquite that largely infest floodplain areas, where difficult terrain restricts access by vehicles, other vegetation is relatively sparse and predictable rainfall provides opportunities for strategic use of this technique. Foliar spraying is not used in the Pilbara, because it requires specialised equipment and it also interferes with the beneficial biological control activities of the leaf tying moth.[327]

For more information on Mesquite management techniques, see:

- DPIRD, 'Mesquite: What You Should Know', DPIRD website: https://www.agric.wa.gov.au/declared-plants/mesquite-what-you-should-know
- Commonwealth Department of the Environment and Heritage, *Weeds of National Significance Weed Management Guide: Mesquite – Prosopis Species*, Canberra: Dept. Environment and Heritage, 2002 https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/prosopis.pdf
- Department of Agriculture and Fisheries, Biosecurity Queensland, *Mesquite Prosopis spp.*, Brisbane: DAF 2016 https://www.daf.qld.gov.au/__data/assets/pdf_file/0004/73489/mesquite.pdf Department of Land Resource Management, *Weed Management Plan for Mesquite (Prosopis spp.)* 2015, Palmerston, NT: Rangelands Division, Department of Land Resource Management NT: 2015 https://nt.gov.au/__data/assets/pdf_file/0018/231426/mesquite-management-plan.pdf - Chapter 6 in particular
- Linda Anderson, *Effective Control of Mesquite – a Pilbara Approach*, Karratha: Pilbara Mesquite Management Committee, 2012 https://pilbaramesquite.com.au/wp-content/uploads/2013/04/Effective-control-of-mesquite-a-Pilbara-approach-v1-2.pdf

[326] See Linda Anderson, *Effective Control of Mesquite – a Pilbara Approach*, Karratha: Pilbara Mesquite Management Committee, 2012

[327] Jon Dodd, Andrew Reeves, Richard Watkins, and Linda Anderson, *Situation Statement: The 'Prickle Bush' Weeds (Mesquite, Parkinsonia and Prickly Acacia) in Western Australia*, Perth: Department of Agriculture and Food, 2012: 10

Figure 57: Mesquite, a weed of national significance

Note: Clockwise from top left – Mesquite branch – note the large thorns; Mesquite seedpod clusters; and an example of how thick a Mesquite bush gets. Several together forms an impenetrable thicket

Source: 'Mesquite: declared pest', Department of Primary Industries and Regional Development (DPIRD) Website https://www.agric.wa.gov.au/declared-plants/mesquite-declared-pest Accessed 1 August 2019

- The PMMC Website contains a range of resources related to managing Mesquite, as well as identification guides. See: https://pilbaramesquite.com.au/resources/external-publications/

Weeds in the Southern Rangelands

As noted above, there are a number of invasive weed species in the Southern Rangelands. Some of these include WoNS, such as Opuntioid cacti, Mesquite and other invasive weeds. The most prevalent weeds in the Southern Rangelands are the Opuntioid cacti, which will be briefly discussed here, and Mesquite, which is found in the Murchison and Gascoyne Junction districts. Mesquite was discussed above.

Opuntioid cacti are commonly known as prickly pears. The Opuntioid cacti are categorised under the botanical names *Austrocylindropuntia, Cylindropuntia* and *Opuntia*, and share a range of commonalities. There are 27 species of Opuntioid cacti, all of which are WoNS. Opuntioid cacti are a group forming one of the sub-families of the Cactaceae family – sub-family Opuntioideae. Cacti from the Opuntioideae sub- family are commonly referred to as opuntioid cacti or opuntioids. Opuntioid cacti are set apart from other Cactaceae sub-families by the presence of glochids – small, detachable, barbed bristles that are found in the plant's areoles. Glochids detach readily by disturbance such as wind or touch, often causing irritation to skin, eyes and lungs. Some species, such as *Opuntia microdasys*, have numerous glochids giving the plants a distinct, furry appearance, while Austrocylindropuntia species have very few.[328]

Given the variety of appearance between the 27 Opuntioid cacti species, this section does not seek to describe them. However, some photos of Opuntioid cacti extant in the Southern Rangelands of WA are provided below. Note that some Opuntioid cacti exist, and are being treated, in the Northern Rangelands, particularly the Pilbara.

For comprehensive information on the appearance of the various Opuntioid cacti found in WA, see:

- M.R. Sheehan and S Potter, *Managing Opuntioid Cacti in Australia: Best practice control manual for* Austrocylindropuntia, Cylindropuntia *and* Opuntia *species*. Perth: DPIRD, 2017: 16-30

The prickly pear was initially introduced at Port Jackson in 1788, and was cultivated in Parramatta. The intent of introduction is thought to have been 'to establish a cochineal industry for dying the distinctive red coats worn by British soldiers'. Several other species of opuntioid were introduced subsequently and, by 1843, were found in Chinchilla on the Western Darling Downs, Queensland. Naturalised populations of cacti are commonly associated with urban gardens, old homesteads and peri-urban areas, where the ornamental value of these plants remains important. Mining areas, where cacti were historically used to delimit and secure leaseholds, and dumping sites for garden and household refuse, are also hotspots. From these point sources, cacti have invaded grazing land, rangelands, pastures, as well as native vegetation, from coastal systems to open grassland and woodlands, roadsides, gardens and recreational reserves. They also commonly occur along water courses and floodplains.[329]

While stock generally avoid Opuntioid cacti, injury and spread can occur from stock brushing past them. Other significant issues for pastoral businesses associated with infestations include the following:

- sharp spines and glochids (fine barbed bristles) can cause injury
- these spines can contaminate and devalue wool and hides

[328] M.R. Sheehan and S Potter, *Managing Opuntioid Cacti in Australia: Best practice control manual for* Austrocylindropuntia, Cylindropuntia *and* Opuntia *species*. Perth: DPIRD, 2017: 1-2

[329] Sheehan and Potter: 4-5

- spines pose a risk to shearers and stock handlers
- injury to working dogs and sheep being moved along roadsides through infestations
- stock may eat fruit or cladodes in the absence of more desirable species or during times of drought, causing injuries to the eyes, nose, lips and mouth
- cattle with diets rich in *opuntia* species may suffer from bloat, and there have been some reports of death from the accumulation of fibre in the gut
- cacti infestations can harbour pests like fruit fly, and provide shelter for foxes and rabbits, which can be detrimental to production systems, industry and the environment.

Figure 58: Opuntioid Cacti, weeds of national significance

Note: Clockwise from top left – A small sample of Opuntioid cacti found in Western Australia's Rangelands. Left – *Opuntia ficus-indica*; Centre – *Cylindropuntia fulgida var. mamillata;* Right – *Cylindropuntia prolifera*

Source: M.R. Sheehan and S Potter, *Managing Opuntioid Cacti in Australia: Best practice control manual for* Austrocylindropuntia, Cylindropuntia *and* Opuntia *species*. Perth: Department of Primary Industries and Regional Development (DPIRD), 2017

In Western Australia, Opuntioid Cacti are predominantly found in the Southern Rangelands, with a few minor populations in the Pilbara and Kimberley.

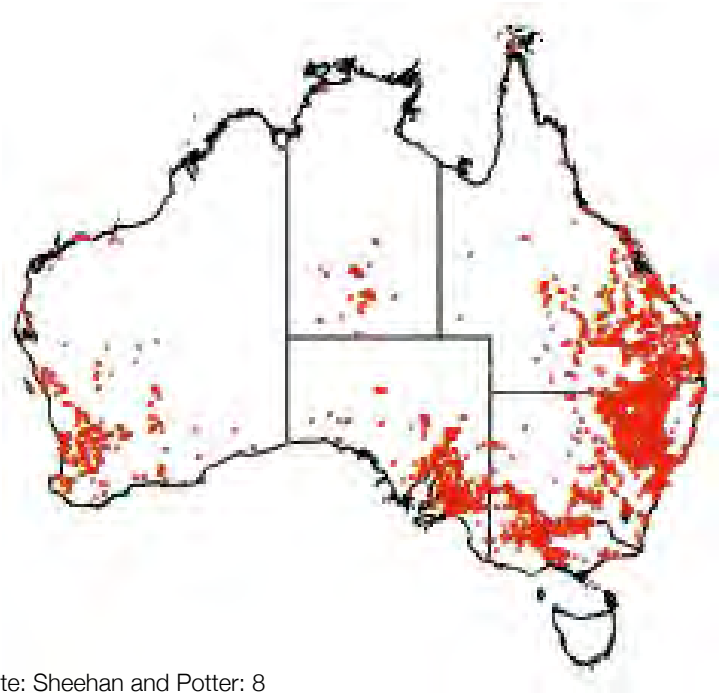
Good management practice for Opuntioid Cacti

Opuntioid cacti control methods are well proven in comparison with other WoNS in the rangelands, given the long period in which infestations have existed in Australia.

Vigilance is required in respect of biosecurity protocols in areas infested with Opuntioid cacti – even light infestations. Because opuntioid cacti are so well adapted to spread, utmost care is required when undertaking management activities. Species that are especially well adapted to vegetative spread, such as and *Opuntia aurantiaca*, are easily moved around on clothing, backpacks, machinery, even shoe laces, without detection.[330]

Biological control methods have been spectacularly successful in respect of several Opuntioid species, most famously the *cactoblastis cactorum* (a moth whose larvae infests the host and eats the flesh of the cactus). However, not all species of Opuntioid have proven biological control agents available, so other methods, such as fire coupled with herbicide, or herbicide coupled with physical removal (mechanical and/or manual), may be appropriate.

Figure 59: Map of distribution of Opuntioid Cacti in Australia



Note: Sheehan and Potter: 8

Source: M.R. Sheehan and S Potter, *Managing Opuntioid Cacti in Australia: Best practice control manual for* Austrocylindropuntia, Cylindropuntia *and* Opuntia *species*. Perth: Department of Primary Industries and Regional Development (DPIRD), 2017: 5

[330] Sheehan and Potter: 8

Figure 60: Demonstration of biological control of Prickly Pear (Opuntia Stricta)

Note: Left – infestation of Opuntia stricta at a farm in Chinchilla, Qld, in May 1928; Right – the same area of the farm in October 1929 following establishment of *cactoblastis cactorum* in the area

Source: M.R. Sheehan and S Potter, *Managing Opuntioid Cacti in Australia: Best practice control manual for* Austrocylindropuntia, Cylindropuntia *and* Opuntia *species*. Perth: Department of Primary Industries and Regional Development (DPIRD), 2017: 109

We know cactus is hard to kill – that is in part why it is a successful weed in Australia. While research is underway to improve management success, the methods currently available to us require ***Follow-Up, Follow-Up*** and more ***Follow-Up***.

Whichever methods are chosen, make sure to document the control methods used, the location, date, and so on, so that the efficacy of the chosen methods can be monitored and changed, if necessary.

For comprehensive information on management techniques for Opuntioid cacti, see:

- Chapter 4: Managing Cacti, in M.R. Sheehan and S Potter, *Managing Opuntioid Cacti in Australia: Best practice control manual for* Austrocylindropuntia, Cylindropuntia *and* Opuntia *species*. Perth: DPIRD, 2017: 75-112. For an electronic version of the document, go to https://www.agric.wa.gov.au/invasive-species/opuntioid-cacti-best-practice-control-manual.

For additional information and resources, see:

- DPIRD Website https://www.agric.wa.gov.au/pests-weeds-diseases/weeds
- Rangelands NRM https://rangelandswa.com.au/what-we-do/focus-areas/weeds/

Introduced animals

Many non-native or introduced vertebrate animals have become established as unmanaged or feral populations across Australia. Some of these animals have become pests, either in localised areas or across wider parts of the landscape. In the pastoral regions of Western Australia, these pests tend to either prey on domestic or farm animals, or compete with livestock for pasture to eat.

This section will focus on feral herbivores, omnivores, and predators that are declared pests under the BAM Act, the issues they present to pastoralists, and methods of control. The animals discussed in this section include:

- large feral herbivores (camels, horses, and donkeys)
- feral pigs
- wild dogs.

These Guidelines also acknowledge that foxes and feral cats can cause significant damage to wildlife in the Rangelands, but note that in the pastoral context, wild dogs are by far a greater cause of livestock loss than either of these animals. Control methods for foxes are similar to those for wild dogs, and, as such, should foxes be a problem in a particular region, the techniques discussed below for dogs may be effective. Feral Cats are a declared pest under the BAM Act but as they do not present a risk to livestock or agriculture, DPIRD is not the lead agency for control and management.[331]

[331] DPIRD, 'Feral Cats', DPIRD Website https://www.agric.wa.gov.au/pest-mammals/feral-cats Accessed 12 August 2019

Large feral herbivores

Large feral herbivores (LFH), defined as 'un-owned Arabian (dromedary) camels (*Camelus dromedarius*), donkeys (*Equus asinus*), and horses (*Equus caballus*) that live in the wild but are descended from domesticated animals',[332] have a significant presence in the WA pastoral estate. The extent to which each of the three species affect pastoral land differs, based on the types of landscapes they are able to inhabit, their size, and the amount of forage they consume, when compared to livestock. The table below demonstrates the potential impact of pest grazing herbivores, based on a comparison to livestock units (see Chapter 4 for more details). Of the 15 highest priority declared animal species in Western Australia, LFH are listed at 10 (camel), 12 (donkey), and 14 (horse) respectively.[333]

Camels are able to survive and thrive in the arid desert areas of Western Australia. They tend to occupy the arid rangelands, but enter the pastoral areas in response to poor seasons, seeking food and water. The Arabian camel is a large animal weighing between 450-650kg. Camels prefer a diet of succulent herbage, high in water and, often, salt content. Grasses make up between 20-40% of their diet, compared to 70-90% in cattle. Camels also eat the fruit, leaves and stems of many shrubs and will badly damage some native trees such as the Quandong or Native Peach. Their long legs and neck enable them to browse trees much further from the ground than any other

[332] DPIRD, *Western Australian Large Feral Herbivore Strategy 2019-2024*, Consultation Draft. Perth: DPIRD, 2019: v

[333] DPIRD, 'High Priority Animal Species', DPIRD Website https://www.agric.wa.gov.au/invasive-species/high-priority-animal-species Accessed 12 August 2019

Table 28: Livestock Equivalents for other Grazers and Browsers

Livestock equivalents for other grazers and browsers		
Other Grazers	Annualised DSE	Annualised CU
Horses and Camels: small (450kg)	11.0	1.6
Horses and Camels: large (635kg)	14.0	2.0
Donkey	7.0	1.0
Kangaroo	0.7	0.1

Source: Department of Primary Industries and Regional Development (DPIRD), 'Livestock Comparisons for Estimating Grazing Pressure in the Rangelands', DPIRD Website https://www.agric.wa.gov.au/rangelands/livestock-comparisons-estimating-grazing-pressure-rangelands Accessed 14 August 2019

terrestrial herbivore in Australia.[334] Feral camels can cause significant damage to pastoral infrastructure when they come onto pastoral leases from the desert. Camels habitually destroy fences by leaning on them until they collapse and may foul or damage water points. Further, they can behave aggressively towards sheep and cattle, sometimes depriving them of feed or water. Additionally, camels are susceptible to a number of diseases that are serious diseases of livestock, such as tuberculosis and brucellosis.[335]

Figure 61: Arabian camel (*Camelus Dromedarious*)

Source: Department of Primary Industries and Regional Development (DPIRD), 'Feral Camel', DPIRD Website https://www.agric.wa.gov.au/pest-mammals/feral-camel Accessed 12 August 2019

[334] DPIRD, 'Feral Camel', DPIRD Website https://www.agric.wa.gov.au/pest-mammals/feral-camel Accessed 12 August 2019

[335] Ibid

Feral donkeys are widely dispersed across the pastoral estate, most commonly found in the Murchison, Pilbara, and Kimberley regions, with some extension into the Goldfields. Donkeys are versatile foragers: they eat a wide variety of grasses, herbs, and bushes. They are well-adapted to semi-arid regions because they can reduce their evaporative water loss when they become dehydrated, tolerate extreme loss of body water, and continue to eat when deprived of water. Feral donkeys live in social groups, while the composition of such groups is unstable: some individual animals move between groups. Donkeys consume the same food as domestic stock, which is problematic, especially when food is scarce. Their pads (trails) contribute to soil erosion, especially in and around water sources. They sometimes foul water holes and may prevent other animals from drinking.[336]

Figure 62: Feral donkey (*Equus Asinus*)

Source: Department of Primary Industries and Regional Development (DPIRD), 'Feral Donkey', DPIRD Website https://www.agric.wa.gov.au/pest-mammals/feral-donkey Accessed 12 August 2019

[336] DPIRD, 'Feral Donkey', DPIRD Website https://www.agric.wa.gov.au/pest-mammals/feral-donkey Accessed 12 August 2019

Feral horses occur most commonly in the Goldfields, Pilbara, and Kimberley regions. Similar to donkeys, feral horses eat what pastoral livestock eat – grass, shrubs, and herbs – and therefore compete directly for resources where these species coexist.[337] Feral horses inhabit a wide variety of country, ranging from semi-arid plains and rocky ranges to tropical grasslands and wetlands, as well as temperate ranges, and subalpine forests. They prefer grassland and shrubland with plentiful water and pasture. As big, hard-hoofed animals, feral horses cause immense ecological damage, especially in fragile ecosystems. Feral horses eat pasture grasses, may destroy fences, and during a muster can cause cattle to scatter. They are potential hosts for several exotic diseases such as equine influenza and African horse sickness, which are serious threats to domestic horses.[338]

Figure 63: Feral horses (*Equus Caballus*)

Source: Department of Sustainability, Environment, Water, Population and Communities, Feral Horse (*Equus caballus*) and Feral Donkey (*Equus asinus*) Fact Sheet, Canberra: Australian Government, 2011. Website: https://www.environment.gov.au/system/files/resources/b32a088c-cd31-4b24-8a7c-70e1880508b5/files/feral-horse.pdf Accessed 12 August 2019

337 DPIRD, *Western Australian Large Feral Herbivore Strategy 2019-2024*, Consultation Draft. Perth: DPIRD, 2019: 6; 11

338 Department of Sustainability, Environment, Water, Population and Communities, *Feral Horse (Equus caballus) and Feral Donkey (Equus asinus) Fact Sheet*, Canberra: Australian Government, 2011: 2

Good Management Practice for Large Feral Herbivores

Humane, safe and effective control practices are very important in LFH management. Below is a list of control techniques and considerations for management of LFH, and a table of appropriate applications of those methods:

- aerial culling
- ground culling
- telemetry ('Judas' technique)
- ground and aerial mustering
- passive trapping
- exclusion fencing
- fertility control.

Table 29: Control Methods for Large Feral Herbivores

Method	Application
Aerial culling	Most effective for removal of large numbers of animals occupying remote and inaccessible terrain. Aerial culling of one herbivore species is often performed in conjunction with other species. It is regarded as the most humane and cost-effective method for removing LFH at the landscape scale. The overall welfare impact that the method has on animals is moderate, with animal welfare risks including but not limited to fear from pursuit, wounding and period of pain and suffering, if not rendered immediately unconscious by the shot. The method is costly and less effective at low animal densities.
Ground culling	Effective for small number of animals and sometimes the only suitable method for removal of LFH. Often combined with mustering and trapping for small-scale management, and useful in assisting with follow-up control activities. Method not suitable in remote and inaccessible terrain. The overall welfare impact of this technique on animals is mild, with animal welfare risks similar to aerial culling.
Telemetry ('Judas' technique)	Successfully used for the landscape-scale control of gregarious animals, such as LFH, and which are difficult to locate by other methods. Chosen 'Judas' animal is fitted with radio-tracking collar and released to seek other animals in the area. The group can then be located by radio tracking and the accompanying animals are removed. It is an expensive technique requiring skilled operators but is particularly useful at low animal densities if local eradication is the objective of the operation. Telemetry control poses additional animal welfare risks to aerial culling alone, including stress of capture, restraint, and handling of the Judas animal.
Ground and aerial mustering	Ground mustering is most suitable for open and flat environments, while aerial mustering is useful in large areas, or where rugged and inaccessible terrain prevents access with ground-based vehicles. Animals are mustered into permanent or portable yards and are trucked live from the yards, or shot on site. Mustering can reduce high densities of LFH at small spatial scales, but the disadvantages include cost, the need for specialised resources and highly trained personnel. The method is not viable at lower animal densities or landscape-scale. Mustering causes stress and exhaustion in the mustered animals and has the potential to cause serious injury. Further potential welfare problems may arise when holding, handling and transporting animals from the yard to an abattoir. The overall welfare impact is mild to moderate, and is highly dependent on how the subsequent stages of holding and handling of animals are conducted.

Table 29: Control Methods for Large Feral Herbivores (cont.)

Passive trapping	The method requires good local knowledge of animal behaviour allowing the best location for trap construction. Traps are usually built near water sources, on high use animal trails, or when conditions are dry, and are equipped with feed or water as an attraction. Animals passively enter the enclosure through trap gates and are either trucked live from the yards or shot on site. The method reduces the need for specialised personnel, and can be cost effective if the animals are sold. It can only be used to capture small groups of animals and is very labour intensive. The overall welfare impact of passive trapping on target animals is mild; however welfare problems may arise during holding, handling and transporting captured animals;[339] the method can also have welfare impacts on non-target species.
Exclusion fencing	Electric or permanent fencing is usually constructed to fence animals in or to exclude them from high value areas and resources, or to prevent animal movement into areas that have been depopulated by removal programs. This method is very costly and requires ongoing monitoring and high-level maintenance, as fences can be damaged by fire, flood and animals (particularly camels and cattle). In general, fencing is only practical for short-term and small-scale containment. Fencing may pose animal welfare risks including but not limited to impeding animal's access to feed and water, and fear, pain, and distress associated with entrapment and injury.
Fertility control	Immuno-contraceptive vaccines have been shown to successfully reduce or inhibit population growth only if used in small, contained and accessible animal populations. The method requires a high proportion (60-80%) of females to be treated to reduce population reproductive rates, gives no immediate reduction to the population size, and there is no long-lasting or permanent vaccine presently available. Consequently, the application of immuno-contraceptive vaccines that control fertility is not feasible for most rangeland conditions, where animal numbers are high, where animals are widely dispersed, or where the management objective is to eradicate or reduce the population to a sustainable level.[340] Animal welfare risks of fertility control include but are not limited to repeated pursuit, capture, restraint, and long-term functional and behavioural changes.[341]

Source: Department of Primary Industries and Regional Development (DPIRD), *Western Australian Large Feral Herbivore Strategy 2019-2024*, Consultation Draft. Perth: DPIRD, 2019: 28-29

More information and assistance

For additional information and assistance in respect of managing LFH, land managers and pastoral lessees are encouraged to contact their local RBG, pay their declared pest rates, and engage in activities and field days being run by their RBG. Contact details for RBGs in the pastoral areas are contained in the section on Recognised Biosecurity Groups above.

339 T Sharp and G Saunders, *A model for assessing the relative humaneness of pest animal control methods* (Second edition). Canberra: Australian Government Department of Agriculture, Fisheries and Forestry, 2011

340 RJ Hobbs and LA Hinds. 'Could current fertility control methods be effective for landscape-scale management of populations of wild horses (*Equus caballus*) in Australia?' *Wildlife Research* 45 (2018): 195-207

341 JO Hampton, et al. 'Is wildlife fertility control always humane?' *Animals* 5 (2015):1047-1071

Wild dogs

Wild dogs, including dingoes, feral dogs and dingo-dog hybrids (*Canis familiaris*), are a controversial subject in the Rangelands. Many pastoralists are adamant wild dogs are pest that must be controlled, while others consider them to be a necessary element in the landscape. Dogs take lambs, sheep, and goats, occasionally calves. The estimated national impact of wild dog predation on livestock production is $89 million per annum.[342] However, wild dogs can regulate kangaroo numbers,[343] thereby reducing competition for pasture.[344]

Wild dogs are a declared pest under the BAM Act, and, as a result, must be managed accordingly. Indeed, wild dogs are listed as a High Profile Species for the pastoral region in the 2015 Invasive Species Position Statement issued by the then-Department of Agriculture and Food.[345]

Figure 64: Wild dog attacking a sheep

Note: Image taken by Chris Thomas in Blackbutt Queensland of a wild dog coming in to feed on a sheep carcass. Supplied with permission through the Centre for Invasive Species Solutions. Whilst a good image, it is important to note this particular carcass was used to lure in wild dogs for trapping and the dog was not responsible for killing the sheep.

Source: P. Cook and N. Taylor, *Carnarvon Rangelands Biosecurity Association: Wild Dog Management Case Study*. PestSmart Toolkit Publication. Canberra: Centre for Invasive Species Solution, 2017: Title Page

342 R McLeod, *Cost of Pest Animals in NSW and Australia, 2013-14*. Report prepared for the NSW Natural Resources Commission by eSYS Development Pty Ltd. Sydney: eSYS Development Pty Ltd, 2016: 24

343 D Choquenot and DM Forsyth, 'Exploitation ecosystems and trophic cascades in non-equilibrium systems: pasture – red kangaroo – dingo interactions in arid Australia', *Oikos* 122 (2013): 1292-1306

344 See, for example, Courtney Fowler and Michelle Stanley, 'Wild Dog Numbers on the Rise and Costing Northern Cattle Producers Millions Each Year', *ABC WA Country Hour*, 9 April 2019, ABC News website: https://www.abc.net.au/news/rural/2019-04-09/wa-pastoralists-wild-dog-fight/10979476; and Rob Edwards, '20190315 File Note Fact Finding Field Trip 1 – Gascoyne-Murchison-Pilbara – Good Pastoral Land Management Guidelines 11-15 March 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019

345 DAFWA, *Biosecurity Regulation Invasive Species Position Statement: Priority Declared Species – Agricultural Impact*, Perth: DAFWA, 2015: 4; 7

Issues around wild dog predation of livestock led to the establishment of the *Western Australian Wild Dog Action Plan 2016-2021*, developed by the WA Wild Dog Action Group. This industry-driven initiative was supported by the State Government. The objective was to identify the key issues for managing wild dogs throughout Western Australia, considering the economic, environmental and social impacts of wild dogs.

The *Wild Dog Action Plan* was established because of growing evidence of the need for targeted control measures at a local and broader state-wide level. PLB data from Annual Returns from 2007 to 2014 demonstrated an increase in stock losses from wild dog predation from $2.4 million to $6 million across the pastoral estate.[346] Further, according to a 2019 article by the ABC, wild dogs are responsible for millions of dollars of damage to livestock in the Northern Rangelands. A dogger interviewed for the story noted he had removed more than 83 dogs from Anna Plains Station in the Kimberley in a six-month period, and 172 in total across the Kimberley and Pilbara in that same time.[347]

The article notes that the *Wild Dog Action Plan* has seen $100,000 allocated to the Pilbara Regional Biosecurity Group from 2017-2018 to 2018-2019.[348] Some of the activities funded by the *Wild Dog Action Plan* include:

1. Repair and maintain the existing 1190km long State Barrier Fence using a model that maximises Aboriginal employment - $4,800,000.
2. Funding eight additional Licensed Pest Management Technicians via Biosecurity Groups over three years - $2,360,000.
3. Murdoch University Veterinary Graduate Program to sterilise dogs in Aboriginal communities over the three years - $165, 000.
4. Rangelands Cell Fencing Program - $2,550,000 State and $2,000,000 Federal funding to contribute to four demonstration cell fences in the WA rangelands.
5. Employment of a DPIRD Project Manager and Development Officer over four years ($1,000,000) plus the delivery of community engagement ($200,000).
6. Wild Dog research and development (R&D) - $615,000. Employment of an early career research officer working on wild dog R&D initiatives and developing a competitive R&D grant fund.
7. Seek approvals and build the 660km long proposed extension to the State Barrier Fence in the Shires of Ravensthorpe and Esperance (the Esperance Extension - $6,900,000).
8. Capacity building and skills development in wild dog management ($1,500,000 in Federal funds). This includes Biosecurity

[346] WA Wild Dog Action Group, Western Australian Wild Dog Action Plan 2016-2021, Perth: WA Wild Dog Action Group / DAFWA, June 2016: 2

[347] Courtney Fowler and Michelle Stanley, 'Wild Dog Numbers on the Rise and Costing Northern Cattle Producers Millions Each Year', *ABC WA Country Hour*, 9 April 2019, ABC News website: https://www.abc.net.au/news/rural/2019-04-09/wa-pastoralists-wild-dog-fight/10979476 Accessed 13 August 2019

[348] Fowler and Stanley, 'Wild Dog Numbers on the Rise…'

Group wild dog management capacity building grants, monitoring and evaluation and an R&D contribution.[349]

Most RBGs invest in Licenced Pest Management Technicians (LPMTs or doggers) and other types of control, and provide training for pastoralists. For Southern Rangelands RBGs, wild dog control includes coordinated wild dog baiting days (two per year) and contracting doggers. Some use aerial baiting exclusively, while some prefer ground baiting. For example, the 2018 Goldfields Nullarbor Rangelands Biosecurity Association Field Days included training on 1080 (sodium fluoroacetate) baiting, how and where to set dog traps, and the very significant health and safety precautions required to be undertaken when handling 1080 and other poisons.[350]

In the Northern Rangelands, LPMTs are now used more regularly, although aerial baiting is still a primary tool. At their 2018 AGM, the Pilbara RBG noted they are working with pastoralists to deliver a range of wild dog control methods, including:

- employing three LPMTs
- aerial baiting
- hand baiting
- traps
- shooting.[351]

Good management practice for wild dogs

Law restricts the use of 1080 and strychnine. Misuse of these chemicals endangers you, your family, your pets, the public, farm animals and wildlife and may impact on the future availability of this poison as a pest control method

There are strict controls on use of 1080 and strychnine for wild dog control. One method of wild dog control with 1080 is 1080-laced meat baits, which is effective because wild dogs have a low tolerance to 1080, while many Western Australian native animals have high resistance due to co-evolution with fluoroacetate-bearing native plants. A low dosage is used and specifically targeted to wild dog levels. Further, 1080 is safe in the environment. It dilutes into harmless compounds in water and is consumed by bacteria in the soil.[352] Aerial or ground deployment is undertaken depending on the conditions. Care must be taken to avoid loss of baits to non-target species, such as bungarras.

[349] DPIRD, 'Western Australian Wild Dog Action Plan 2016-2021', DPIRD Website https://www.agric.wa.gov.au/invasive-species/western-australian-wild-dog-action-plan-2016-2021 Accessed 10 October 2019

[350] Rob Edwards, '20181018 File Note Kalgoorlie Trip AGM and Field Day on Mt Vetters Station – Goldfields Nullarbor Rangelands Biosecurity Association 16 and 17 October 2018', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2018

[351] Rob Edwards, '20181116 File Note Karratha Trip AGM and LFH Forum – Pilbara Regional Biosecurity Group 14 and 15 November 2018', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2018

[352] DPIRD, 'The Use of 1080 in Wild Dog Control', DPIRD Website https://www.agric.wa.gov.au/invasive-species/use-1080-wild-dog-control Accessed 13 August 2019

Another delivery system for 1080 toxins is the Canid Pest Ejectors (CPEs) method. CPEs are spring-activated baiting devices that use a piston to propel the contents of a 1080 capsule directly into the mouth of a wild dog or fox as it pulls the bait placed on the head of the ejector. Dried meat covers the lure holder that contains the capsule. The lure holder sits atop the ejecting mechanism, which is contained in a 15-18cm hollow tube placed firmly in the ground. The main advantages offered by CPEs include:

- Greater target specificity than conventional meat baits as deployment of 1080 is conditional on the upwards pulling force easily achieved only by canids.
- CPEs can be reused repeatedly as the device is staked into the ground by a sturdy metal peg and cannot be easily moved by animals.
- Unlike conventional dried meat baits, the 1080 capsules used in CPEs are sealed and protected from the elements; baits can be left in place for extended periods preventing 1080 degradation over time.
- CPEs should still be checked regularly (monitoring bait uptake, and replaced when activated). The 1080 capsules are more resistant to moisture/rain, but not impervious to rain.

1080 capsules are available in 3mg and 6mg for foxes and wild dogs respectively and treated as equivalent dosage strength for 1080 commercial bait products under the Code of Practice for the Safe Use and Management of 1080 in Western

Figure 65: Dog control methods – rack of baits and setting a metal-jawed dog trap

Source: Left – WA Wild Dog Action Group, *Western Australian Wild Dog Action Plan 2016-2021*, Perth: WA Wild Dog Action Group / DAFWA, June 2016: 27; Right – DAFWA Regulatory Standards and Invasive Species, *Landholder Information for the Safe Use and Management of Strychnine for Wild Dog Traps*. Perth: DAFWA 2015: 9

Australia.[353] In the rangelands of WA, baits and CPE capsules should only be sourced at 6 mg (dog strength) to avoid developing control aversion behaviour in wild dogs in response to consuming sub-lethal doses. Even if targeting foxes in pastoral area, should use 6 mg strength baits/capsules.

Another dog control method, which also uses poison, is strychnine-laced metal-jawed traps. Strychnine is added to the jaws of the trap, and is ingested by the wild dog when it bites down on the jaws of the trap in attempting to free its leg. Under the *Animal Welfare Act 2002* and associated Animal Welfare (General) Regulations 2003, it is mandatory to use strychnine on jawed traps for wild dog control in WA. The strychnine ensures a rapid death and reduces the long-term suffering of a trapped dog.[354]

To use either 1080 or strychnine, land managers must complete appropriate training, apply for, and obtain, the appropriate permit(s) to purchase these chemicals. Both chemicals are highly toxic and can be lethal to humans. Part of the permit application process is a risk assessment of the property, signed off by a DPIRD biosecurity officer. Further, DPIRD officers undertake audits, to ensure the proper measures and risks are being addressed.

Prominent warning signs must be placed at entry points onto a property on which 1080 or strychnine is being used. Neighbours must also be provided with at least 72 hours' notice in writing prior to using either chemical.

A warning sign should look like the one pictured below:

Figure 66: Bait warning sign for 1080 and Strychnine

Source: DAFWA Regulatory Standards and Invasive Species, *Landholder Information for the Safe Use and Management of Strychnine for Wild Dog Traps*. Perth: DAFWA 2015: 18

[353] DPIRD, 'Canid Pest Injectors', DPIRD Website https://www.agric.wa.gov.au/invasive-species/canid-pest-ejectors Accessed 13 August 2019

[354] DPIRD, 'The Use of Strychnine in Wild Dog Control', DPIRD Website https://www.agric.wa.gov.au/invasive-species/use-strychnine-wild-dog-control Accessed 13 August 2019

The DPIRD Website contains a wide range of information on the safe use and management of both 1080 and strychnine. See the list of websites in the more information section below.

Law restricts the use of 1080 and strychnine. Misuse of these chemicals endangers you, your family, your pets, the public, farm animals and wildlife and may impact on the future availability of this poison as a pest control method.

Initially, pastoral lessees and managers should engage with their local RBG and learn about good management practice through them. DPIRD is another key point of contact, whether via regional offices, or the website.

More information on wild dog control

Key sources of information on wild dog control methods include:

- Pastoral Area Recognised Biosecurity Groups – See list and contact details above.
- DPIRD, 'The Use of 1080 in Wild Dog Control', DPIRD Website https://www.agric.wa.gov.au/invasive-species/use-1080-wild-dog-control

Figure 67: Example of an exclusion or barrier fence to manage wild dogs

Source: Wild Dog Action Group, *Western Australian Wild Dog Action Plan 2016-2021*, Perth: WA Wild Dog Action Group / DAFWA, June 2016: 56

- DPIRD, 'The Use of Strychnine in Wild Dog Control', DPIRD Website https://www.agric.wa.gov.au/invasive-species/use-strychnine-wild-dog-control
- DPIRD, 'Canid Pest Ejectors', DPIRD Website https://www.agric.wa.gov.au/invasive-species/canid-pest-ejectors - includes a link to an instructional video on how to install and set a CPE.
- DPIRD, 'Baiting & Poison Permits', DPIRD Website https://www.agric.wa.gov.au/pests-weeds-diseases/control-methods/chemicals/baits-poisons/baiting-poison-permits
- WA Wild Dog Action Group, Western Australian Wild Dog Action Plan 2016-2021, Perth: WA Wild Dog Action Group / DAFWA, June 2016. DPIRD Website https://www.agric.wa.gov.au/invasive-species/western-australian-wild-dog-action-plan-2016-2021

Feral pigs

Feral pigs (*Sus scrofa*) are pigs which are free-living and unowned. They are widespread and abundant throughout the southwest and Kimberley regions of Western Australia (WA) and occur in more localised populations elsewhere in WA. Shortly after introduction to Australia in the late 18th and early 19th centuries, populations of pigs became feral and subsequently spread via natural dispersal and escapes as well as through intentional releases. Feral pigs occur in WA as self-sustaining populations, many of which are still expanding, in four main areas: the river systems of the east and west Kimberley; the Pilbara; north-west lower Murchison and Geraldton areas; and the river systems, swamps and forest country in the south-west.[355] High densities of feral pigs occur in parts of the Kimberley, particularly along the Fitzroy River, where the wet/dry seasonal conditions, combined with agricultural and pastoral activities and abundant water sources support large numbers of feral pigs. Similarly, in the Pilbara, localised concentrations of feral pigs can occur; however, these populations persist only in close association to large watercourses, which typically hold water year-round.

Feral pigs impact directly on pastoral operations through reduced animal productivity (due to predation, competition and disease transmission), and damage to infrastructure (i.e. fences, irrigation equipment),[356] while also consuming or

[355] JL Long, *Introduced birds and mammals in Western Australia*. Forrestfield, WA: Agriculture Protection Board of Western Australia: 1988

[356] D Choquenot, JC McIlroy, and T Korn, T. (1996) *Managing Vertebrate Pests: Feral Pigs*, Canberra: Australian Government Publishing Service, 1996

Figure 68: Feral pig (*Sus Scrofa*) wallowing, Kimberley Region, WA

Source: Department of Primary Industries and Regional Development (DPIRD)

digging up pasture, which may ultimately degrade pasture quality.[357]
Soil disturbance associated with feral pig ground rooting results in significant losses of both introduced and native pasture grass species, with a converse increase in abundance of broad leaf weeds.[358]

Feral pigs directly compete with livestock for pasture and food plant resources year-round. Prolonged wallowing by feral pigs due to hotter ambient temperatures leads to increased fouling and degradation of permanent water sources and may see livestock excluded from watering points and/or increase the rate of disease transmission. Further, feral pigs may cause negative impacts on both food and fodder crops in the Kimberley, as they are capable of persisting almost entirely within central pivot irrigation areas if undisturbed.

Feral pigs contribute to environmental degradation due to their foraging for subterranean food, which significantly disturbs the ground.[359] This 'rooting' for food is often associated with weed incursions or increases in weed abundance; however, whether this is due to feral pigs introducing weed seeds to new areas or increasing the suitability or likelihood of weed establishment through soil disturbance or nutrient enrichment (via deposition of urine and faeces) is unknown. Feral pigs are known to disseminate several WoNS, including mesquite (Prosopis pallida), via ingestion and subsequent

[357] Ibid

[358] JH Cushman, TA Tierney, and JM Hinds, 'Variable effects of feral pig disturbances on native and exotic plants in a California grassland', *Ecological Applications* 14 (2004): 1746-1756; TA Tierney and JH Cushman, 'Temporal changes in native and exotic vegetation and soil characteristics following disturbances by feral pigs in a California grassland', *Biological Invasions* 8 (2006): 1073-1089

[359] AJ Bengsen, MN Gentle, JL Mitchell, HE Pearson, and GR Saunders, 'Impacts and management of wild pigs (*Sus scrofa*) in Australia', *Mammal Review* 44 (2014): 135-147

excretion in their faeces.[360] However, seed dispersal via attachment to feral pig hair may be a more important mechanism of weed spread by feral pigs.[361]

In the Kimberley and Pilbara regions of WA, feral pigs have the greatest impact on ephemeral wetlands and riparian vegetation associated with river systems, with strong declines in water quality due to increased turbidity, water fouling, and elevated nutrient levels.[362] These impacts are exacerbated when wetland areas contract in size during the dry season.

Disease Transmission

Feral pigs can act as hosts or vectors of both endemic and exotic diseases which can represent significant impacts to livestock production, biodiversity conservation, and public health. In Australia, feral pigs harbour a range of endemic diseases including; leptospirosis (*Leptospira* spp.), brucellosis (*Brucella suis*), melioidosis (*Pseudomonas pseudomallei*), tuberculosis (*Mycobacterium* spp.), salmonellosis (*Salmonella* spp.), campylobacterosis (*Campylobacter* spp.), cryptosporidiosis (*Cryptosporidium* spp.), giardiasis (*Giardia* spp.), balantidiasis (*Balantidium* spp.), sparganosis (*Spirometra erinaceieuropaei*), porcine parvovirus, Murray Valley encephalitis and other arboviruses.[363] The two most common diseases isolated from feral pigs in Australia are *Leptospira* spp. and *Brucella* spp., both of which can have serious health implications for livestock, wildlife and humans if infected. In recent years an increase in *Brucella* spp. infections has been observed in both feral pig hunters and their hunting dogs in northern NSW.[364] Disease transmission is most often associated with direct contact with feral pigs and/or their bodily fluids coupled with poor hygiene or hand washing practices, or the consumption of undercooked meat harvested from feral pigs.

Feral pigs are susceptible to numerous exotic diseases including; foot and mouth disease (FMD), swine vesicular disease, African swine fever, Aujeszky's disease, trichinosis (*Trichinella* spp.), and classical swine fever. In the event of a FMD incursion within Australia, feral pigs could contribute to the persistence and transmission of the disease as they are highly susceptible to the virus and are efficient amplifiers and transmitters of the virus to other pigs

[360] AC Grice, 'Seed production, dispersal and germination in *Cryptostegia grandiflora* and *Ziziphus mauritiana*, two invasive shrubs in tropical woodlands of northern Australia', *Australian Journal of Ecology* 21 (1996): 324-331; BC Lynes and SD Campbell, 'Germination and viability of mesquite (*Prosopis pallida*) seed following ingestion and excretion by feral pigs (*Sus scrofa*)', *Tropical Grasslands* 34 (2000): 125-128;

[361] MN Barrios-Garcia and SA Ballari, 'Impact of wild boar (*Sus scrofa*) in its introduced and native range: a review', *Biological Invasions* 14 (2012): 2283-2300

[362] D Fordham, A Georges, B Corey, and BW Brook, 'Feral pig predation threatens the indigenous harvest and local persistence of snake-necked turtles in northern Australia', *Biological Conservation* 133 (2006): 379-388; J Mitchell, *Experimental research to quantify the environmental impact of feral pigs within tropical freshwater ecosystems*. Final Report to the Department of the Environment, Water, Heritage and the Arts, Canberra, 2010

[363] Choquenot, et. al., *Managing Vertebrate Pests: Feral Pigs*; J Hampton, P Spencer, A Elliot, and RC Thompson, 'Prevalence of zoonotic pathogens from feral pigs in major public drinking water catchments in Western Australia', *EcoHealth* 3 (2006): 103-108

[364] MJ Irwin, PD Massey, B Walker, and DN Durrheim, 'Feral pig hunting: a risk factor for human brucellosis in north-west NSW?', *New South Wales Public Health Bulletin* 20 (2009): 192-194

and susceptible livestock.[365] It has been estimated that a large, multi-state FMD outbreak in Australia would result in a financial cost of between $49.3 billion and $51.8 billion over 10 years.[366]

Good Management Practice for Feral Pigs

Non-government groups such as landholder community groups, industry groups and associations, animal welfare societies, hunting groups and conservation organisations can all play an important role in conducting or supporting feral pig control programs. Community-led feral pig control groups and RBGs play an integral role in delivering seasonal on-ground operational management activities to mitigate feral pig impacts, and these groups cover a significant area of WA where feral pigs are known to occur. There is growing interest in developing improved feral pig control options in the Kimberley, driven by wildlife conservation groups and LCDC in collaboration with the Kimberley Recognised Biosecurity Association.

RBGs may undertake feral pig control programs on pastoral stations and other land holdings, as well as on publicly-owned land such as state forests,

Figure 69: Feral pig (Sus scrofa) amongst cattle at water hole, Kimberley, WA

Source: Department of Primary Industries and Regional Development (DPIRD)

[365] CRP Pech and JC McIlroy, 'A model of the velocity of advance of foot and mouth disease in feral pigs', *Journal of Applied Ecology* 27 (1990): 635-650; RJ Doran and SW Laffan, 'Simulating the spatial dynamics of foot and mouth disease outbreaks in feral pigs and livestock in Queensland, Australia, using a susceptible-infected-recovered cellular automata model', *Preventive Veterinary Medicine* 70 (2005): 133-152; MP Ward, SW Laffan, and LD Highfield, 'The potential role of wild and feral animals as reservoirs of foot-and-mouth disease', *Preventive Veterinary Medicine* 80 (2007): 9-23

[366] B Buetre, et. al. *Potential socio-economic impacts of an outbreak of foot-and mouth-disease in Australia*. ABARES research report. Canberra: ABARES, 2013

national parks, and reserves as part of the biosecurity remit under the BAM Act. These groups, in concert with Rangelands NRM, Commonwealth, State, and Local Governments, are able to collaborate with all land managers to foster and support valuable partnerships that increase the capacity of collective responses to the landscape-scale issue of feral pig infestation and management. The best approach to managing feral pigs is an integrated, tenure-blind approach, utilising multiple control methods.

There are several methods for controlling feral pigs, including:

- baiting
- trapping
- fencing
- shooting; and
- detection dogs.

Table 30: Control Methods for Feral Pigs

Method	Considerations
Baiting	• Grain and pellets are the only approved baits for use with 1080 concentrate. As per the Code of Practice for the Safe Use and Management of Registered Pesticides containing 1080, PAPP and STRYCHNINE in Western Australia mixing of 1080 liquid concentrates can only be performed by an authorised DPIRD Biosecurity Officer, Approved Pastoralist, or Licenced Pest Management Technician (LPMT). • Commercially manufactured PIGOUT® 1080 baits are registered for use in WA (Landholder 1080 poison permit required for use). • HOGGONE paste bait is also available for the control of feral pigs, but must be used in conjunction with a HOGGONE hopper/feeder. HOGGONE paste bait is an S6 chemical, therefore purchase and use does not require a Restricted Chemical Permit as for 1080 or Strychnine.
Trapping	• Trapping is extensively used and there are numerous effective trap designs available. Similarly there are many different types of food attractant used including; fruit (apples most commonly), grain (wheat, barley, maize, lupins), and vegetables. • Use of animal carcasses or swill feeding is not permitted. • Trapping must conform to animal welfare standards. Traps should be built where possible in locations that will provide natural shade or shade must be provided, using designs approved by the national model Code of Practice. • Water should be provided and traps should be checked a minimum of every 24 hrs. • Standard cage traps of various designs including silo or 'figure 6' traps, heart shaped traps, and cage traps with a number of designs for trap doors are commonly used.
Fencing	• Feral pig exclusion fencing may or may not incorporate an electrified wire(s). • Fencing is expensive and is typically used to protect high value resources or crops. In southwest WA fencing is used by DBCA to protect some Reedia spathacea populations. Exclusion fencing has also been erected around high value crops such as truffle and avocado farms in the southwest region. • For best results and to minimise maintenance requirements, exclusion fencing needs to be installed prior to feral pigs 'finding' the high value food resource.

Shooting	• Shooting as a control method for feral pigs is typically only useful for dealing with small numbers of pigs (i.e. 1-2, typically lone boars) or recalcitrant individuals which have avoided baiting or trapping programs. • Ground shooting and hunting operations are more likely to disperse feral pigs within the landscape than reduce their abundance. Baiting or trapping programs concentrate pigs and are more effective and reducing local abundance. • Aerial shooting of feral pigs in the rangelands is more commonly associated with targeted large feral herbivore culling programs. For best results, aerial culling of feral pigs needs to be integrated with ongoing baiting and trapping programs.
Detection dogs	• Detection dogs are trained to only track and locate (NOT hold) feral pigs to enable operators to destroy the pig by shooting only. • The use of dogs to attack and bring down feral pigs is an unacceptable practice under the Code of Practice for the Capture and Marketing of Feral Animals in Western Australia (2003), and it is in contravention to the Animal Welfare Act (2002). • Some community-led feral pig control groups utilise detection dogs to identify feral pig presence or locations of recent feral pig activity for trap placement or feral pig removal. • Bait aversion training is strongly recommended for detection dogs used in feral pig control. Pest control operators can choose to muzzle or have non-muzzled dogs. DBCA Guidelines for Approving the Use of Dogs for Feral Pig Control Activities is for animal pest control contractors and pest control organisations and specifies the conditions where a dog can be used on CALM land, UCL and UMR.

Source: Department of Primary Industries and Regional Development (DPIRD), *WA Feral Pig Strategy 2020-2025*. Perth: DPIRD, 2019

More information on feral pig control

Key sources of information on feral pig control methods include:

- Pastoral Area Recognised Biosecurity Groups – See list and contact details above.
- DPIRD, 'Feral pig control: 1080 baiting', DPIRD Website https://www.agric.wa.gov.au/pest-mammals/feral-pig-control-1080-baiting
- DPIRD, 'Feral pig control: trapping', DPIRD Website https://www.agric.wa.gov.au/mechanical-physical-and-cultural/feral-pig-control-trapping
- DPIRD, *WA Feral Pig Strategy 2020-2025*, DPIRD Website https://www.agric.wa.gov.au/feral-pig-strategy
- Pest Smart Website https://www.pestsmart.org.au/pestsmart-factsheet-practical-feral-pig-control/

Native animals

Kangaroos are the principle native animals competing with livestock for food on the pastoral estate. They eat the same grasses, forbs, and shrubs that sheep, cattle, and goats do, and have thrived as a result of the additional waters that pastoralists established to service their livestock.[367] Across the board, pastoralists and those associated with the industry argue that one of the major challenges for managing total grazing pressure is managing kangaroos. Indeed,

> Pastures that have been destocked for regenerations (e.g. after a fire) can be a prime target for kangaroos and feral pests. Closing down watering points in these paddocks may help reduce their numbers, however, some evidence shows that moisture in plants alone may sustain kangaroos for a reasonable period. In stocked paddocks, fencing off reticulated water with swing or trap gates may encourage kangaroos to graze elsewhere.
>
> Kangaroo numbers can also be managed by licenced harvesting or culling. (…) Some graziers are attempting to fence their properties to exclude kangaroos.[368]

Additionally, rotational grazing systems, which allow for periods of rest and recovery for grazed pastures, are rendered less effective by grazing kangaroos. This affects both the productive capacity of the pastoral business and the desired environmental outcomes of good ground cover, ecological sustainability, and increased long-term soil organic carbon levels.[369]

Accordingly, the three key approaches to managing kangaroos on pastoral land:

- closing down watering points
- fencing (both waters and exclusion fences around properties)
- culling.

Closing down water points is a simple enough concept – turn off the water and the kangaroos (and stock) do not have a water source, so they move elsewhere. This approach should only be taken when livestock have been removed from the paddock. However, as noted above, moisture in plants kangaroos consume may sustain them for a period of time – possibly until they have depleted the resource significantly.

Therefore, exclusion fencing is increasingly being seen as an appropriate course of action (see Chapter 4: Infrastructure). Coupled with other forms of control, fencing can be an effective kangaroo management technique. Indeed, the former Department of Environment and Conservation (now DBCA), produced a fact sheet relating to fencing for kangaroos, which provides a range of useful information (see below).

DBCA also administers licences to cull kangaroos under the Biodiversity Conservation Regulations 2018. To cull kangaroos, the minimum licence required is a Fauna causing damage licence. If a land manager wishes to take kangaroos

[367] Department of Environment and Resource Management, *Managing Grazing Lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 5

[368] Department of Environment and Resource Management, *Managing Grazing Lands in Queensland*, Brisbane: Queensland Department of Environment and Resource Management, 2011: 5

[369] Cathleen Waters, *Addressing Feed Supply and Demand Through Total Grazing Pressure Management*, North Sydney: Meat and Livestock Australia, 2018: 8

for commercial purposes, a Fauna taking (commercial products) licence is the minimum requirement, with a range of other licences for processing, dealing, exporting, and importing fauna licences. A fact sheet on these matters is also included below.

When considering a cull, land managers must comply with the *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-Commercial Purposes*. The Code of Practice specifies the types of firearms considered suitable for shooting kangaroos and wallabies, ensuring a sudden and humane death, and the areas the shooter should target when firing at the animal (generally the brain unless specific circumstances exist). Information on the Code of Practice is also provided below.

More information on kangaroo management

Key sources of information on kangaroo management include:

- Department of Environment and Conservation, *Fauna Notes: Information about Western Australia's Fauna*. No. 32: Fencing and Gates to Reduce Kangaroo Damage. Perth: DEC, 2009. Website: https://www.dpaw.wa.gov.au/images/documents/plants-animals/animals/kangaroos/32_fencing_kangaroos.pdf
- DBCA, Biodiversity Conservation Regulations 2018 – *Fact Sheet: Commercial Use of Kangaroos*. Perth: DBCA, 2018. Website: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Biodiversity%20Regs_Fact%20Sheet_Kangaroos.pdf
- Department of the Environment, Water, Heritage and the Arts, *National Code of Practice for the Humane Shooting of Kangaroos and Wallabies for Non-Commercial Purposes*. Canberra: Commonwealth of Australia, 2008. Website: https://www.environment.gov.au/system/files/resources/8ae26c87-fb7c-4ddc-b5df-02039cf1483e/files/code-conduct-non-commercial.pdf

Good Pastoral Land Management
Guidelines

7 Regenerating and rehabilitating degraded areas

Contents

A guiding principle of this document is that prevention is more effective than rehabilitation. Further, good land management is a long-term enterprise, inextricably linked to the profitability of a pastoral business. These two concepts should inform anyone using these Guidelines. However, land can and does get degraded over time, sometimes through neglect or bad management, sometimes because of acts of nature – fires, floods, droughts and so on. When regenerating degraded land, it can take a long time to see on-ground results. For example, the Ord River Regeneration Reserve took 40 years to be rehabilitated, starting in the 1960s. The scale was immense – some 10,000 km^2 – and included 'strip contour cultivation and seeding (which proceeded at various levels of intensity during the 1960s, 1970s and 1980s), fencing and destocking of cattle by mustering over many years, and the eradication of donkeys'.[370]

The timescale for land management activities to begin to show results in a degraded landscape vary between the Northern and Southern Rangelands. The Kimberley receives regular rainfall, so changes in land condition as a result of rehabilitation activities may become visible after five years, although pastoralists in the Kimberley suggest that to ensure the regeneration was properly sustainable can take between five and ten years.[371] In the Pilbara, similar timescales are suggested. However, in the Southern Rangelands, the timescale for regeneration is considered to be generational.[372]

While regeneration can be hard, costly, and time consuming, the results can be spectacular, if not immediate, and well worth the investment. Healthy landscapes and pastures filled with palatable plants securing the topsoil and feed stock are profitable landscapes that ensure the success and sustainability of a pastoral business.

This chapter discusses a range of techniques to deal with land degradation. These techniques, together with those discussed in the previous chapters, are geared towards remediating and preventing degradation for, as Tinley and Pringle argue,

> Because of the interactive linkages in ecology… stemming the loss of top soils and haemorrhaging of soil moisture together with herbivore grazing management is the crux to successful, sustainable pastoralism and maintenance of biodiversity.[373]

Once regeneration has occurred, the imperative to prevent the land from degrading again becomes the focus, which requires careful attention to stocking rates, responsiveness to seasons, managing how and where stock graze, and careful placement and maintenance of infrastructure, among other factors.

[370] A. L. Payne, I. W. Watson, P. E. Novelly, *Spectacular Recovery in the Ord River Catchment*, South Perth: Department of Agriculture and Food, Western Australia, 2004: 1

[371] See Rob Edwards, '20190412 File Note Fact Finding Field Trip 2 – Kimberley – Good Pastoral Land Management Guidelines 8-11 April 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019

[372] Rob Edwards, '20190315 File Note Fact Finding Field Trip 1 – Gascoyne-Murchison-Pilbara – Good Pastoral Land Management Guidelines 11-15 March 2019', Lands File 50246-2004. Perth: Department of Planning, Lands and Heritage, 2019: 11

[373] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 10

In this chapter, planning and prioritising regeneration and rehabilitation of degraded areas is discussed and then several important elements of land regeneration will be outlined, including:

- remediation of degraded areas
- revegetation of degraded areas
- slowing the flow of water across the land
- remediation of eroded areas.

Each of these activities are designed to rehydrate the land and then retain that moisture and translate it into plant growth, root stability and, consequently, soil stability and healthy pastures.

Defining land degradation

Land degradation is a term used to describe changes that are

> additional to those occurring naturally and carries with it the notion of changes that is undesirable and brought about by humans. Land degradation then refers to chemical and biophysical changes in land that reduce both its quantity and quality. Frequently, these changes are linked to a reduction in the productive capacity of land and its economic value.[374]

Schedule 6 of the Queensland *Land Act 1994* also provides a practical definition of degradation:

(a) soil erosion, salinity or scalding

(b) destruction of soil structure, including, for example, the loss of fertility, organic matter or nutrients

(c) decline in perennial pasture grasses, pasture composition and density

(d) low ground cover

(e) thickening in woody plants

(f) stream bank instability and slumping

(g) the presence of any declared pest

(h) water logging

(i) rising water tables

(j) a process that results in declining water quality.[375]

Each of these issues are significant, and the practical definition provides a clear indication of what to be aware of when seeking to identify degraded areas. However, other processes, such as sedimentation, may be considered degradation, despite not being included in the above definition.

[374] Mick Lumb, 'Land Degradation', The Australian Collaboration: A Collaboration of National Community Organisations, 2012: 1 The Australian Collaboration Website http://www.australiancollaboration.com.au/pdf/FactSheets/Land-degradation-FactSheet.pdf Accessed 16 August 2019

[375] Department of Natural Resources and Mines, *State Rural Leasehold Land Strategy: Guidelines for Determining Land Condition*, Brisbane: Queensland Government, July 2013: 3-4

Priority setting

As noted in Chapter 3, priority setting is a vital to good land management. Once goals and objectives have been set, a land manager must determine, in order of priority, the land management actions to be undertaken. This process is the same for rehabilitation and remediation activities. Should rehabilitation and/or remediation activities be required, the lessee then must consider which activities should be undertaken and where.

A key element of station planning is mapping the land under the lease. The same principles operate in respect of land rehabilitation. Lessees need to know where any areas of degradation may exist, their extent, and their effect on productivity and ecosystem function. Chapter 3 touches on mapping for rangeland rehabilitation, with reference to EMU and ESRM plans. It further explains the differences between these two plans.

Briefly, EMU is a land system-based approach to developing an understanding of landscape processes and how they interrelate with land management. ESRM plans provide a whole-of-property approach that seeks to balance maintaining the natural resource base with achieving the business goals of the pastoral land manager. Both ESRM and EMU plans place high value on mapping the landscape as a tool for station planning.

According to the EMU methodology, developed by Ken Tinley and Hugh Pringle, the mapping process is the fundamental prioritisation tool for land rehabilitation. In the EMU formulation, the process is as follows:

1. *Initial meeting* – explore landholder's key issues and objectives, management history, etc.
2. *Overlay mapping exercise* – build the ecological baseline of the property using the landholder's knowledge. Identify the key issue areas and most important interactions and drivers of change.
3. *Aerial survey of key issues and areas mapped* – an aerial traverse route is planned together based on an assessment of the landholders' mapped knowledge. Digital photos are taken of key issues during the flight.
4. *Flight debrief and plan ground inspections* – what did we see, map the key issues we saw and consider them in context of the initial mapping… what do we think is going on? Use photos from flight on a TV. Visit key areas on the ground to check interpretations and assessments.
5. *Major review: Reassess and identify (map) management priority areas*
    i. Where is the most important country in need of some strategic intervention? Identify them on an overlay with simple dot points to capture just what really matters and what we think needs to be done.
    ii. Consider if additional expertise is needed to build a few key projects based on mapped priority areas.

iii. Is existing monitoring telling you what you really want to know where you want to know it? Make a plan to fill the gaps of what you really want to do.

a. Build priority project proposals – Seek external funding if required.

b. Implement project(s) – establish baseline monitoring BEFORE starting works that will record if it 'worked'.

6. *Install property monitoring system* – your 'intelligence' system of what matters and where, based on mapped management priorities. YOUR 'finger on the pulse' system of feedback information.

7. ***REVIEW, REVISE AND REFINE –*** Ongoing learning by doing; Map all major observations and revelations on a new overlay left out on a small table for this purpose; Revisit the visual plan at least annually.[376]

Tinley and Pringle note that pastoralists' assumptions about priority areas change after a mapping exercise has been undertaken. The areas in which lessees will achieve more for less, or, in Tinley and Pringle's words, 'bang for the buck' are 'rarely the same areas the pastoralist was initially concerned about'.[377] Additionally, priority projects need to focus on what is achievable in the time available.

Aerial surveys are excellent vehicles for understanding the area of land under lease that require the most attention. However, time in an aeroplane or helicopter is expensive. An alternative to using an aircraft to undertake the aerial survey may be to utilise satellite imagery as part of the mapping process. Tim Wiley has demonstrated that even widely accessible satellite imagery tools, such as Google Earth, can provide insights into land condition and land management in the rangelands.[378] He argues, similarly to Tinley and Pringle, that:

> Identifying and focussing on the critical points in the landscape is particularly important in the rangelands due to the vast scale of pastoral properties. It is easy to become overwhelmed by the scale of what is required on these stations. But by understanding how a station's landscape functions it is possible to strategically target the critical areas with management intervention.[379]

Intervention in these critical areas can then provide an efficient and cost-effective method of regenerative land management. To do so, it might pay for land managers to seek out a professional rangeland consultant, including Government and NGO staff, to assist with the development of the map and facilitate a prioritisation process that identifies areas of critical intervention and places in which 'bang for buck' can be achieved. Information on contacts and resources for land rehabilitation and regeneration are included in the 'More Information' section below.

[376] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 41

[377] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 2: Manual*, Perth: Rangelands NRM, 2013: 72

[378] Tim Wiley, 'Catchment Function Analysis using Google Earth Mapping', *Australasian Agribusiness Perspectives*, Volume 20, paper 1 (2017): 1-33

[379] Ibid.: 2

Remediation of degraded areas

One of the best examples of remediation of degraded areas in Australia is the Ord River Catchment Regeneration Project. It was undertaken by the then-Department of Agriculture, from 1960 to the mid-1990s – so successful that it formed part of a 2014 best-practice review undertaken by the Queensland Department of Agriculture and Fisheries, in relation to remediating land in the Great Barrier Reef catchments.[380] One of the first conclusions drawn from the Ord study by Queensland research related to total grazing pressure. The report notes,

> Initially, the Ord River Regeneration Reserve (ORRR) regeneration developed very slowly, while total grazing pressure was not managed, resulting in continuing over-grazing of the native pasture and the new sown exotic pastures. Successful regeneration required complete removal of cattle, donkeys and camels, and restricting native fauna grazing by reducing the spread of water supplies.[381]

Overgrazing and failure to control total grazing pressure are key themes across these Guidelines. Therefore, ensuring total grazing pressure is managed, or the land is destocked, is vital to regeneration and remediation. Regeneration cannot occur when the vegetation required to restore landscape health is constantly being grazed.

Alongside destocking, a number of remedial works may be required to assist in the process of returning the landscape to a productive and functioning state. These include works and techniques to remediate erosion and to slow the flow of water across the landscape, as well as revegetating areas that have been denuded of vegetation or that are showing a negative ground cover trend.

Revegetation of degraded areas (restoration works)

When an area is denuded of its vegetation, a number of significant issues arise. The surface becomes more vulnerable to both wind and water erosion, and is likely to lose soil and nutrients, which are concentrated in the top five or ten centimetres. Once this occurs, rain is less able to penetrate the soil, dehydrating the land and contributing to further degradation. The soil surface then gets worn smooth and is sealed by the action of either wind, or water, or both, meaning its 'ability to trap and incorporate even small amounts of organic matter and water declines further'. The landscape then 'becomes less fertile and very inhospitable for seedling establishment', leading to ever more degradation.[382]

[380] Trevor J Hall, *Impacts of Rehabilitating Degraded Lands on Soil Health, Pastures, Runoff, Erosion, Nutrient and Sediment Movement. Part IV: The Kimberley Rehabilitation Programs and Lessons for the Great Barrier Reef Catchments*. Final Report for the Australian Government's Care for Our Country Reef Rescue Water Quality Research and Development Program, Toowoomba: Queensland Department of Agriculture and Fisheries, 2014

[381] Ibid.: 1

[382] Don Burnside, Alec Holm, Alan Payne, and Georgina Wilson, *Reading the Rangeland: A Guide to the Arid Shrublands of Western Australia*. South Perth: Department of Agricutlure, Western Australia, 1995: 18-19

Therefore, a key element of remediation of degraded areas is restoring ground cover vegetation to the land. Revegetation is vital to preventing or arresting erosion, and beginning the work of recovery. This can be undertaken as part of a process of excluding livestock and, where possible, native and feral herbivores from a degraded area via the establishment of exclusion fences. Spelling pasture in this way, seasons permitting, can enable perennial grasses and shrubs to recover, strengthen root systems, and recruit new plants. As noted in Chapter 5, if nothing else, exclusion can prevent further decline of ground cover and perennial grasses and shrubs, enabling swifter recovery when seasons turn, and rain comes.

However, there are situations in which just exclusion is not sufficient to enable land to recover, although it is a good first step. In the Ord River Regeneration Project, several revegetation activities were undertaken to prevent further erosion and begin the recovery process. These included:

- fencing and destocking
- eradication of feral donkeys
- contour cultivation and seeding in the degraded areas that were accessible by machinery.[383]

Fencing, destocking, and control of feral donkeys are the subjects of earlier chapters and will not be covered again here. However, the process of contour cultivation and seeding is another key element of the revegetation process. The method employed by the Department of Agriculture for cultivation and seeding was as follows:

> Cultivation was carried out using tractor-mounted implements, specifically 5-7 tyne chisel ploughs, opposed disc ploughs with centrally mounted rippers and disc pitters. All cultivations were carried out on the contour, with contours being marked using a mobile hose level. The contour cultivations were in discontinuous parallel strips about 3m wide and usually separated from each other by 5-10m of uncultivated ground. Seed boxes were mounted on the tractor or cultivating implements and the introduced species kapok bush, buffel grass and Birdwood grass were seeded together.[384]

Additional follow up cultivation and seeding activities occurred in the same areas for the next twenty years, with many areas treated up to three or four times. Photographs within the report on the Ord regeneration project demonstrate both the scale of the problem and the significant success the project had over time. The photographs below provide examples of the enormous changes the project achieved over forty years. The first two photos (Figure 70) demonstrate the success of contour strip cultivation over a very short period – three years. Figure 71 shows the success of the project over the forty-year period.

[383] Payne, et.al., *Spectacular Recovery in the Ord River Catchment*: 15

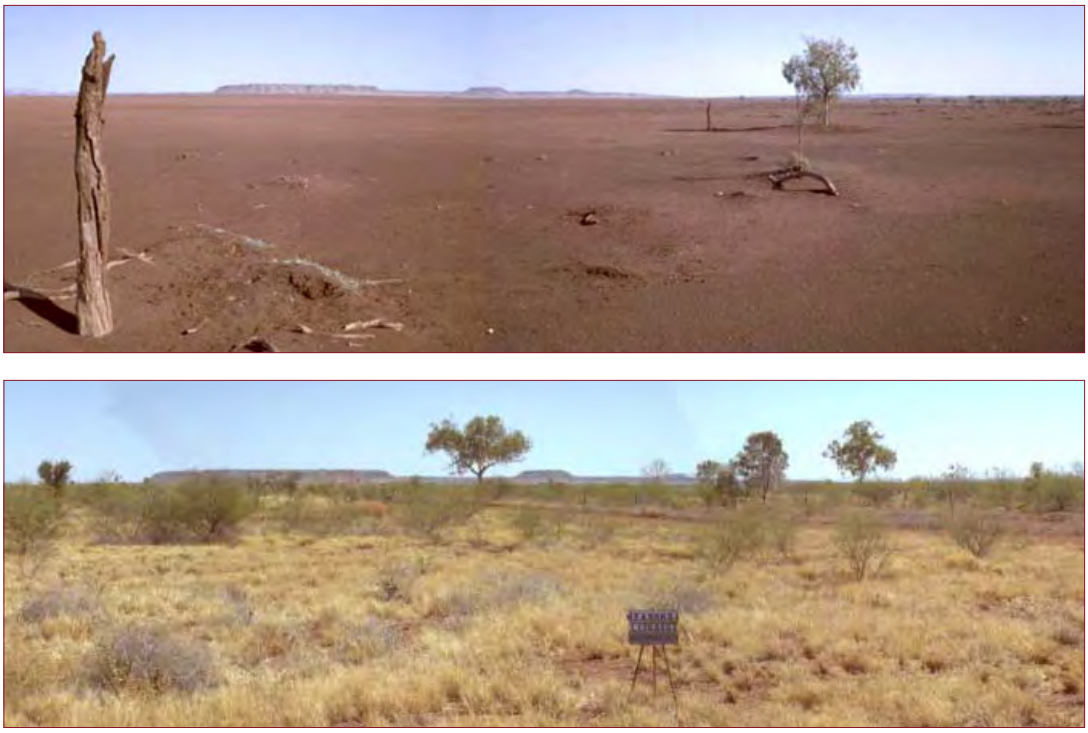
[384] Ibid

Figure 70: Discontinuous strip cultivation, Ord River Regeneration Project, before (June 1962) and after (1965)

Note: Left – Discontinuous Strip Cultivation on the Nelson Land System, June 1962; Right – Revegetation on the Nelson Land System – Growth along the contour cultivation lines, 1965

Source: A. L. Payne, I. W. Watson, P. E. Novelly, Spectacular Recovery in the Ord River Catchment, South Perth: Department of Agriculture and Food, Western Australia, 2004: 21; 22

Figure 71: Nelson Land System, Ord River Regeneration Project, before (1964) and after (2002)



Note: Top – Site NLSH4 Nelson Land System (NT) July 1964.
Bottom – Near Site NLSH4 Nelson Land System (NT) August 2002

Source: Top – A. L. Payne, I. W. Watson, P. E. Novelly, Spectacular Recovery in the Ord River Catchment: 34
Bottom – A. L. Payne, I. W. Watson, P. E. Novelly, Spectacular Recovery in the Ord River Catchment: 35

Revegetation activities on stream-banks and streambeds is another key area for erosion control. Revegetating riparian and aquatic environments is important to broader revegetation programs, as noted below:

Stream-bank and streambed stabilisation

Riparian and aquatic vegetation is highly valuable as it reduces the risk of stream-bank and streambed erosion. Revegetation must be a major component of any erosion-control program and without revegetation almost all erosion control works are likely to fail in the long term.

Riparian vegetation reduces the risk of erosion in the following ways:

- Roots provide reinforcement and stability to watercourse bed and banks.
- Ground-hugging vegetation provides direct protection from the erosive action of high-velocity water.
- The draining of the soil along the stream banks is improved by trees utilising this water and thus reduces the risk of bank failure due to heavy saturated soils.
- Vegetation can considerably reduce water velocity by contributing to the roughness of the stream.[385]

Other activities, discussed below, that may reduce erosion and assist in regeneration, include:

- slowing the flow of water across the landscape
- dedicated activities designed to stop erosion in its tracks.

Slowing water flow across the landscape

Remediating eroded landscapes requires a reduction of the erosive impact of fast-flowing water. Fast flowing water scours the land, removing topsoil and carrying it away. Ground cover is a major factor in determining the velocity of water flow across the land. The more ground cover, the slower water will flow, and the more moisture will be absorbed by the soil. This moisture then provides opportunities for seeds, recruited by the plants, to germinate, leading to ever more ground cover. However, in the absence of plants, water flows quickly and is less likely to infiltrate the soil. The exposed soil is washed away, either by sheet erosion or the development of erosion gullies, which further drain the soil of moisture.

As Tinley and Pringle put it, draining incisions 'migrate upslope and laterally, led by erosion nickpoints (headcuts) that 'pull the plug' out of the system, and alter the soil moisture towards aridity'.[386] Therefore, one of the first remediation activities required is to slow the flow of water across the land. Techniques for slowing water flow, remediating erosion, and rehydrating the landscape are plentiful, and generally fall into the following categories:

[385] Department of Environment, Water and Natural Resources, *A Practical Guide to Rural Land Management: Course Booklet*, third edition. Adelaide: Government of South Australia, 2016: 44

[386] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 10

1. Sieve structures, such as:
    a. live plant filters
    b. scrub/brushwood filters (loppings)
    c. mesh / netting
    d. sheet materials
    e. rakes
    f. gabions.
2. Gully stabilisation
3. Banks / bunds (Embankments)
4. Solid structures, such as:
    a. drop structures
    b. stone or earth sills
    c. weirs
    d. sand dams
    e. rock bars.[387]

The Ord River Regeneration project saw a range of banks constructed for regeneration purposes:

> Additional methods of regeneration such as the construction of large banks for water ponding and water harvesting, spreader sills, check banks and small gully control structures were tested during the course of the project.[388]

The banks, if constructed correctly, not only slow the flow of water, but also provide areas in which seed recruitment can occur, beginning the process of revegetation. Compare the photos in Figure 72 below for contrasting results for contour banks. On the left, the banks are high and rough, and on the right, low and smooth. The left bank has had significantly more success in recruiting plants.

Figure 72: Contrasting examples of contour banks – Gascoyne/Murchison Region, WA

Note: Left – well constructed contour bank, which demonstrates clear recruitment of plants, topsoil, litter and seeds on Carey Downs Station. Right – poorly constructed contour banks, which display no recruitment of plants, topsoil, litter and seeds in the Gascoyne Junction region.

Source: Rob Edwards 2019

[387] Ibid.: 44

[388] Payne, et.al., *Spectacular Recovery in the Ord River Catchment*: 15

Remediating eroded areas

Erosion control measures provide land rehydration benefits to a landscape. While some of the rehydration works listed above contribute to erosion prevention, there are specific elements of degraded landscapes that need remediation beyond those activities, including addressing sheet erosion, gully and rill erosion, and the nick points that begin the erosion process. Erosion control works can be categorised as follows:

- Works to control incision are often called bed control structures (as they control the height of the bed of the waterway).
- Bank protection works prevent the lateral (sideways) progression of erosion into the banks of the waterway.

The materials used in works are chosen according to their characteristics and availability.

Sheet erosion

In respect of sheet erosion, usually there are remnant topsoil islands scattered through the landscape (see Figure 73 below). These islands can be reconnected by laying cut scrub or dead branches along the contour across those gaps. The scrub will slow and filter flows of water and wind, trapping sediment, litter and seeds.[389] However, care must be taken to ensure that the scrub sieves are built up onto each island, to avoid the water cutting around the sides of the sieves. Ripping at right angles to the flow of water, and adjacent to the scrub filters on the upslope can accelerate

Figure 73: Sheet Erosion on a pastoral station, Kimberley Region, WA

Note: the bare earth, and the remnant topsoil islands

Source: Rob Edwards 2019

[389] Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013: 48

revegetation behind the sieves, but can be expensive. Another method of remedying sheet erosion is to run a spiked roller across the bared areas. The pitting of the soil traps seeds and water and increases infiltration, thus reducing run-off. Gibber surfaces can be lightly graded, sweeping only the surface stones into bands three to four metres broad at right angles to the flow. These bands of stone will slow down the water and trap seeds and silt, thus assisting with revegetation and stopping erosive activity.[390]

Gully erosion

In respect of erosion gullies and gutters, a wide range of activities are available. The first thing that is required is for the gully to be stabilised. Gully heads are the active face of erosion and tend to split and spread as they cut back upstream or upslope. While they are generally regarded as a soil erosion issue, the most ecologically and commercially damaging aspect of gully heads is that they literally draw water to them from the surrounding land.

Gully heads typically require a combination of stabilising methods, depending on the size and severity of the gully system, and what materials and machinery are available. A key action is to knock the walls of the gully head down so that they become a gently sloping or level platform with battered sides. A down-curved bank can then be built around the head to either spill the water away from the gully, or to slow it down and direct it back into the gutter lower down.[391] Whether the former or the latter bank option is chosen will depend on the shape of the surrounding landscape.

When building banks, Tinley and Pringle recommend the following key points be observed:

- keep all slopes gentle, this will minimise ongoing maintenance
- build every bank on a platform deep ripped at right angle to the flow so that it forms a solid core below landscape level
- spill the water away slowly and widely, no spurting water away
- do your level measurements to make sure your spillways will work as planned before and after construction
- keep all disturbances (especially vehicles and motor bikes) away from spill zones at the end of banks whether you make the bank higher or lower, just make sure you do not create new problems.[392]

Several of these techniques contain similarities with aspects of road design, particularly in respect of the need to ensure water being redirected away from gullies is spilled away slowly and widely. In chapter 4, drains away from roads are recommended to be wide and flat-bottomed to ensure the water was moved away slowly and not simply channelled away from the road, creating new problems elsewhere.

[390] Ibid

[391] Ken Tinley and Hugh Pringle, Rangeland Rehydration 1: Field Guide, Perth: Rangelands NRM, 2013: 65

[392] Ibid

More information

Details and examples of these techniques, including excellent photos and illustrations, can be found in the following publications, which are arguably the best guides to Rangeland rehabilitation in Western Australia:

- Ken Tinley and Hugh Pringle, *Rangeland Rehydration 1: Field Guide*, Perth: Rangelands NRM, 2013
- Ken Tinley and Hugh Pringle, *Rangeland Rehydration 2: Manual*, Perth: Rangelands NRM, 2013

Some of the types of assistance that are available to land managers include:

- ESRM Plans (Ecologically Sustainable Rangelands Management). For more information, see https://rangelandswa.com.au/projects/esrm-rehydration/
- EMU (Ecosystem Management Understanding). For more information, see http://www.emulandrecovery.org.au/home
- DPIRD has a large amount of information on managing soils on its website: https://www.agric.wa.gov.au/climate-land-water/soils/managing-soils
- The Queensland Government Department of Science, Information Technology and Innovation published a detailed set of soil conservation guidelines in 2015, which contains a large amount of very useful information for land managers:

  BW Carey, B Stone, PL Norman, P Shilton, *Soil Conservation Guidelines for Queensland*, Brisbane: Department of Science, Information Technology and Innovation, 2015 https://www.publications.qld.gov.au/dataset/soil-conservation-guidelines

Documents and Guides that might prove useful:

- Ian D. Rutherfurd, Kathryn Jeri and Nicholas Marsh, *A Rehabilitation Manual for Australian Streams*: volumes 1 and 2. Melbourne: Cooperative Research Centre for Catchment Hydrology/Land and Water Resources Research and Development Corporation, 2000 http://www.engr.colostate.edu/~bbledsoe/CIVE413/Rehabilitation_Manual_for_Australian_Streams_vol1.pdf; http://www.engr.colostate.edu/~bbledsoe/CIVE413/Rehabilitation_Manual_for_Australian_Streams_vol2.pdf

For additional information and guides to rangeland rehabilitation and revegetation, land managers may wish to contact the following organisations:

- Rangelands NRM
- Greening Australia
- Local Catchment Groups
- KPCA – they hold regular field days and extension courses
- MLA
- DPIRD Rangelands Team.

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