Sustainable land management practices for graziers

Best management practices for grazing in the Tablelands and Southern Highlands of NSW

NSW GOVERNMENT | Industry & Investment

This document has been prepared by the authors for Industry & Investment NSW for and on behalf of the State of New South Wales, in good faith and on the basis of available information.

Title: Sustainable land management practices for graziers in the Tablelands and Southern Highlands of NSW

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The publication is a revised edition of Best Management Practices for Graziers in the Tablelands of New South Wales published in 2004.

The technical details of this publication have been derived from the experience from staff of I&I NSW and the SCA together with other documents and research reports. Where possible, these are referred to in the text, and have also been referenced as sources of further information.

Disclaimers

The information contained in this publication is based on knowledge and understanding at the time of writing (September 2009). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of Industry & Investment NSW or the users independent adviser.

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Users of agricultural or veterinary chemical products must always read the label and any permit, before using the product, and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or not made in this publication.

Warnings

Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

The Native Vegetation Act 2003 restricts some pasture improvement practices where existing pasture contains native species. Inquire through your office of the Department of Environment, Climate Change and Water for further details.

NSW GOVERNMENT Industry & Investment

SYDNEY CATCHMENT AUTHORITY

Sustainable land management practices for graziers

Best management practices for grazing in the Tablelands and Southern Highlands of NSW

Foreword

This booklet provides valuable advice on a range of best management practices that will help land managers improve the health and productivity of their pasture systems.

The Sydney Catchment Authority and Industry & Investment NSW are pleased to have developed this revised guide for graziers in the Southern and Central Tablelands and Southern Highlands of NSW.

The publication outlines sustainable ways to manage soils, pasture and livestock to increase profit.

Grazing is the single largest land use in NSW. It's an important and valuable part of the NSW economy and can have considerable influence on the condition of natural resources.

Grazing covers around a third of the drinking water catchment for greater Sydney or more than 550,000 hectares. This drinking water catchment supplies around 60 per cent of the State's population with water.

That's why it's important we work together to support graziers with the best possible advice and training, to ensure their businesses are profitable, as well as environmentally sustainable.

While grazing is extremely important to the State's economy, it can also be a potential source of water quality contaminants such as pathogens, sediment, nutrients, pesticides and organic material.

By using the practices recommended in this guide, graziers can significantly reduce pollutants, such as nitrogen and phosphorus produced by some activities.

The entire community can benefit from improved management practices, which can result in better water quality, increased biodiversity and a healthier environment.

I would encourage all graziers to read this guide.

Yours sincerely

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Sustainable land management practices for graziers

Contents

Introduction

'Creation of wealth as in monetary wealth, is very hard to achieve until you get environmental wealth. And that's just basically looking after your country better, keeping it covered better, and not letting those one-off rainfall events leave your farm.'

Nigel Kerin, 2008 NSW Farmer of the Year

What are the *Sustainable Land Management Practices for Graziers?*

The Sustainable Land Management Practices for Graziers are a collection of best management practices to support sustainable grazing and land management.

What do they aim to do?

They aim to help graziers develop whole farm practices for healthy and productive pasture systems and landscapes. These practices will also benefit the wider community through cleaner water runoff and better catchment health.

Who are they for?

These management practices are primarily for dryland beef and sheep production on grazed pastures in the Sydney drinking water catchment area. The principles also apply to other extensive grazing enterprises in these areas. The practices do not address highly intensive systems such as dairies or stock feedlots.

How is this document organised?

Each section identifies key issues affecting the sustainable use of land and water and provides practices to address them.

Elements of best practice for each area of management are highlighted. These are followed by recommended activities to help manage your grazing system. The sections address separate issues, however they have similarities and common themes as many sustainable land management issues are addressed by a few key actions.

The Top Ten Tips are a summary of the key principles for best practice grazing. A glossary of key terms is provided at the end of the book.

How to get the most from the *Sustainable Land Management Practices for Graziers*

There are a wide range of land types across the catchment. Each land type has opportunities and constraints. Understanding the land capability of your farm is essential to making decisions about activities your farm can sustain, and those that could harm the land, deplete your bank balance or have negative consequences downstream. In other words, it can tell you the best parts of your farm for grazing or cropping, and which parts are best left in their natural state.

Using these best management practices will improve your knowledge and understanding of issues that can impact on the health and productivity of your farm landscape and help you to make decisions and take actions that are economically, socially and environmentally sustainable.

The practices described in this document are also underpinned by practical, hands-on training specifically designed for graziers. The courses and workshops cover topics including grazing and pasture management, interpreting and managing landscapes and soils, and identifying important grasses, weeds and other plants. The courses are delivered on-farm and include PROGRAZE™, LANDSCAN™ and Paddock Plants.

You are strongly encouraged to attend one or all of these courses to build on the information in this publication.

Why practices for sustainable grazing management?

Grazing occurs over 585,000 hectares or 38 percent of the Sydney drinking water catchments and is the largest single private land use in this area. Grazing enterprises are a significant and valuable part of the regional economy. However, grazing is also a potential source of water quality contaminants such as pathogens, sediment, nutrients (phosphorus and nitrogen), pesticides and organic material. Combining appropriate grazing management with other sustainable land management practices can reduce these contaminants, as well as improve productivity and profitability.

This publication is a revised edition of *Best Management Practices for Graziers in the Tablelands of New South Wales (2004).* It has been updated with a specific focus on practices to benefit water quality, and includes new sections on establishing pastures, stock health, biodiversity and soil sodicity.

Top 10 Tips

There are a range of practices you can adopt to improve the productivity and sustainability of your farm landscape.

This publication provides a useful guide to help you implement best management practices for managing your farm.

A summary of these practices is provided in these Top 10 Tips to help you attain a healthier, more productive and sustainable farm.

It is important to note that the practices described should be performed in association with each other to reduce land degradation and to improve pasture and livestock health, groundcover and water quality and the value of your farm.

Tip 1

Match paddock use to land capability

Different parts of your farm landscape have different capabilities. Manage your farm based on land capability to improve productivity and sustainability. *Photo: D Chalker, Industry & Investment NSW*

What you can do

- Conduct a soil test
- Fence your property according to land capability
- Prevent livestock access to erosion prone areas
- Attend a LANDSCAN™ course

See

- *Section 3:* Managing soil fertility
- *Section 4:* Management practices to reduce soil erosion
- *Section 9:* Managing landscapes for biodiversity

Land capability is the ability of your farm landscape to sustain a certain type of land use without causing permanent damage. If land is used beyond its capability it will degrade. When assessing land capability, features such as soil depth, stability and fertility, topography, aspect, erosion risk and stream proximity are examined. By looking at these factors and limitations, parcels of land that have the same capability can be identified and managed according to capability.

The most important point about land capability is to recognise the differences between different parts of your farm, and manage these accordingly. This will help you to decide which parts of your property will give a positive return on inputs (fertilisers, improved pastures etc.) without compromising long term sustainability.

Tip 2

Maintain more than 80% groundcover

Aim to maintain groundcover above 80% to protect soil structure and minimise erosion and to slow and retain rainfall. *Photo: B Stein, Industry & Investment NSW*

What you can do

- Match grazing pressure to feed availability and pasture targets
- Use rotational grazing
- Attend a PROGRAZE™ course to learn how to manage pastures and grazing animals

See

- *Section 1:* Managing grazing for pasture persistence, production and livestock performance
- *Section 2:* Managing groundcover, stock and riparian areas for clean water
- *Section 3:* Managing soil fertility
- *Section 10:* Managing the impacts of drought on pastures

Groundcover is the layer of grasses and/or other plants or plant litter that protect soil against erosion.

Groundcover slows rainfall runoff and helps retain moisture in the soil profile for pasture growth and productivity. Groundcover also protects soil from the impact of rain and filters nutrients, sediment and pathogens before they reach waterways. Groundcover of 80 to 100 percent, predominantly made up of perennial species, is ideal.

Tip 3

Increase perennial plants in permanent pastures

Perennial grasses provide year-long groundcover and are able to access soil moisture to greater depths than annual species.
Photo: B Stein, Industry & Investment NSW

What you can do

- Learn to identify your pasture species and manage them accordingly – attend a Paddock Plants field day
- Change from continuous grazing to an appropriate form of rotational grazing
- Use strategic combinations of grazing management, fertilisers and herbicides

See

- *Section 1:* Managing grazing for pasture persistence, production and livestock performance
- *Section 10:* Managing the impacts of drought on pastures
- *Section 11:* Rejuvenating perennial pastures

Perennial pastures are deep-rooted and live for several years.

Perennial pastures offer higher pasture yields, superior feed quality in summer and autumn, reduced supplementary feeding and support higher stocking rates than pasture systems dominated by annual species. In addition to production benefits, deep-rooted perennial species provide year-long groundcover and together with trees and shrubs reduce groundwater recharge and associated salinity.

Tip 4

Implement a rotational grazing system

Subdivide large paddocks into smaller units and rotationally graze your livestock based on production targets and plant growth rates.
Photo: H Warren, Industry & Investment NSW

What you can do

- Subdivide large paddocks into smaller units
- Join mobs or herds into larger groups
- Match grazing and rest periods to the growth patterns of the most desirable species in the paddock
- Attend a PROGRAZE™ course to learn about grazing strategies

See

- *Section 1:* Managing grazing for pasture persistence, production and livestock performance

Under rotational grazing livestock are moved frequently through a number of paddocks. This exposes pastures to a period of grazing followed by a period of rest. The rest period or rotation length is generally influenced by pasture growth rate. The goal is for pasture to recover and reach a given stage of regrowth before the next grazing. Rotational grazing can improve pasture composition, production, use and persistence.

Tip 5

Feed your pastures - not your creeks

Soil testing is the only way to monitor soil nutrient levels, soil chemistry and changes in them. *Photo: Industry & Investment NSW*

What you can do

- Conduct soil tests
- Match nutrient applications to pasture types and enterprise needs
- Increase soil organic carbon to encourage healthy soil ecosystems
- Attend a LANDSCAN™ course to learn how to sample soils and interpret soil tests

See

- *Section 3:* Managing soil fertility

Grazing enterprises export nutrients from the farm in the form of meat, fibre or plant products. Unless these nutrients are replaced (usually in the form of fertilisers) the ability of your soils to maintain healthy levels of groundcover and pasture production will decline over time. Conduct regular soil tests to make informed decisions about the nutrient requirements of your soils and pasture systems. Remember that although nutrients may be beneficial for pasture production, they can also have detrimental effects on water quality. Avoid applying fertilisers too close to streams and drainage lines or in drainage depressions where runoff is likely.

Tip 6

Maintain groundcover in drainage lines and drainage depressions

A drainage depression funnelling rainfall runoff after a heavy rainfall event. *Photo: J Caddey, Sydney Catchment Authority*

What you can do

- Keep as much groundcover in drainage lines and drainage depressions as possible
- Fence-off drainage lines and revegetate if possible

See

- *Section 2:* Managing groundcover, stock and riparian areas for clean water
- *Section 4:* Management practices to reduce soil erosion

Drainage depressions and drainage lines are dips and depressions in the paddock that convey rainfall runoff into waterways during or immediately after periods of heavy rainfall. It is important to keep these areas well covered with as much groundcover as possible to trap sediments, nutrients and pathogens before they enter waterways. Avoid ploughing these areas or applying fertilisers or herbicides when rainfall runoff is expected, for example runoff associated with high intensity summer storms.

Tip 7

Develop a drought management plan

Restricting these sheep to a droughtlot is protecting pastures and groundcover on the remainder of the property. *Photo: Industry & Investment NSW*

What you can do

- Develop a drought plan **before** a drought
- Gradually destock to reduce damage to pastures
- Restrict livestock to containment paddocks or droughtlots
- Attend a PROGRAZE™ course or STOCKPLAN® workshop

See

- *Section 1:* Managing grazing for pasture persistence, production and livestock performance
- *Section 10:* Managing the impacts of drought on pastures

Droughts deplete both the financial and natural resources of farms. Direct costs include loss of income and increased supplementary feed expenses. Indirect costs include the loss of perennial pastures, groundcover and topsoil. Having a drought plan in place before a drought can help you to manage these costs. Your drought management plan should include trigger points you will use for destocking, measures to protect perennial pastures, and establishment of droughtlots.

Tip 8

Keep juveniles and sick animals away from streams

Juvenile animals under four months of age shed significantly higher loads of pathogens such as *Cryptosporidium* and *Giardia* than older animals. *Photo: B Stein, Industry & Investment NSW*

What you can do

- Fence-off waterways
- Keep at least one paddock between juvenile animals and waterways
- Quarantine sick animals in properly located hospital yards or hospital paddocks

See

- *Section 2:* Managing groundcover, stock and riparian areas for clean water

Research has shown that juvenile animals and their lactating mothers can contaminate water with the human infective diseases *Cryptosporidium* and *Giardia*. These diseases pose a serious threat to both human and animal health. Sick animals may also shed high levels of these pathogens. The most effective way to prevent water contamination is to keep these animals as far away from drainage lines and streams as practical. Quarantine sick animals in hospital yards until they have recovered.

Tip 9

Establish riparian buffer zones and provide water for stock off-stream

This farmer has fenced off his creek to protect creek banks and water quality and is providing off-stream water in troughs. *Photo: Courtesy of the Hawkesbury Nepean Catchment Management Authority*

What you can do

- Fence-off waterways
- Provide off-stream watering points
- Establish or maintain native trees, shrubs and grasses along waterways

See

- *Section 1:* Managing grazing for pasture persistence, production and livestock performance
- *Section 2:* Managing groundcover, stock and riparian areas for clean water
- *Section 4:* Management practices to reduce soil erosion
- *Section 9:* Managing landscapes for biodiversity

Riparian areas are the areas immediately adjacent to creeks, rivers and wetlands. Uncontrolled stock access and grazing degrades riparian areas and reduces water quality. Therefore it is important to keep these areas vegetated or rehabilitated. Well vegetated riparian areas filter sediment, nutrients and pathogens and reduce the amount of contaminants entering waterways. Riparian areas should ideally be made up of native trees and shrubs as well as grasses that are 10 to 15 centimetres tall, with as close to 100 percent groundcover as possible. Fencing off these areas and providing off-stream water points allows you to control stock access and grazing.

Remember to leave your riparian buffer zones wide enough to allow for weed and pest control.

Tip 10

Locate new infrastructure away from streams, drainage lines and drainage depressions

These sheep yards have been located away from creeks and drainage depressions to prevent the contamination of waterways with animal waste. *Photo: Industry & Investment NSW*

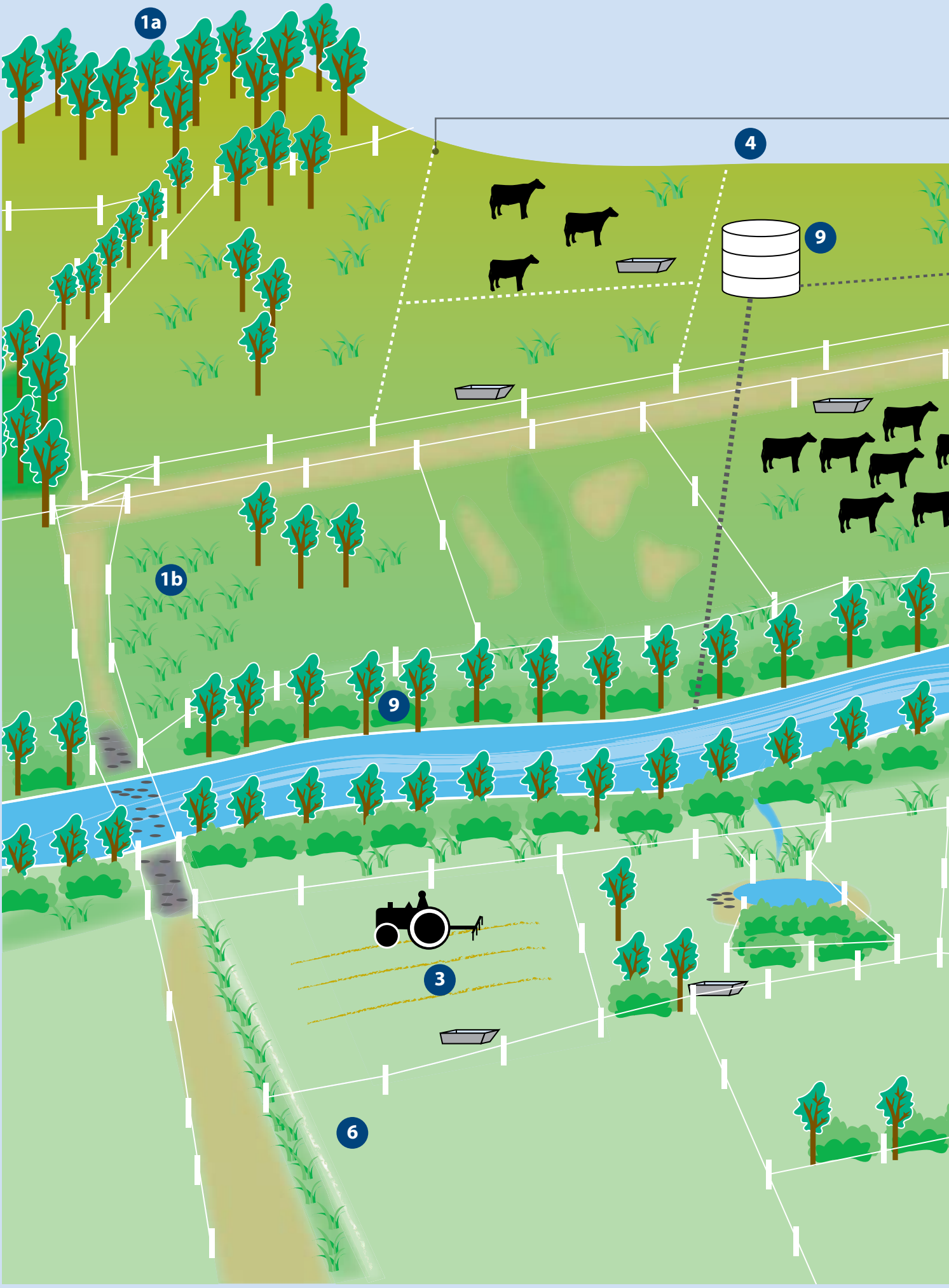
What you can do

- Locate new farm infrastructure away from streams, drainage lines and drainage depressions
- Install runoff diversion structures or capture effluent before it reaches a waterway

See

- *Section 2:* Managing groundcover, stock and riparian areas for clean water

The location of stock yards, laneways, droughtlots, hospital yards, stock watering points and other infrastructure may have a significant impact on water quality. If practical, place new infrastructure as far away from streams, drainage lines and drainage depressions as possible. If you cannot avoid these areas, include structures to divert rainfall runoff away from these areas, or capture and store contaminated runoff from these sites using effluent ponds or sediment basins.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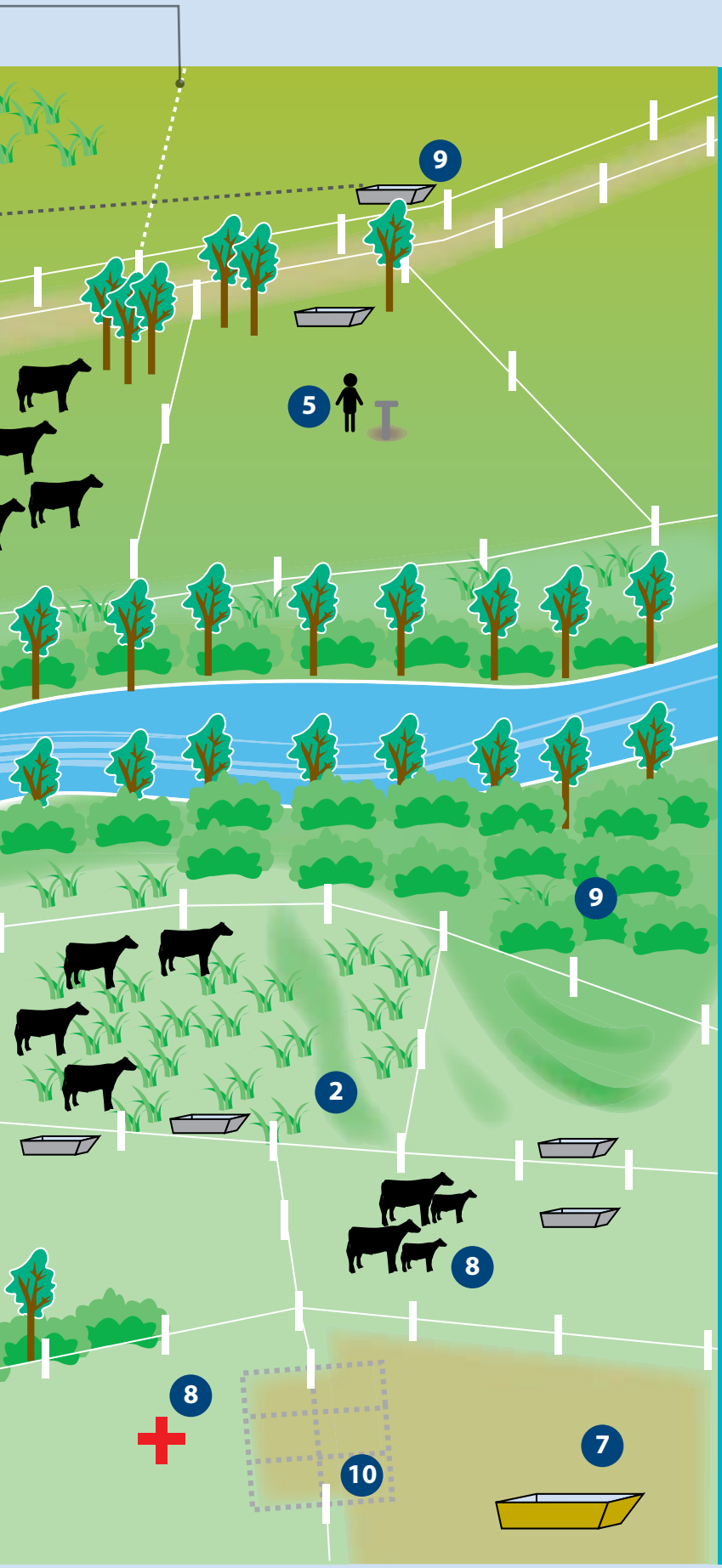

Match paddock use to land capability

- **1a** This remnant vegetation is best fenced off and used occasionally for livestock shelter
- **1b** This paddock has good soil depth, is fertile and is better suited to higher stock densities
- **2** Maintain groundcover above 80% to capture more rainfall runoff and to protect water quality and soil health
- **3** Increase perennial species in permanent pastures using tactical grazing management and/or minimum till sowing techniques such as direct drilling
- **4** Implement a rotational grazing system. Subdivide large paddocks into smaller units
- **5** Conduct regular soil tests to better manage soil nutrient levels and soil chemistry, eg pH, salinity, sodicity
- **6** Avoid disturbing or fertilising drainage lines when rainfall runoff is expected, eg high intensity summer storms
- **7** Confine livestock to droughtlots to protect pastures and preserve groundcover and topsoil
- **8** Juvenile and sick animals shed large amounts of disease causing organisms. Graze juvenile animals (under 4 months of age) and sick animals away from streams and drainage lines if possible
- **9** Establish riparian buffer zones and provide off-stream water supplies
- **10** Locate new infrastructure that congregates animals, eg stock yards, away from streams, drainage lines and drainage depressions

Funding to help you protect natural resources and water quality

There are several sources of funds available to make your farm more sustainable and to help you to protect water quality for your animals and downstream users. Contact your local Industry & Investment NSW (I&I NSW) office or catchment management authority (CMA) for current funding opportunities.

Sustainable Grazing Program

This program offers subsidised training, workshops and on-site farm visits to help you make decisions that will improve the productivity and sustainability of your enterprise.

Contact the program course coordinator at I&I NSW on 02 4828 6600 for more information.

Catchment Protection Scheme

The Catchment Protection Scheme is a joint Sydney Catchment Authority (SCA) and CMA initiative to repair land degradation throughout the Sydney drinking water catchment areas.

Funding is available to:

- fence vulnerable areas including gullies
- stabilise creek crossings
- install river bank and bed erosion control works
- construct flumes (a concrete or rock chute that protects an eroded gully)
- install sediment trapping weirs
- construct contour or graded banks
- reshape eroded gullies
- plant native vegetation in treated areas

For more information contact the Hawkesbury Nepean Catchment Management Authority **http://www.hn.cma.nsw.gov.au** or Southern Rivers Catchment Management Authority **http://www.southern.cma.nsw.gov.au**

Riparian management assistance grants

The Sydney Catchment Authority provides grants for property owners to protect and conserve riparian zones along priority creeks and associated streams and gullies.

You can find information on current priority creeks and download a copy of the Riparian management assistance grants guide and application form from the SCA website at **www.sca.nsw.gov.au**

Visit the following websites for more information on grants, incentives and assistance programs:

Hawkesbury Nepean Catchment Management Authority
http://www.hn.cma.nsw.gov.au

Southern Rivers Catchment Management Authority
http://www.southern.cma.nsw.gov.au

Community builders.nsw:
http://www2.communitybuilders.nsw.gov.au/funding/programs

Greening Australia:
http://www.greeningaustralia.org.au/

Grantslink:
www.grantslink.gov.au/

Australian Government Department of Agriculture, Fisheries and Forestry grants & assistance:
www.daffa.gov.au/about/grants_and_assistance

Department of Environment, Water, Heritage and the Arts grants & funding:
www.environment.gov.au/programs/index.html

Foundation for Rural and Regional Renewal grants:
www.frrr.org.au/currentprojects.asp

Caring for our Country funding:
www.nrm.gov.au/funding/index.html

1 Managing grazing for pasture persistence, production and livestock performance

KEY ISSUES

- Well managed pastures provide the cheapest feed for grazing animals
- Changes in seasonal pasture growth affect grazing plans
- Grazing animals can be used as a tool to manipulate pasture composition, quality and persistence

KEY ACTIONS

- Graze to maintain a productive perennial pasture
- Develop a grazing plan to manage seasonal growth
- Match livestock requirements to pasture availability

KEY WORDS

- grazing management
- kilograms dry matter per hectare (kg DM/ha)
- pasture benchmarks
- pasture composition
- rotational grazing
- selective grazing
- stocking rate

Grazing management means that you manage what your animals graze rather than your animals choosing what they will eat.

For more information on managing native pastures see Section 9 and ask your local Industry & Investment NSW office for a copy of *Managing Native Pastures for Agriculture and Conservation.*

Actively managing your pastures will improve production, increase profits and improve the sustainability of your farm. Grazing management involves manipulating the grazing habits of livestock to achieve a desired result for the pasture, the animals or both. You need to manage:

- timing (when)
- frequency (how often)
- intensity (how hard) pastures are grazed.

Most graziers' primary goals are to improve animal performance and increase farm income. Grazing management can be a very powerful and cost effective tool to do this and maintain a vigorous and persistent pasture at the same time.

A grazing management plan is just as important for native pastures or grasslands.

An ideal pasture for livestock production consists of:

- 50-70 percent perennial grasses
- 20-30 percent legumes
- 10-30 percent annual grasses.

The most productive pastures are generally:

- 5-15 centimetres tall
- 1000-3000 kilograms of dry matter per hectare (kg DM/ha – see Appendix 1)
- rapidly growing - this is shown as Phase 2 growth in Figure 1.1.

Why is this important to me as a farmer?

Grazing management is essential to match pasture quantity and quality with livestock and environmental targets. It will also improve profitability for farms that use pasture as the primary source of feed for livestock.

A well-grazed pasture is more productive, longer-lived and of better feed quality than a poorly grazed pasture. Timing stock movement between paddocks, assessing pasture growth stages and establishing critical pasture benchmarks are important skills for grazing managers. Leaving stock in a paddock for too long may remove desirable species through selective grazing or over-grazing, and cause pasture degradation and erosion. On the other hand, excessively long rest periods or undergrazing may lead to a decline in feed quality (digestibility and protein), low utilisation rates or excessive waste and a change in pasture composition.

Benefits of grazing management

- ✓ Good management of perennial pastures benefits the environment, by improving water quality, reducing weed invasion, and reducing soil degradation.
- ✓ It might take a considerable time for most graziers to recover the cost of sowing a new pasture. An economic assessment is critical before investing in a new pasture.
- ✓ Grazing to encourage a well-developed root system will ensure that feed quality and quantity are good and pasture growth is maintained. Vigorous growth of roots and shoots improves plant access to soil water and rainfall.

A well managed pasture is more productive, longer-lived and of higher feed quality than a poorly grazed pasture.
Photo: G Johnson, Industry & Investment NSW

What is best practice?

- ✓ Use rotational grazing to achieve a pasture which is perennial, persistent, productive, resistant to weed invasion and does not need re-sowing
- ✓ Maintain groundcover above 80 percent
- ✓ Match livestock requirements and pasture availability

How can you achieve this?

To achieve best practice, you should:

1. graze to maintain a productive perennial pasture
2. develop a grazing plan to manage seasonal plant growth
3. match livestock requirements to pasture availability.

Graze to maintain a productive perennial pasture

- ✓ Learn to identify pasture species and their characteristics, including growth cycles and associated critical management practices. Attend a Paddock Plants field day.
- ✓ Monitor pastures. Regularly assess pasture condition, height and groundcover (see Appendix 1) to determine stocking rates and length of grazing periods.
- ✓ Recognise key pasture benchmarks (see Appendix 2) and regularly assess your pasture and livestock against them. Attend a PROGRAZE™ course to learn how.
- ✓ Use grazing animals to manipulate the species composition balance in favour of perennial grasses and to ensure 20-30 percent legume content for high quality pastures, especially for lactating and finishing animals. Attend a PROGRAZE™ course to learn how.
- ✓ Change your grazing regime from continuous grazing to rotational grazing to better control grazing, prevent overgrazing and to allow pasture recovery (see Figure 1.2).
- ✓ Apply higher grazing pressure in late winter/early spring to prevent legumes and annual grasses from out-competing native perennial grasses.
- ✓ Avoid defoliation of perennial grasses when they are under stress, for example when suffering from moisture stress in summer, as this can lead to plants dying.

PHASE I	PHASE II	PHASE III
Characteristics: Below about 1000 kg green DM/ha of a moderately dense pasture	Between about 1000 - 3000 kg green DM/ha of a moderately dense pasture	Above about 3000 kg green DM/ha of a moderately dense pasture
Positive aspects: • Grazing enables control of unwanted species • Grazing enables reduction of litter prior to germination of desirable species • High digestibility	• High yield of high quality pasture • Grazing pressure will delay onset of flowering • Rapid pasture growth • Good livestock weight gain • High yields of feed • Good use of soil water • Good protection from runoff	• Replenishes energy reserves of perennial species • Allows seed set and replenishment of seed reserves in the soil • Low risk of runoff and erosion
Negative aspects: • Slow pasture growth rate • Long term grazing threatens plant survival - root reserves of perennials not adequately replenished • Increased runoff and soil erosion risk • Poor use of soil water • Low livestock weight gains	• May not allow desirable pasture species to seed down	• Low pasture quality • Slow pasture growth rate • Suppression of companion species in pasture • Low livestock weight gains • May inhibit germination of annuals the following season • Poorer use of soil water
Yield: low **Quality: high**	**Yield: good to high** **Quality: good to high**	**Yield: high** **Quality: low**
Slow growth after grazing	**Rapid growth due to high leaf area**	**Slow growth due to shading of growth points**

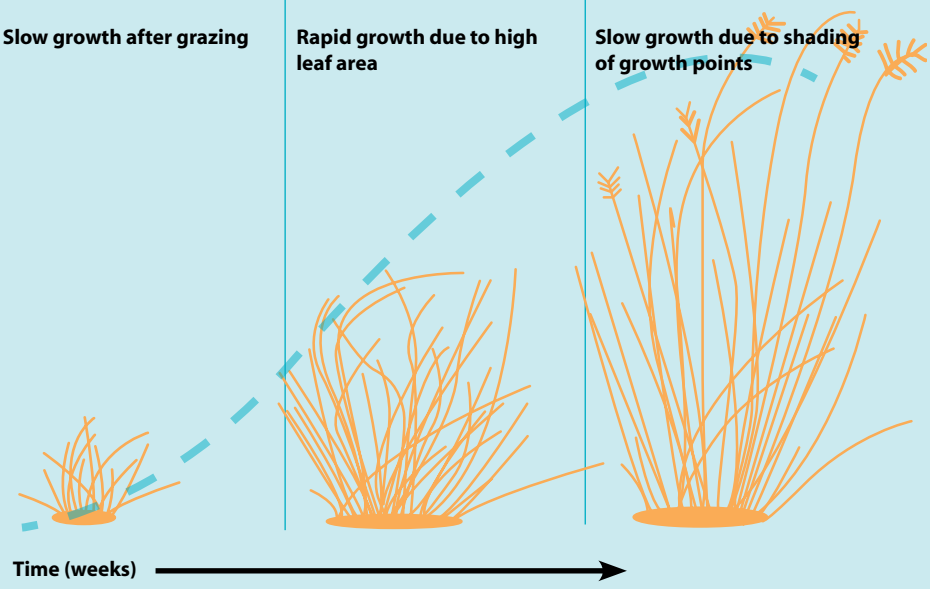

Figure 1.1: Pasture growth after grazing (Source: PROGRAZE™ manual)

Graziers attend a PROGRAZE™ course run by Industry & Investment NSW.
Photo: Industry & Investment NSW

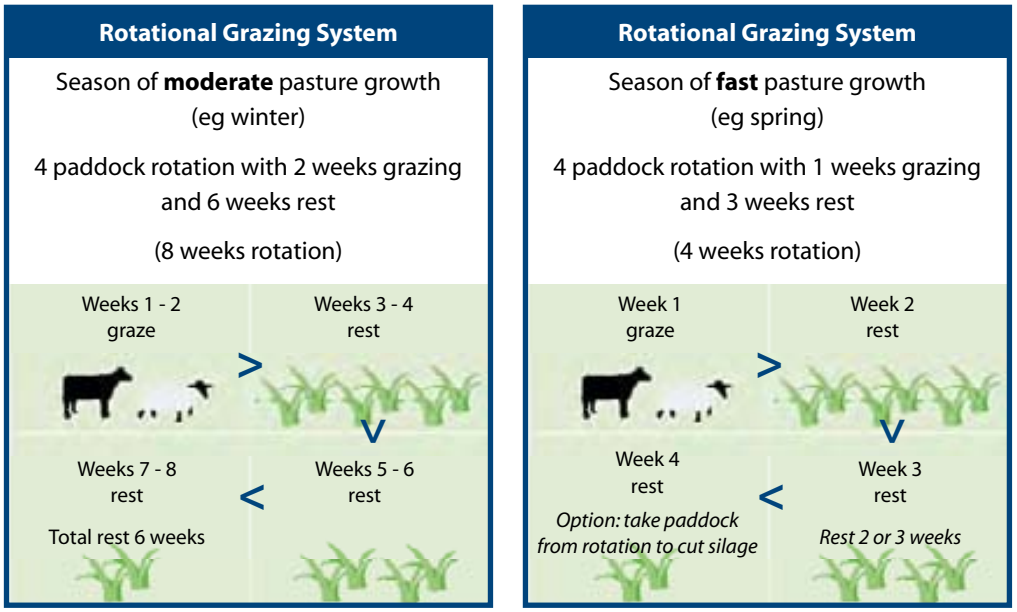

Figure 1.2: A simple representation of the principle of rotational grazing

What is 'rotational grazing'?

Rotational grazing involves a period of grazing followed by a period of rest. The rest period is generally based on the pasture growth rate, or on a critical growth phase of the target plant species, eg seeding of a native perennial grass.

Benefits of rotational grazing include:

- more efficient use of pasture
- more pasture grown
- more persistent perennial grasses
- ability to ration feed and control animal intake
- reduced selective grazing and stock camps
- decreased proportion of annual grasses
- improved groundcover over summer.

To get started, trial a simple four paddock rotation:

✓ Combine animals from four paddocks, or subdivide one paddock into four with temporary electric fences

✓ Rotate stock around the four paddocks in a general program of two weeks grazing and six weeks rest

✓ Stock may need to be moved more often in spring (one week grazing, three weeks rest) to keep pastures in the Phase 2 growth phase (see Figure 1.1)

✓ One paddock can be shut out of the rotation for silage to efficiently manage the growth of feed in the other three paddocks, or graze pastures down to 1,000 kg green DM/ha, then remove and rest the pastures until they reach 2,500-3,000 kg green DM/ha. At this point they are grazed again, ie rotate animals to maintain pasture in a rapid growth phase (Phase 2 growth shown in Figure 1.1).

✓ Rotational grazing needs to be flexible enough to accommodate the needs of plants, animals as well as climate variability.

Develop a grazing plan to manage seasonal plant growth

Pasture management needs to be based on an understanding of the growth and development stages of the pasture species and the influence of seasons. The following sample grazing strategy is provided to illustrate seasonal pasture management principles for temperate pastures.

Autumn	Excessive pasture growth can limit legume germination	• Graze pastures to about 5-10 cm in height in late summer/early autumn to encourage light penetration, germination and re-establishment of legumes • Reduce stocking rate or rest paddocks after the autumn break to allow legumes to germinate and establish until the 3-5 leaf stage to maximise winter production
Winter	Cold temperatures limit pasture growth	• Rest key paddocks to maximise leaf area and increase growth potential • Use longer rests between grazing to maximise leaf area and growth potential • Monitor pasture damage from pugging and remove stock if damage becomes excessive
Spring	High plant growth potential	• Control pasture growth to maintain a good clover and perennial grass balance • Use high intensity grazing to keep spring growth at 5cm high / 1000 kg DM/ha for sheep or 15 cm high / 3000 kg DM/ha for cattle • Speed up grazing rotations so paddocks are re-grazed before they reach Phase 3 *(see Figure 1.1)* and start to flower. This will maintain the feed quality of the pasture • Remove some paddocks from the rotation and either manage for hay or silage making, or where appropriate allow thin/degraded pastures to run to head (set seed) to facilitate regeneration • Don't allow the same paddocks to run to head in consecutive years or sub clover seeding will be reduced. Don't cut hay from first year established pasture
Summer	Hot, dry conditions will stress pastures and cause plant death	• Avoid grazing pastures too short which exposes plant crowns in hot, dry conditions

Table 1.3: Sample grazing strategy for temperate pastures

Note: Appropriate grazing strategies for summer growing species such as kikuyu and kangaroo grass will differ from the example above. A PROGRAZE™ course will help you develop individual grazing strategies for your property.

Match livestock requirements to pasture availability

When determining grazing rates, remember to factor in the grazing pressure of other animals eg native and pest animals. Nine rabbits consume as much grass as one sheep.

It is important to recognise that pasture supply and animal demands will not coincide all year round for most grazing enterprises.

- ✓ Identify and set minimum pasture benchmarks to match animal production targets (see Appendix 2).
- ✓ Monitor animal liveweight or fat scores at key times to achieve livestock targets.
- ✓ Develop a fodder budget to manage both feed shortages and surpluses.
- ✓ Consider changing the pattern of feed demand of livestock to better match pasture production by altering lambing or calving times, flock or herd structure, type of enterprise, sale times and shearing time (see Figure 1.4).
- ✓ Implement an animal health plan to cover vaccination, worm control and overcome nutritional disorders, for example grass tetany.
- ✓ Attend a PROGRAZE™ course to learn more about livestock and pasture benchmarks and targets and fodder budgeting.

Selected resources

Publications

Managing native pastures for agriculture and conservation (2004) by CM Langford, PC Simpson, DL Garden, DA Eddy, MJ Keys, R Rehwinkel and WH Johnston. Published by the former NSW Department of Primary Industries.

Websites

More information can be found in a range of publications including the former NSW Department of Primary Industries Primefacts and the former NSW Agriculture Agfacts and Agnotes which are available through district offices or directly from the website: www.dpi.nsw.gov.au

Courses

PROGRAZE™: a course to help graziers assess pastures and manage the interaction between pastures and grazing livestock. Contact Industry & Investment NSW for more information.

Contacts

Industry & Investment NSW (Goulburn Office)
Phone: 4828 6600
Website: www.dpi.nsw.gov.au

Figure 1.4 shows the difference in pasture feed availability versus pasture feed requirements for an autumn lambing enterprise. The slight pasture production peak in autumn is unreliable and insufficient to meet the needs of ewes and their autumn lambs as they approach winter. This means heavier pressure on remaining pasture during the feed gap and the cost of supplementary feeding. A change in enterprise type or a shift to spring lambing may be a worthwhile option to better match feed demand to feed availability.

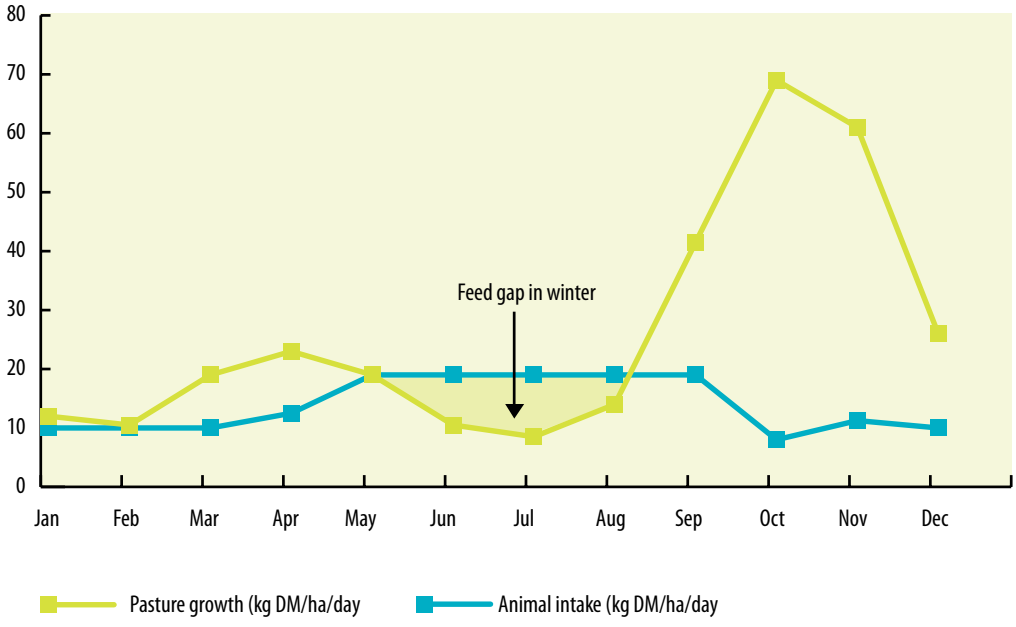

Figure 1.4: Differences in pasture growth and feed requirements for autumn lambing

2 Managing groundcover, stock and riparian areas for clean water

Providing stock with off-stream watering troughs has benefits for stock health and for water quality. *Photo: Industry & Investment NSW*

KEY THEMES

- Clean water improves stock health, productivity and economic returns
- Sediment, nutrients and pathogens reduce water quality
- Juvenile animals have significantly higher pathogen loads (and therefore present a higher risk to water quality) than adults

KEY ACTIONS

- Maintain more than 80 percent groundcover to filter waterborne pathogens and retain valuable soil and nutrients for pasture growth
- Implement good animal health practices to improve productivity and reduce the spread of pathogens in water
- Fence riparian areas to control stock access and provide off-stream water supplies, eg troughs or dams

KEY WORDS

- *Cryptosporidium*
- *Giardia*
- farm dams
- grassy filter strips
- groundcover
- inflow area
- juvenile animals
- riparian buffer zones
- sediment, nutrients and pathogens
- water quality

Clean water benefits livestock health and productivity. It is essential to the health and sustainability of our farms, waterways and catchments.

Poor quality water can adversely affect stock growth, lactation and reproduction and, in severe cases, contaminated water can cause stock death. All of these are economic losses for graziers. Managing water quality is as important as pasture management for a grazing enterprise.

Juvenile animals have significantly higher pathogen loads than adults and are more likely to carry human infective pathogens. Juvenile animals and their lactating mothers should not be grazed in riparian zones or paddocks adjoining waterways until the juveniles are at least four months old.

Areas of your property which are important for protecting water quality include:

- streams
- riparian areas
- drainage lines and drainage depressions
- areas surrounding lakes
- wetlands and river floodplains which interact with the river in times of flood
- farm dams.

Why is this important to me as a farmer?

✓ Improved water quality will increase economic returns by increasing:
- pasture use and feed intake by stock
- stock weight gains, health and vigour.

✓ Management practices that enhance water quality also reduce costs associated with:
- loss of valuable topsoil and nutrients
- silting of watercourses and farm dams
- treatment of stock affected by blue-green algae or waterborne diseases such as *E. coli, Cryptosporidium, Giardia, Salmonella, Campylobacter* and *Leptospirosis*.

✓ Better management of riparian areas can optimise productivity and environmental outcomes by:
- providing a valuable windbreak for livestock, eg trees can provide shelter for sheep off-shears
- local native riparian tree species shade streams, reducing the risk of algal blooms and improving the habitat of aquatic organisms
- supporting beneficial organisms including native fish, birds, frogs and insects, which can reduce pest insects
- reducing the risk of stock falling down steep riverbanks, being bogged or washed away during floods.

✓ Better groundcover management significantly reduces runoff and soil loss (see Figure 2.1).

Work in Canada has demonstrated weight gains in steers of up to 25 percent by providing watering systems such as troughs with clean and uncontaminated water supply (Willms et al., 1994)

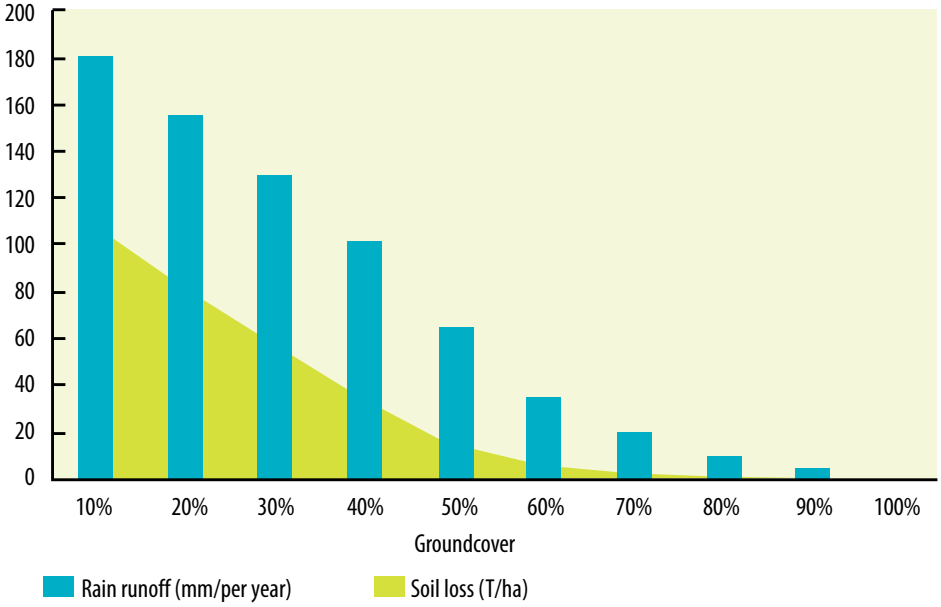

Figure 2.1: The relationship between percent groundcover and average rainfall runoff (mm per year) and soil loss (tons per hectare) from pastures. Adapted from Lang (1979). Note: Complete groundcover does not imply zero rainfall runoff in all conditions. Lang (1979) demonstrated that the average rate of runoff with complete cover was low (2mm per year or 0.3 percent of the average annual rainfall).

What is best practice?

- ✓ Maintain more than 80 percent groundcover to minimise rainfall runoff
- ✓ Manage livestock health and husbandry to reduce the spread of pathogens to watercourses
- ✓ Manage livestock access to riparian areas

How can you achieve this?

The most effective ways of improving water quality are to:

1. maintain more than 80 percent groundcover
2. maintain stock health
3. manage farm dams
4. manage riparian areas and control stock access through fencing and providing off-stream watering points.

Other management options include providing shade and shelter and using mineral licks in paddocks to encourage stock away from watercourses.

Maintain more than 80 percent groundcover

- ✓ Maintain more than 80 percent groundcover in paddocks (see Appendix 1). Aim for more than 80 percent with increases in slope, erodibility and rainfall intensity
- ✓ Establish or manage pastures to promote the persistence of perennial grasses Attend a PROGRAZE™ course to learn how to manage pastures
- ✓ Change from continuous grazing to rotational grazing to limit selective grazing and to improve the persistence of desirable perennial species
- ✓ Minimise soil erosion by implementing minimum or no till practices, eg direct drilling rather than ploughing
- ✓ Locate stock laneways away from streams, riparian areas, drainage lines and drainage depressions
- ✓ Avoid disturbing, ploughing or spraying out grassed drainage lines and drainage depressions
- ✓ Develop a drought management strategy, such as destocking or establishing droughtlots for feeding, to reduce pasture damage and promote pasture recovery after drought (see Section 10).

What is groundcover?

Groundcover generally refers to anything that covers the ground surface and reduces erosion. Preferably this is a vegetative layer of pasture and/or other low-growing plants, but it can also be plant residues, such as leaf litter and tree debris.

Managing pastures to maintain adequate levels of groundcover is the most effective way to limit soil erosion. Well managed pastures providing good groundcover (more than 80 percent) are more efficient in capturing and retaining rainfall and nutrients for plant growth, soil health and minimising contamination of water, than pastures with less groundcover.

The amount of groundcover is usually expressed in percentage terms – 100 percent groundcover means that you cannot see the soil, and 0 percent groundcover is bare soil. Up to 15 times more soil can be lost from a pasture if groundcover drops from 80 percent to 40 percent. It is important to keep more than 80 percent groundcover to minimise soil erosion.

Groundcover has two components:

- **Canopy cover** is standing vegetation more than 5 centimetres tall
- **Contact cover** is vegetation that is in contact with the soil and includes prostrate stems and leaves and plant litter.

Why is this important?

A stand of lucerne approaching flowering may have canopy cover of 80 percent, but because lucerne has little contact cover erosion can still occur. Contact cover is a better measure of groundcover, particularly on sloping land, than canopy cover.

How do I measure groundcover?

There are several different ways to estimate groundcover. Groundcover levels will vary across a paddock so you need to select representative areas.

Visual assessments - A simple method involves visualising a square, say 50 centimetres square (18 inches square) in front of your feet and look vertically into the pasture to estimate the percentage of the area that is covered with plant material and litter. Do this ten times in a paddock and average out the results. Figure 2.2 shows some relative groundcover percentages in a pasture. See Appendix 1 for more groundcover images.

Alternative methods of assessing groundcover include the step point or pointed stick methods. These methods also measure botanical composition of pastures and are described in Appendix 4.

40% groundcover

80% groundcover

Figure 2.2: Visual assessment of groundcover percentages. *Photos: B Stein, Industry & Investment NSW*

A study in the US showed that when given the choice, cattle drank from an off-stream water trough 92 percent of the time. Providing off-stream water reduced streambank erosion by 77 percent, and reduced key water quality pollutants by more than 50 percent (Sheffield *et al*., 1997)

REMEMBER, if soil is being washed into your farm dam then:

- nutrients, herbicides, animal dung, salt, pathogens and other undesirable materials may also be washed in
- you may have to spend more money to have the dam cleaned out

Maintain stock health and reduce the spread of disease

- ✓ Quarantine newly purchased animals for 21 days to monitor their health.
- ✓ Quarantine sick animals and prevent their access to streams, riparian areas, drainage lines, dams and other stock.
- ✓ Separate healthy and sick animals during outbreaks of diarrhoea.
- ✓ Implement good animal health practices such as appropriate drenching regimes and segregating supplementary feed from animal wastes.
- ✓ Dead animals and other animal wastes are a significant health risk to livestock and humans and can potentially contaminate watercourses. Prevent animal access to dead animals (this is an obligation under the Stock Diseases Act 1923) and do not dispose of carcasses within 100 metres of a watercourse. Contact your local Industry & Investment NSW for more information on carcass disposal.
- ✓ Locate new farm infrastructure that brings animals together (eg shearing sheds or cattle yards, feed areas, hospital paddocks, droughtlots) away from streams, riparian areas, drainage lines and drainage depressions.
- ✓ Ensure that you provide for the collection, stockpiling and treatment of manures around infrastructure.
- ✓ Excessive stocking rates can significantly increase disease transmission amongst animals. Ensure that stocking rates are matched to the carrying capacity and land capability of your paddocks and farm (see Appendix 3).
- ✓ Control pest animals to limit the potential of disease transmission to livestock and contamination of watercourses. Speak to your local Livestock Health and Pest Authority about advice on control options.

Manage farm dams

Dams are used as water for animals, irrigation or domestic use and often provide greater flexibility in pasture and stock management. Important secondary uses include soil erosion control, bushfire protection, wildlife habitat, recreation and aesthetics.

Poor water quality in farm dams can reduce production. In some cases it has been linked to the death of livestock by poisoning, eg from blue-green algae. Useful practices which will have a positive impact on water quality in farm dams are described below and illustrated in Figure 2.3.

- ✓ Identify and fence-off inflow areas (areas which concentrate the flow of water before it enters the dam). This will help protect pasture which slows and filters sediment and nutrients before entering your dam.
- ✓ Maintain 100 percent groundcover in inflow areas.
- ✓ Modify inflow areas so that there is a small flat area immediately above the dam that is well vegetated and can act as a filter zone for water flowing into the dam. This should be planted with suitable sedges, grasses and shrubs.
- ✓ Slow water down by using contour banks and/or vegetation strips. This will help stop it from dislodging soil and other contaminants and carrying them into the dam or watercourse.
- ✓ If feasible, fence-off the dam to discourage stock from congregating near it, damaging the dam edges, and fouling the water. Water may be piped or gravity fed to troughs.
- ✓ If you cannot fence the whole dam, limit stock access by providing access points at one or two strategic places along the dam edge and fencing the remainder. Access points should be stabilised with rocks or gravel to prevent pugging, bogging and erosion.
- ✓ Consider using wetland species and reeds on farm dam edges to minimise movement of nutrients into dam water.
- ✓ Check regularly for aquatic weeds. Weeds can indicate high nutrient water entering the dam.

This creek has been fenced off and is being revegetated with suitable trees, shrubs and grasses.
Photo: Industry & Investment NSW

- ✓ Encourage stock camps away from dam areas by locating shade trees in clumps away from the dam, and away from drainage lines and depressions that feed into the dam.
- ✓ Keep trees away from the dam wall to prevent damage by roots.

Manage riparian areas

Riparian land is the land that adjoins or directly influences a body of water. It includes the land immediately alongside small creeks and rivers, including the river bank and wetlands. Other important areas to manage for water quality are:

- gullies
- drainage depressions that sometimes run with water
- areas around lakes
- river floodplains.

Riparian areas are often highly productive due to their fertile soils and retained moisture. These areas are very important for protecting water quality and stream health. Trees and shrubs in riparian areas stabilise and protect streambanks, while grasses trap sediment, nutrients, and pathogens. Riparian areas also provide important habitat for native plants and animals. Land managers may be faced with the challenge of using the productive potential of riparian areas whilst minimising the impact of grazing animals in these sensitive locations.

Grazing management may be the most important factor influencing the condition of riparian vegetation and water quality. Uncontrolled stock access to riparian areas can result in over grazing and trampling of vegetation, leaving areas of bare soil and stock tracks that are prone to erosion.

Animal wastes foul the water and can transmit diseases (eg *Cryptosporidium* and *Giardia*) that can reduce stock growth and production and affect human health.

You should restrict the access of grazing animals to riparian areas to reduce the movement of sediment, nutrients and pathogens into watercourses and to limit damage to native vegetation and stream banks. Restricting animals from riparian areas also reduces stock losses and improves stock manageability.

Reasons to fence-off streams from livestock:

- Stabilise stream banks
- Reduce erosion
- Improve water quality
- Protect herd and flock health
- Better manage pastures
- Improve fish and wildlife habitat
- Enhance landscape

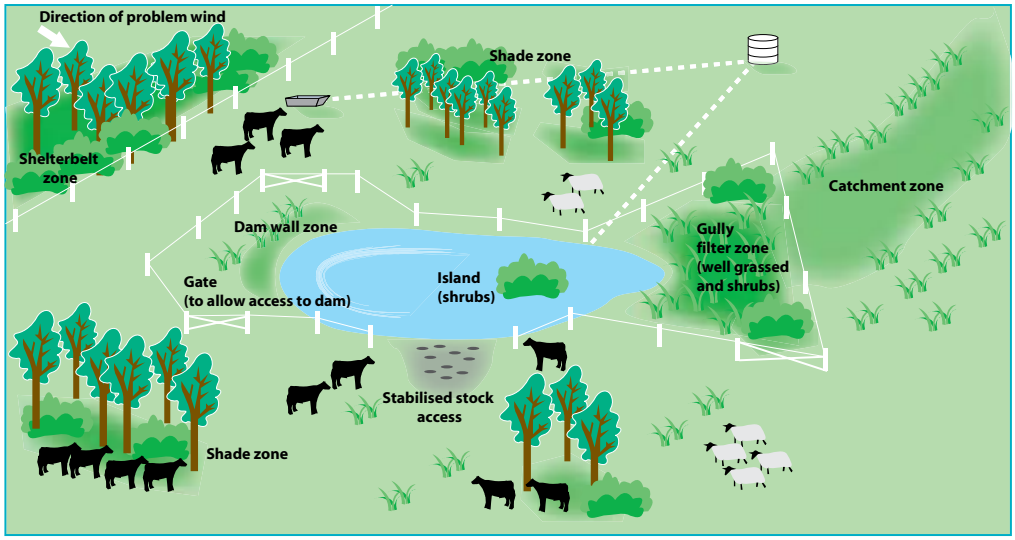

Figure 2.3: Example of a layout of trees and shrubs around a farm dam

Riparian buffer zones

To protect streambanks and retain soil and nutrients on your property, it is important to establish and maintain vegetation in riparian buffer zones. Riparian buffer zones should ideally consist of two types of vegetation (see Figure 2.4):

- native trees and shrubs – which minimise rainfall impact and help stabilise and protect streambanks
- grass strips– which help filter out sediment, nutrients, and pathogens such as *Cryptosporidium*.

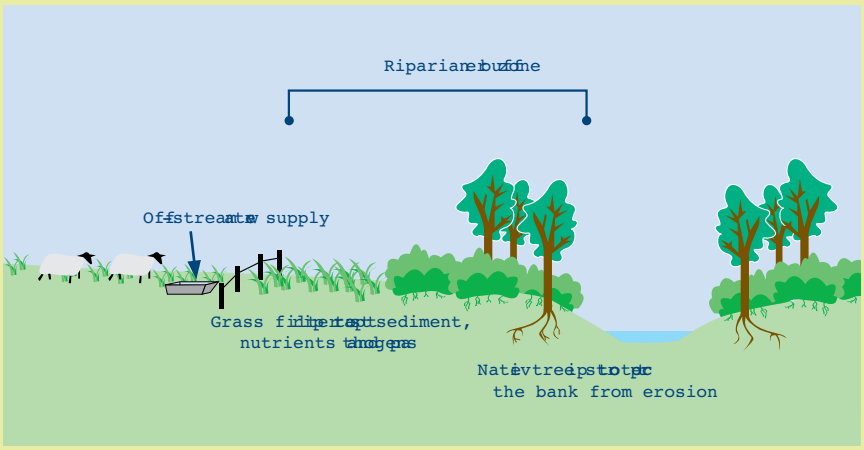

Figure 2.4: An ideal riparian buffer strip, consisting of native vegetation and a grassy filter strip. Modified from Staton, J & O'Sullivan, J. 2006. Stock and waterways: a managers guide. Land and Water Australia, Canberra

By combining trees, shrubs and grasses, you can achieve many riparian management objectives for water quality, productivity, farm health and catchment health.

Riparian buffer zones should be fenced to restrict stock access. This does not mean 'losing' land area from production. Instead, it enables you to control and manage grazing to achieve particular environmental goals and retain nutrients on your property.

Where you locate your riparian fence lines will depend on many factors such as:

- how you intend to use the riparian area
- condition of the riparian area
- vegetation, including grass cover
- adjoining land use
- rainfall, flood levels and frequency
- size and shape of the waterway
- landform features such as soils and slopes
- size of the catchment.

The benefits of reduced erosion, improved water quality, and wildlife habitat increase as the distance from the watercourse increases. As a general rule, try to build your fence at least 10 metres from the top of the banks. Generally, the greater the slope and the more erodible the soil, the wider the buffer zone needed to adequately protect the watercourse.

When considering where to put your riparian buffer fences, remember to provide enough room for vehicle and implement access so that you can enter the area to control weeds or slash grasses.

There are four principal actions you can take to manage your riparian areas well.

Understand your riparian areas

✓ Assess your riparian areas to identify:
- degraded areas that require total stock exclusion to prevent further erosion and require specific actions to repair damage, eg erosion control structures, bank stabilisation works or revegetation (see Section 4)
- suitable water access points and crossings (see Figures 2.5 and 2.6)
- stable areas which may be suited to controlled or short term grazing
- appropriate buffer zone distances

✓ Monitor your riparian areas continually and remove stock or reduce grazing pressure in response to signs of actual or potential damage.

Fence-off riparian areas

✓ Fence-off riparian zones to manage livestock access. Aim to exclude stock from riparian areas, but provide for controlled grazing under certain conditions (eg crash graze to control weeds or to remove standing dead grass to promote vigorous new grass growth).

✓ Locate creek crossings in stable areas. If you must move stock across watercourses, use points that are less prone to damage or erosion, eg along a straight section of a waterway or on the inside of a bend where water flow is slower and banks less prone to erosion (see Figure 2.5).

Manage stock access

✓ Provide off-stream water supplies, eg troughs or dams.

✓ Keep juvenile livestock and their lactating mothers away from riparian areas until juveniles are at least four months old. Juveniles under four months of age shed significantly higher numbers of pathogens than other age classes.

✓ Suitable riparian areas may be crash grazed for short periods to utilise standing feed, control weeds and reduce fire risk.

✓ Exclude livestock if the riparian area is in poor condition or has been impacted by very intensive grazing practices and requires time to recover.

✓ Exclude stock from riparian areas if rainfall is expected, or after rain, to avoid pugging, soil compaction, and contamination from pathogens.

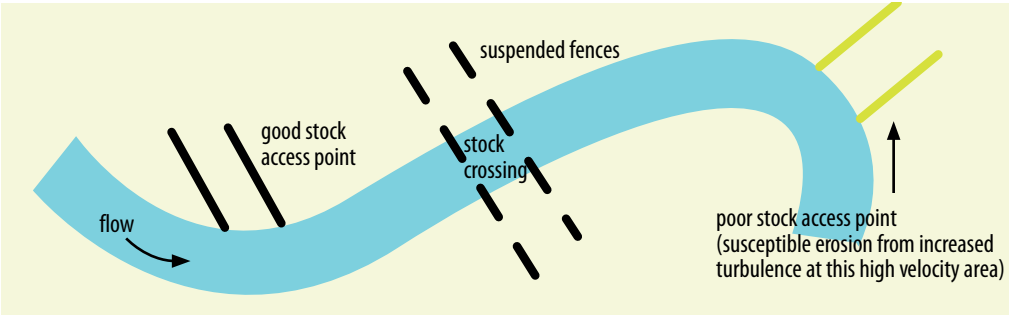

Figure 2.5: Locations for stock or vehicle crossings. Adapted from Price, P. & Lovett, S. (eds) 1999, Riparian Land Management Technical Guidelines, Volume Two: On-ground management tools and techniques, LWRRDC, Canberra p.114

Establish buffers and manage vegetation

- ✓ Establish a suitable riparian buffer zone to protect streambanks and slow the flow of runoff thereby trapping nutrients and pathogens before they reach waterways (see Figure 2.4).
- ✓ Manage riparian buffer zones to keep grass 10-15 centimetres tall, with at least 80 percent groundcover and as close to 100 percent groundcover as possible.
- ✓ Avoid fertilising riparian areas.
- ✓ Control weeds with a combination of grazing, mechanical and chemical methods. Only use herbicides registered for use in riparian areas and near watercourses (see Section 8).
- ✓ Control pest animals. Note that there are distance restrictions for placing poison baits near domestic water supplies or water draw points. Consult your local Livestock Health and Pest Authority for advice.
- ✓ Remove and relocate burrowing animals from riparian areas if possible. Note: Native animals are protected by State and Federal legislation. Seek advice from the NSW Department of Environment, Climate Change and Water.

Selected resources

Publications

Stock and Waterways : a Manager's Guide by J Staton & J O'Sullivan. Published by Land & Water Australia, Canberra (2006).

NSW Department of Primary Industries Agfact (1999) *Maintaining groundcover to reduce erosion and sustain production.* Available from www.dpi.nsw.gov.au

Websites

Industry & Investment NSW (division of Primary Industries) – www.dpi.nsw.gov.au

Industry & Investment NSW (division of Primary Industries) – fencing riparian zones. Available from: www.dpi.nsw.gov.au/fisheries/habitat/rehabilitating/habitats/fencing-riparian-zones

Land and Water Australia: www.lwa.gov.au

Hawkesbury Nepean Catchment Management Authority - www.hn.cma.nsw.gov.au

Southern Rivers Catchment Management Authority - www.southern.cma.nsw.gov.au

Livestock Health and Pest Authority - www.lhpa.org.au

Legislation regulates the construction of crossings and other structures in waterways. Always seek advice from Industry & Investment NSW and the Department of Water and Energy on permits.

Managing stock access does not mean permanent exclusion of stock from watercourses. Rather, stock movement and grazing pressure are managed by you to maintain the valuable functions of riparian areas.

Grassy strips have been shown to:

- improve the capture of *Cryptosporidium* during mild to moderate rainfall events (Atwill et al., 2002)
- Significantly decrease rainfall runoff by increasing water infiltration (Davies *et al.*, 2004)

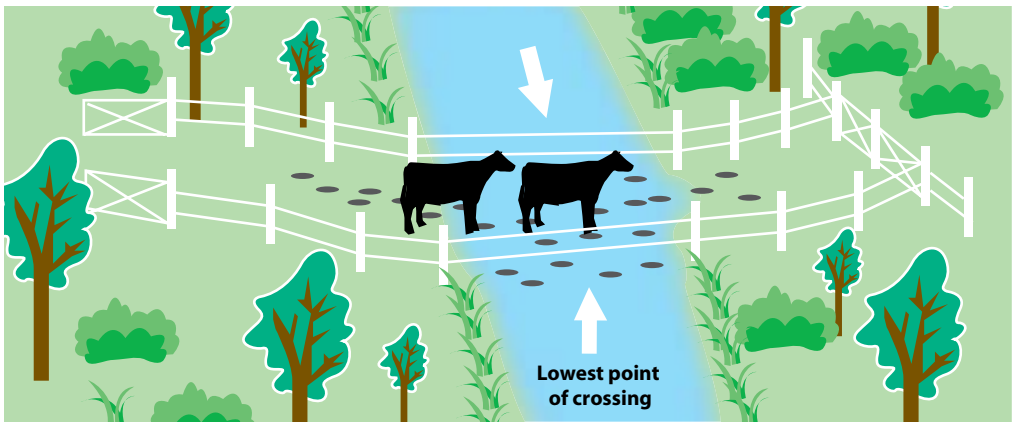

Figure 2.6: This crossing has been stabilised with rocks and gravel to minimise damage and erosion. *Adapted from Water Note 6, Water and Rivers Commission (Western Australia)*

A healthy soil is a valuable farm asset.
Photo: S Orgill, Industry & Investment NSW

KEY WORDS

- fertilisers
- leaching
- nitrogen fixation
- nutrient budget
- nutrients
- organic matter
- soil tests

Ask your local Industry & Investment NSW office for a free copy of *Fertilisers for Pastures*

Not all pasture species will respond favourably to fertiliser inputs, eg native pastures dominated by kangaroo grass may decline following fertiliser applications

3 Managing soil fertility

KEY THEMES

- Pastures need adequate nutrients for productivity and persistence
- You need to replace nutrients lost through product removal, leaching and movement to stock camps
- Fertiliser use can have both positive or negative environmental impacts

KEY ACTIONS

- Conduct regular soil tests to make informed decisions about using fertilisers
- Match fertiliser applications to pasture requirements and enterprise type
- Encourage healthy soil ecosystems to improve nutrient cycling in soils

Soils supply pastures with essential nutrients as well as physical and biological requirements for plant growth. However, soils in this region are often deficient in phosphorus, sulphur and molybdenum, and can have low levels of organic matter.

As well as soils being naturally low in some elements, nutrients are removed in farm products (meat, wool, hay), by leaching, being concentrated in stock camps and becoming bound to clays in the soil. Nutrient shortfalls, if not rectified, can severely restrict pasture growth, groundcover and livestock production.

Efficient use of fertilisers requires soil testing and nutrient budgeting. Inappropriate use of fertiliser can be costly and environmentally damaging, especially for water quality. Some native plant species are very sensitive to fertilisers and can die if inappropriate fertiliser is used.

Why is this important to me as a farmer?

- ✓ Maintaining adequate soil fertility is good for productivity and the environment.
- ✓ Fertile soils can better maintain groundcover which will limit weed invasion and minimise erosion and contamination of waterways.

What is best practice?

- ✓ Match nutrient inputs to pasture, environmental and enterprise needs
- ✓ Minimise nutrient waste and movement
- ✓ Encourage a healthy soil ecosystem

How can you achieve this?

To achieve best practice, the following strategies and actions are recommended:

1. Provide appropriate soil nutrients
2. Minimise off-site movement of nutrients
3. Encourage a healthy soil ecosystem by
   - increasing soil organic carbon
   - using soil-friendly agronomic practices
   - increasing soil biodiversity.

Provide appropriate soil nutrients

Grazing enterprises rely on healthy and fertile soils to produce quality pastures and fodder crops. To maintain pasture production nutrients lost from the farm system have to be replaced. Fertilisers (inorganic or organic) are usually required.

Figure 3.1 shows the effect of fertiliser on pasture growth. The paddock on the right has not been fertilised and the stocking rate is lower. The paddock on the left hand side has been fertilised and is able to support higher stocking rates and increased groundcover.

- ✓ Use soil tests on a regular basis (at least every three years) to determine the factors limiting plant growth, such as plant nutrients, soil pH, soil sodicity and salinity. Soil tests enable you to make informed decisions about fertiliser use. To optimise returns on your investment, match application rates to pasture requirements. Pastures will not respond to excess nutrients. Applying nutrients above recommended benchmark rates may not give an immediate economic return and can pollute the environment.
- ✓ Attend a LANDSCAN™ course to learn how to sample soils, interpret soil test results, understand nutrient budgets and make better decisions about soil nutrient management.
- ✓ Achieving the best responses requires matching fertiliser rates and types to different soils, pastures and landscapes. For example, fertilising pastures that contain a legume or other responsive species will achieve a better result than fertilising a non-responsive native grass pasture.
- ✓ Avoid spreading quick release phosphate fertilisers (eg superphosphate, mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP)) in cold wet conditions or when heavy rain is expected and likely to wash fertiliser into waterways.
- ✓ Apply fertiliser from late spring to early autumn when pastures are growing actively.
- ✓ Keep paddock records of soil test results, fertiliser use (date, rate and type), livestock and fodder production to help future decision making.

Figure 3.1: The effect of fertiliser on pasture growth.
Photo: H Warren, Industry & Investment NSW

Minimise off-site movement of nutrients

Nitrogen fertilisers are very soluble. Nitrogen can be leached into the groundwater and washed into waterways, especially in high rainfall areas and on sandy soils.

Phosphorus binds to the soil quickly after application and is not easily leached. However, phosphorus enters waterways when soil particles are blown or washed away.

- ✓ Minimise soil erosion to prevent the loss of nutrients (see Section 4).
- ✓ Apply nitrogen fertilisers only to actively growing pastures (Note: if you have sufficient legumes in your pastures these provide sufficient nitrogen without the need for nitrogen fertilisers)

Fertilisers should NOT be applied to:

- ✗ bare soil (except when sowing)
- ✗ waterlogged soils
- ✗ drainage lines, riparian buffer areas and waterways
- ✗ stock camps
- ✗ paddocks or drainage depressions when rainfall that could result in runoff is expected, eg when summer storms are anticipated in the next few days
- ✗ some native grass species, eg Kangaroo Grass.

Nitrate leaching can contaminate groundwater and presents a serious human health hazard

Phosphorus, when attached to sediments entering waterways, encourages algal blooms, particularly in stagnant water. Blue-green algae may produce toxins, which can be harmful to fish, animals and humans

Soil testing is vital to making informed decisions about fertiliser use.
Photo: S Orgill, Industry & Investment NSW

An algal bloom represents both a waste of nutrients and a waste of money. *Photo: Industry & Investment NSW*

Animal manure can be a useful source of organic carbon. However, manure may also contain high levels of pathogens which can affect stock health and water quality. Compost manure before spreading and prevent contact with waterways to reduce the risk of contamination

A grazing cow returns 79% of the nitrogen, 66% of the phosphorus and 92% of the potassium to the pasture (Bartlett, 1996)

Encourage a healthy soil ecosystem

Increase soil organic carbon

- ✓ Increase soil organic carbon (SOC) levels by increasing the organic matter put into soils. For example you could use manure, plant debris and composts. Some of these recycled organics also contain significant amounts of nutrients and can act as organic fertilisers.
- ✓ When applying animal manures:
  - ensure there is at least 80 percent groundcover
  - don't apply near drainage lines, water-courses and riparian areas at any time
  - don't apply near drainage depressions if you are expecting rain that will lead to runoff.

Use soil friendly agronomic practices

- ✓ When sowing use direct drilling (see Section 11) instead of cultivation. Cultivation destroys beneficial fungal hyphae mats that hold soil together and accelerates the decomposition of organic matter.
- ✓ Reduce soil compaction. Compacted soil reduces the space available for larger organisms to move through the soil, water infiltration and soil moisture holding capacity. Avoid compacted soil by:
  - minimising vehicle and animal traffic on wet paddocks
  - encouraging perennial pastures
  - maintaining more than 80 percent groundcover
  - droughtlotting animals to confine impacts during drought (see Section 10).

Increase soil biodiversity

- ✓ Manage soil acidity (see Section 5). Most beneficial soil organisms require a pH above 4.5. Strongly acid soils are detrimental to nitrogen-fixing bacteria and earthworms.
- ✓ Minimise the use of insecticides and herbicides to reduce detrimental effects on soil organisms such as earthworms and dung beetles.
- ✓ Dung beetles play an important role burying and shredding dung, recycling nutrients, minimising pasture fouling, reducing nutrient runoff into waterways, removing fly and parasite breeding habitats, minimising pathogens and improving water infiltration and aeration.

Encourage dung beetles by:

- growing good quality pasture which results in dung high in moisture and nitrogen which increases dung beetle egg production
- choosing chemicals (eg drenches and ectoparasite control agents) which have a low impact on dung beetle populations and using them when beetles are less active (ie autumn, winter and dry periods).

Dung beetle *(Onthophagus binodus). Photo: S Kidd, Southern Rivers Catchment Management Authority*

Selected resources

Publications

Fertilisers for Pastures (2005) by E Havilah, H Warren, R Lawrie, A Senn and P Milham. Published by NSW Department of Primary Industries (2005). Available from www.dpi.nsw.gov.au/agriculture/resources/soils/fertilisers/pastures

NSW Department of Primary Industries Primefact 534 (2007) *Best practice guidelines for using poultry litter on pastures*. Available from www.dpi.nsw.gov.au/agriculture/field/pastures/management/soils-fertilisers/poultry-litter

NSW Department of Primary Industries Primefact 442 (2007) *Dung beetles - working for you*. Available from www.dpi.nsw.gov.au/agriculture/field/pastures/management/soils-fertilisers/dung-beetles

Courses

LANDSCAN™: a course to help graziers interpret landscapes and soil tests for sustainable farm management

4 Managing soil erosion

Streambank erosion
Photo: S Orgill, Industry & Investment NSW

KEY THEMES

- Erosion degrades the natural assets of your farm
- Erosion removes large amounts of soil and nutrients from paddocks
- Once topsoil is lost it takes a very long time to build up

KEY ACTIONS

- Achieve and maintain more than 80 percent groundcover
- Minimise erosion risk, including reducing runoff
- Repair past damage

KEY WORDS

- erosion
- flumes
- groundcover
- gully
- land classes
- nutrients
- sediment
- topsoil

Soil erosion is the movement of soil by water, wind and gravity – often from a position where it is valuable to a position where it is problematic. In addition to sedimentation of waterways and dams, eroded soil carries large amounts of nutrients and organic matter which can pollute surface water and reduce the productive potential of paddocks.

In most circumstances it is difficult and uneconomic to move soil back to its original position. Emphasis should therefore be placed on soil conservation, not remediation.

There are five major forms of erosion: rill, gully, sheet, streambank and tunnel erosion.

Rill and gully erosion

A channel caused by the concentrated but intermittent flow of water usually during and immediately after heavy rains. A rill is less than 30 centimetres deep and a gully is more than 30 centimetres deep.

Sheet erosion

Removal of material by sheet flow, usually a fairly thin layer of surface soil. Water sheet flow and wind commonly removes fine material, leaving coarser material behind. Also called hillwash, sheetwash and slopewash, sheet erosion is not as visible as gully erosion.

Streambank erosion

Removal of soil from streambanks by the direct action of streamflow, wind or wave action. It is associated with large water flows (ie rivers and creeks) and usually happens during periods of high streamflow and where the streambank material is not stable. Removing riverbank vegetation can lead to unstable banks and bank erosion.

Tunnel erosion

Removal of subsurface soil while the surface soil remains relatively intact. This produces large cavities beneath the soil surface which usually collapse resulting in a gully. Also known as piping. This form of erosion is a common symptom of sodic or dispersive soils (see Section 6).

Soil erodibility: the susceptibility of a soil to the detachment and transportation of soil particles by erosive agents, such as water runoff. Erodibility is a function of the mechanical, chemical and physical properties of the soil. Although other factors directly influence soil erosion, highly erodible soils are those which detach easily, for example sandy soils low in organic matter

Right: gully erosion. *Photo: B Stein, Industry & Investment NSW*

Left: rill erosion. *Photo: M Hardie, Tasmanian Department of Primary Industries and Water*

Left: sheet erosion. *Photo: S Orgill, Industry & Investment NSW*

Right: tunnel erosion. *Photo: S Orgill, Industry & Investment NSW*

Eroded soil cannot be readily replaced. Where soil is left unprotected by groundcover, up to 100 tonnes/ha of valuable topsoil can be lost in a year

Appendix 1 provides a guide for assessing groundcover

Appendix 3 provides a guide for understanding land capability classes

Why is this important to me as a farmer?

The loss of 1 millimetre of soil from your paddock is equivalent to approximately 14 tonnes of soil removed per hectare. This same 1 millimetre of soil can take up to 3,000 years to reform from bedrock.

Reducing soil erosion will:

- ✓ minimise the loss of valuable topsoil and nutrients – eg most soil phosphorus is in the top 5 millimetres of soil
- ✓ retain nutrients and organic mater in the topsoil promoting biological activity
- ✓ improve water quality in farm dams and watercourses by restricting movement of sediments and attached nutrients into water supplies

What is best practice?

- ✓ Maintain more than 80 percent groundcover
- ✓ Manage erosion risk
- ✓ Remediate erosion sites

How can you achieve this?

To achieve best practice, it is recommended that you:

1. maintain more than 80 percent groundcover
2. reduce run off
3. minimise erosion risk
4. repair past damage.

Snow gum revegetation. Contact your local catchment management authority for advice and assistance with revegetation programs. *Photo: J Reynolds, Hawkesbury Nepean Catchment Management Authority*

Maintain more than 80 percent groundcover

Your groundcover targets should consider soil type, soil erodibility and slope in individual paddocks.

- ✓ Maintain a good cover of perennial pasture. Perennials are deep-rooted and have a longer growing season than annual grasses.
- ✓ Conduct a soil test to identify soils which are especially vulnerable to erosion, eg sodic soils in sloping paddocks, saline areas.
- ✓ Use rotational grazing and provide grazing rest periods to minimise the formation of stock tracks, preserve groundcover and boost production and persistence of perennial grasses.
- ✓ For disturbed or degraded areas, exclude stock temporarily and revegetate with perennial species that will establish and persist in your area.
- ✓ Use minimum tillage practices to conserve groundcover and maintain soil structure, eg establish pastures by direct drilling rather than ploughing. Retain stubble and straw in cropping paddocks.
- ✓ Use appropriate fertilisers and companion legumes to maintain perennial pasture vigour. (Note: Using fertilisers on some native grasses may be inappropriate. Consult your local agronomist before applying fertilisers to native pastures.)
- ✓ Control pest animals. Pest animals, such as rabbits, pigs and deer, can denude paddocks. Consult your local Livestock Health and Pest Authority for pest control options. Note: You are legally obliged to control rabbits, pigs and wild dogs under the *Rural Lands Protection Act 1998*.
- ✓ Attend a PROGRAZE™ course to learn how to measure and assess groundcover and to use grazing as a tool to increase pasture vigour and persistence.

Reduce run off

- ✓ Reduce runoff by maintaining ground-cover levels appropriate to the different land classes on your property (see Appendix 3). As a general rule, aim for:
  - 80 percent groundcover on land capability classes I to V
  - 90 percent groundcover on capability classes VI and VII
  - 100 percent groundcover in drainage lines and riparian buffer zones.

- ✓ Fence out riparian areas (see Section 2).
- ✓ Drainage lines and drainage depressions funnel large amounts of water, often under high velocity. Protect vegetation in these areas from vehicle and stock tracks, cultivation, over grazing and clearing.

Minimise soil erosion risk

- ✓ Establish windbreaks to minimise wind erosion and conserve soil moisture in paddocks.
- ✓ Do not cultivate slopes over 8 degrees. Direct drilling may be an option (see Section 11).
- ✓ For sodic soils (see Section 6), minimise disturbance, increase organic matter, and apply gypsum or lime to improve soil structure where applicable.
- ✓ When using herbicides take care not to destroy useful groundcover. Although herbicides are useful for weed control, they can also cause significant damage to non-target species, creating areas of bare earth which are prone to erosion. Where possible control weeds by hand-hoeing and spot spraying or short bursts of high intensity grazing.
- ✓ Enrol in a LANDSCAN™ course to learn how to identify erosion risk and develop treatment strategies.

Repair past damage

- ✓ Temporarily fence and remove livestock from eroded areas to allow revegetation.
- ✓ Revegetate disturbed or degraded areas with perennial species that will establish and persist in your area.
- ✓ Facilitate natural recruitment and colonisation of grasses and trees by fencing sensitive areas prone to degradation.
- ✓ Gully heads should be protected and stabilised. Prevent stock access to these areas to facilitate revegetation. If sowing immediately above the gully head work along the contour.
- ✓ Consider implementing water diversion measures or engineering works to repair damage or prevent further erosion. Examples include:
  - gully control structures, eg concrete or rock flumes
  - dams
  - grade stabilisation structures
  - diversion/contour banks and channels
  - fencing
  - in-stream bed or bank control structures. Any work involving in-stream structures must be discussed with Industry & Investment NSW and the Department of Environment, Climate Change and Water before starting *(Fisheries Management Act 1994, Water Management Act 2000)*.
- ✓ Get help. Talk to your local catchment management authority for more information and help, and about incentives available for erosion control works (eg Catchment Protection Scheme in the Sydney drinking water catchments).

Selected resources

Websites

More information can be found in a range of publications including the former NSW Department of Primary Industries Primefacts and the former NSW Agriculture Agfacts and Agnotes which are available through district offices or directly from the web site: www.dpi.nsw.gov.au

Courses

LANDSCAN™: a course to help graziers interpret landscapes and soil tests for sustainable farm management.

Contacts

For further information about the Catchment Protection Scheme contact

- Hawkesbury Nepean Catchment Management Authority
  Phone: (02) 48286747
  Website: www.hn.cma.nsw.gov.au
- Southern Rivers Catchment Management Authority
  Phone: (02) 48422594
  Website: www.southern.cma.nsw.gov.au

Lining a degraded drainage line with rocks to prevent further erosion (above)
A cement flume, preventing erosion associated with dam overflow (below)
(Photos courtesy of the Hawkesbury-Nepean Catchment Management Authority)

Below: Rock groynes. *Photo: Sydney Catchment Authority*
Left: Bank stabilisation. *Photo: Industry & Investment NSW*

Brittle Gum is indicative of highly acidic soils. *Photo: B Stein, Industry & Investment NSW*

5 Managing soil acidity in pastures

KEY THEMES

- Agricultural production can contribute to soil acidity
- Soil acidity limits the choice of pasture species you can sow
- Subsoil acidity is very difficult and expensive to correct

KEY ACTIONS

- Measure and monitor the acidity of your soils
- Slow the rate of acidification
- Begin a liming program early

KEY WORDS

- pH
- aluminium
- cation exchange capacity
- liming
- manganese
- molybdenum
- subsoil

The gross value of agricultural production lost in NSW due to soil acidity has been estimated at $378 million per year (Land and Water Audit, 2002)

It is estimated that the removal of 1 tonne of lucerne hay requires 70 kg of lime to neutralise the resulting acidity

Soil acidification is a major soil degradation issue in some areas. It is often a subtle process, developing slowly. Potential indicators that soil pH is falling to critical levels include:

- reduced yields
- decline of acid sensitive species
- lack of response to fertilisers.

Soil acidification may lead to a decline in groundcover and decreased farm productivity. It increases the risk of erosion and pollution of waterways.

Many of the region's soils are highly weathered and naturally acidic (pH less than 5.5) throughout the soil profile. However, soil acidification has increased under agriculture. Once the soil surface acidifies, acidity can move to depth where it is difficult to manage.

What is pH?

pH is an indicator of the acidity or alkalinity of the soil, on a scale of 1-14. A pH less than 7 indicates acidity and more than 7 indicates alkalinity.

pH is measured in water (pHw) or calcium chloride (pH_{CaCl}). Measurements are preferred in pH_{CaCl} as these are less affected by seasonality, although pHw values can be useful when comparing historical soil tests. Water pH values tend to be around 0.8 units higher than pH_{CaCl}.

Note: All references to pH in this publication are for pH measured in calcium chloride (pH_{CaCl}), unless otherwise indicated.

The main causes of agriculturally induced acidity are:

- leaching nitrogen below the root zone - this can happen when nitrogen fixed by legumes is not used by the grasses in the pasture (eg clover dominant pastures, predominantly annual pastures, or where there has been heavy use of nitrogenous fertilisers)
- removal of agricultural products - most agricultural products (eg meat, fibre, hay) are slightly alkaline. Removing these products acidifies soil. For example, lucerne hay cutting is one of the most acidifying practices
- type of nitrogenous fertiliser - the most acidifying fertilisers are ammonium sulphate and mono-ammonium phosphate (MAP), followed by di-ammonium phosphate (DAP). Less acidifying are urea, ammonium nitrate and anhydrous ammonia.

A soil pH between 5.0 and 6.5 is best for most agricultural plants. If the pH drops below 5.0, plants that are highly sensitive to acidity, such as lucerne and barley, are adversely affected. Plants that are more tolerant of acidity continue to grow normally until the pH falls below 4.6. Below pH 4.4 most introduced plants show a significant reduction in production. Note: Many native plants have adapted to pH below 4.4 and should not be removed.

Why is this important to me as a farmer?

Acid soils can lower productivity due to:

- aluminium and manganese toxicity which stunts plant root development (aluminium becomes increasingly available to plants as soil pH drops below 4.6)
- reduced vigour and number of *Rhizobia* species on legume roots which fix nitrogen in the soil
- loss of, or inability to establish, acid sensitive pasture species such as lucerne or phalaris
- increased weed invasion
- declining pasture vigour
- reduced solubility and availability of nutrients such as molybdenum, potassium, phosphorus, magnesium and calcium.

It is important to remember that while acidity may affect plant growth, you also need to consider other limiting factors, such as plant nutrient availability. A soil test is the best way to determine the most limiting factor affecting plant growth.

What is best practice?

- ✓ Maintain or increase topsoil pH_{CaCl} above 5
- ✓ Minimise the rate of further acidification
- ✓ Maintain or establish pasture species suited to your soils

How can you achieve this?

To achieve best practice you should:

1. measure and monitor the acidity of your soils
2. slow the rate of acidification
3. begin a liming program early

Measure and monitor the acidity of your soils

- ✓ Use a soil test to measure the pH, aluminium percentage and nutrient status of your soil before planning a strategy to manage soil acidity. This is particularly useful before establishing new pastures or sowing a crop.
- ✓ For soil tests to be meaningful, samples should be:
  - taken from the topsoil (0-10 centimetres) **and** the subsoil (10-20 centimetres)
  - performed every three years (or more often in intensively used paddocks)
  - taken at the same time of year (eg in March).
- ✓ When sampling soils, divide paddocks into management units, eg. divide the paddocks on the basis of soil type, slope and aspect.
- ✓ Attend a LANDSCAN™ course to learn how to sample soils correctly, to interpret soil tests, and to develop appropriate management strategies for the variety of soil types and landscapes on your farm. Contact your local Industry & Investment NSW office for more information.

Table 5.1: Aluminium sensitivity of some pasture plants and suggested exchangeable aluminium upper limits

Aluminium sensitivity	Upper limit for aluminium (% of CEC)	Example pasture plants
Highly sensitive	5%	Lucerne, Medics, Strawberry Clover, Berseem and Persian clovers, Buffel Grass, tall wheat grass
Sensitive	10%	Red Grass, Phalaris, Red Clover, Balansa Clover, Caucasian and Kenya White Clovers
Tolerant	15%	Rye grasses, Tall Fescue, Haifa White and Subterranean Clovers,
Highly tolerant	20%	Microlaena, Cocksfoot, Kikuyu, Paspalum, Yellow and Slender Serradella, Maku Lotus, Common Couch, Consol Lovegrass

Cocksfoot is tolerant of acid soils.
Photo: B Stein, Industry & Investment NSW

With increasing acidity, aluminium becomes soluble and may reach toxic levels, and molybdenum becomes increasingly unavailable

Superphosphate has no direct effect on soil pH. Superphosphate ('super') does however encourage legume growth which may result in increasing soil nitrogen levels and soil acidification if this nitrogen is subsequently leached

Legume to pasture ratios should not exceed 30:70. More than 30% legumes in your pasture mix will generally produce more nitrogen than can be used by grasses, resulting in leaching of excess nitrogen and further acidification

Spreading lime or dolomite remains the only practical way to neutralise soil acidity. *Photo: B Stein, Industry & Investment NSW*

It is estimated that the removal of 1 tonne of lucerne hay requires 70 kg of lime to neutralise the resulting acidity

Liming will have little to no effect on subsoil acidity (below 10 cm). If subsoils are acidic, your best strategy is to use plant species which tolerate acid soils

Slow the rate of acidification

- ✓ Use grazing animals to maintain the vigour of perennial pastures and to prevent legume dominance.
- ✓ Preserve acid tolerant native perennial pastures especially on soils that are acidic to a depth below 10 centimetres and of poor fertility.
- ✓ Where native perennial grasses are absent, sow acid/aluminium tolerant introduced species on soils with subsoil (below 10 centimetres) acidity (see Table 5.1). Note: Mature phalaris is relatively acid tolerant, but seedlings are sensitive to acidity and best sown with lime.
- ✓ Limit highly acidifying practices (eg lucerne hay production) to land classes where lime can be incorporated. If possible, feed stock on the same paddock from which hay was cut.
- ✓ If pastures require nitrogen, use nitrogen fertilisers with a lower acidifying effect. Use urea, ammonium nitrate and anhydrous ammonia instead of ammonium sulphate, mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP).

  Note: Ensure nitrogen inputs do not exceed plant demands and are applied to actively growing plants. If high inputs are required, consider split applications to reduce the potential for nitrate leaching.
- ✓ Spreading lime or dolomite is the only practical way to neutralise soil acidity. Dolomite should only be used when magnesium levels are low (less than 15 percent of Cation Exchange Capacity) to avoid soil structural dispersion.
- ✓ The amount of lime required to neutralise soil acidity depends on the quality of the liming product used (determined by the neutralising value and fineness of the lime) and the buffering capacity (Cation Exchange Capacity) of the soil. Consult your local agronomist for advice on planning a liming strategy.
- ✓ Liming a paddock to achieve a surface soil (0-10 centimetres) pH above 5.2 will remove most problems associated with an acidic topsoil.
- ✓ Avoid liming to increase the pH of the top-soil above 6.5 as it can induce deficiency of plant nutrients such as zinc, boron and manganese, especially in sandy soils.
- ✓ Topdress lime 12 months before direct drilling. Lime is relatively inert and may take several months to move down to seeding depth, depending on the soil type and rainfall.
- ✓ Topdressed lime moves through the soil profile most effectively in soils with good structure and water infiltration rates, and sandy soils.
- ✓ For soils with a pH less than 5 use moly-bdenum for effective legume nodulation every 5 years. When sowing legumes, inoculate and lime pellet the seed.
- ✓ Use farm mixed lime or prilled lime and fertiliser at sowing for a cheaper option than topdressing with heavy rates of lime when sowing acid sensitive seedlings.
- ✓ Do not apply lime and nitrogen fertilisers at the same time. Liming can cause freshly applied nitrogen, either as fertiliser or manure, to be lost as gas.
- ✓ Do not spray herbicides or insecticides onto paddocks where lime is still visible as the pesticide may not be as effective.

Begin a liming program early

Liming is likely to be most beneficial if your topsoils have a pH below 4.6 and sensitive/responsive pasture species are present. At higher levels, it is best to consider the aluminium percentage and nutrient status of the soil to first determine the cost effectiveness of applying lime. Liming is unlikely to provide any benefit for subsoil acidity (>10cm soil depth).

Under most circumstances it will be uneconomic to use high rates of lime over large areas to correct pH and aluminium toxicity. Use of lime may need to be strategic, for example use lime only in high production areas or when establishing an acid sensitive pasture or crop. In other areas, maintain a good cover (more than 80 percent) of acid tolerant native and/or introduced pastures. Consult your local agronomist for advice.

Selected resources

Publication

NSW Department of Primary Industries *Soil Acidity and Liming,* Agfact AC.19, 3rd edition 2005, Brett Upjohn, Greg Fenton, Mark Conyers. Available from www.dpi.nsw.gov.au

Course

LANDSCAN™: a course to help graziers interpret landscapes and soil tests for sustainable farm management

6 Managing soil sodicity

Exposed sodic subsoils showing a melting, worm-like appearance and undercutting. *Photo: B Stein, Industry & Investment NSW*

KEY THEMES

- Sodicity is a major cause of soil degradation
- Sodic soils are prone to dispersion, soil erosion and waterlogging
- Soils that are sodic below the root zone often go unnoticed by land managers

KEY ACTIONS

- Identify areas of sodic soil
- Prevent disturbance of sodic soils
- Exclude stock from eroding areas

KEY WORDS

- dispersable soil
- erosion
- Exchangeable Sodium Percentage (ESP)
- gypsum
- sodic soil
- sodicity

Soil sodicity is a major cause of land degradation in this region, resulting in poor pasture growth, loss of groundcover, waterlogging and gully or tunnel erosion. In Australia, about 30 percent of agricultural land is sodic. This is about five times the area of land estimated to be saline.

What is sodicity?

A soil is considered sodic when sodium in the soil reaches a concentration where it starts to affect soil structure. High levels of exchangeable sodium percentage (more than or equal to 6 percent of the Cation Exchange Capacity) make sodic soils structurally unstable.

Sodicity is often confused with salinity (see Section 7). Sodicity and salinity are both undesirable but have opposite effects on soil structure.

- sodium disrupts soil structure, causing soils to disperse if disturbed
- salt in saline soils prevents dispersion but reduces the ability of plants to take up water.

Sodicity can occur at any depth in the soil, but is most common in the subsoil. Signs of sodicity may be more or less obvious depending on where it occurs within the soil profile (ie topsoil, subsoil or both), the climate (particularly rainfall), and slope (hilly country may be more susceptible to tunnel erosion).

What are the causes of sodicity?

Sodicity is caused by the presence of sodium attached to clay in soil. When sodium makes up more than 6 percent of exchangeable cations (positively charged ions) bound to clay particles, structural problems can occur and the soil is said to be sodic. This is accentuated when soil organic matter levels are low.

Soils can be naturally sodic due to a combination of climate and geology. Excess sodium can accumulate where chlorine has leached out of previously saline soils over tens or thousands of years or during soil formation from granitic and some sedimentary rocks.

Soils that are sodic and saline

A soil can be both saline and sodic. These soils are unlikely to disperse because sodium chloride in the soil water causes clay to bind together (this is known as 'flocculation'). In sodic soils that were previously saline, much of the chloride has been leached away. High concentrations of sodium remain attached to clay in the soil, which can lead to dispersion and a breakdown of soil structure.

The annual cost of soil sodicity in lost agricultural production is estimated to be in excess of $2 billion (NOVA 1999)

Sodicity and salinity are both undesirable but have different effects on soil structure

Sodic soils are prone to erosion

Compacted soil, surface crusting and loss of groundcover are signs of sodicity.
Photo: B Stein, Industry & Investment NSW

Subsoils which have high sodium content may not display surface symptoms. These are prone to tunnel erosion and can be identified by soil testing to depth (more than 20 centimetres), or indicated through signs of waterlogging, such as the presence of pin rushes

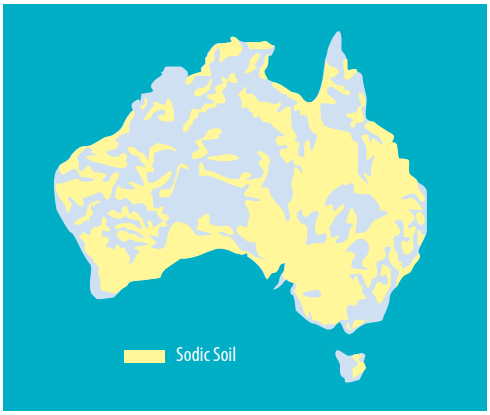

Figure 6.2: Distribution of sodic soils in Australia (Cooperative Research Centre for Soil and Land Management)

What are the signs of a sodic soil problem?

Typical signs of a soil sodicity problem in the rooting zone of pastures include:

- waterlogging caused by poor structure and drainage
- increased runoff and poor water storage
- compacted soil and surface crusting
- poor emergence of pastures and crops
- loss of groundcover
- soil erosion.

Why is this important to me as a farmer?

Sodic soils will have important management and investment implications for farmers. Poor plant growth on sodic soils increases the risk of erosion, as does mechanical disturbance of sodic soils (eg by cultivation or deep ripping).

Soils that are sodic below the root zone often go unnoticed by land managers because there are frequently no obvious impacts on plant growth and farm management. However, in high rainfall areas or after high rainfall events, sodic subsoils can reduce drainage causing permeability problems and waterlogging. This may not always be obvious by looking at the surface soil. These areas may become prone to tunnel erosion when water flowing through natural soil cracks or pores in non-sodic topsoil carries away clay in the sodic subsoil layer. This undermines the topsoil which eventually collapses to form a new erosion gully.

What is best practice?

- ✓ Know where the sodic soils are on your farm
- ✓ Retain topsoil and minimise disturbance and exposure of sodic soils
- ✓ Maintain more than 80 percent groundcover to improve soil structure and increase soil organic matter

How can you achieve this?

To achieve best practice you should:

1. identify areas of sodic soil
2. prevent disturbance of sodic soils
3. exclude stock from eroding areas.

Identify areas of sodic soil

- ✓ Look for signs of soil sodicity:
  - soil crusting, surface soil sealing, dense and compacted soil
  - signs of waterlogging such as mottled soils and/or the presence of toad rush, pin or spike rush and docks
  - cloudy dam water which never settles out
- ✓ Conduct a soil test to measure the levels of Exchangeable Sodium Percentage (ESP) in your soil. An ESP of 6 percent or more indicates a sodic soil. You can learn more about soil sampling and interpreting soil tests by attending a LANDSCAN™ course.

Subsurface 'tunnels' and 'pipes' are also symptoms of sodic subsoils.
Photo: S Orgill, Industry & Investment NSW

Prevent disturbance and dispersion of sodic soils

- ✓ If topsoils are sodic, topdress with gypsum (calcium sulphate) for a fast, short to medium-term improvement of soil structure before sowing a pasture. For sodic soils which are also acidic (pH_{CaCl} less than 5) using lime (calcium carbonate) may be a better option. A mixture of lime and gypsum may be considered on sodic soils with a pH in the 5 to 6.5 range to provide a more long-lasting effect than gypsum only.
- ✓ When sowing, direct drill to reduce mechanical soil structural breakdown and to preserve soil organic matter which dilutes the effect of sodium and provides a biological 'glue' (see Section 11).
- ✓ Promote healthy plant growth and groundcover to add organic matter and increase structural stability.
  - **do not** use dolomite (calcium and magnesium carbonate) on sodic soils as this may exacerbate the problem.
  - **do not** mix sodic subsoils with non-sodic topsoils (by cultivation) and **never** deep rip sodic soils.

Exclude stock from eroding areas

- ✓ Exclude stock from erosion gullies and revegetate to prevent further erosion. Contact your local catchment management authority to help you with erosion control works on your property.

Selected resources

Website

More information can be found in a range of publications including the former NSW Department of Primary Industries Primefacts and the former NSW Agriculture Agfacts and Agnotes which are available through district offices or directly from the web site: www.dpi.nsw.gov.au

Course

LANDSCAN™: a course to help graziers interpret landscapes and soil tests for sustainable farm management.

Avoid deep ripping sodic soils.
Photo: S Orgill, Industry & Investment NSW

A salt scald illustrating how salinity causes loss of groundcover and thus loss of pasture production. *Photo: S Orgill, Industry & Investment NSW*

7 Managing dryland salinity

KEY THEMES

- Removing vegetation from landscapes, particularly trees and deep-rooted perennial grasses and shrubs, has contributed to rising groundwater tables and salinity
- Salinity is a major type of land degradation
- Salinity affects pasture productivity and reduces groundcover

KEY ACTIONS

- Conduct soil tests to identify areas which may be saline
- Establish and/or maintain deep-rooted perennial grasses and trees on saline soils to maximise soil water use and limit the rise of groundwater tables
- Fence out saline discharge sites to control livestock access to encourage maximum vegetation growth

KEY WORDS

- discharge area
- dryland salinity
- electrical conductivity
- groundwater
- recharge
- revegetation
- salt scald

Recharge areas are typically found in the upper catchment, in hills and ridge tops with shallow soils. Retain remnant vegetation in these areas or revegetate if necessary

The annual cost of dryland salinity in lost agricultural production is estimated to be $243m (Hill 1997)

What is dryland salinity?

Dryland salinity is the accumulation of salt in surface soil in non-irrigated areas, usually due to rising groundwater tables. As the soil surface dries out, dissolved salts are left behind. These salts impede the ability of plants to extract water from soil, resulting in the loss of pasture and groundcover, and subsequent erosion.

What are the causes of dryland salinity?

Salt is a natural part of the Australian landscape. In the last two hundred years, some land management practices have increased the area impacted and the effects of salinity.

Removing vegetation from landscapes, particularly trees and deep-rooted perennial grasses and shrubs, is a significant cause of rising groundwater tables and associated salinity.

Groundwater tables rise when water infiltrating the soil moves beyond the reach of plant roots ('recharge'). Sometimes the water table will 'discharge' above the ground surface, at a point lower in the landscape or at the junction between two different types of rock (see Figure 7.1). If the groundwater is saline, the discharge will bring salt to the soil surface. In other instances salt discharge occurs through capillary action as the water table rises close to the soil surface (see Figure 7.2).

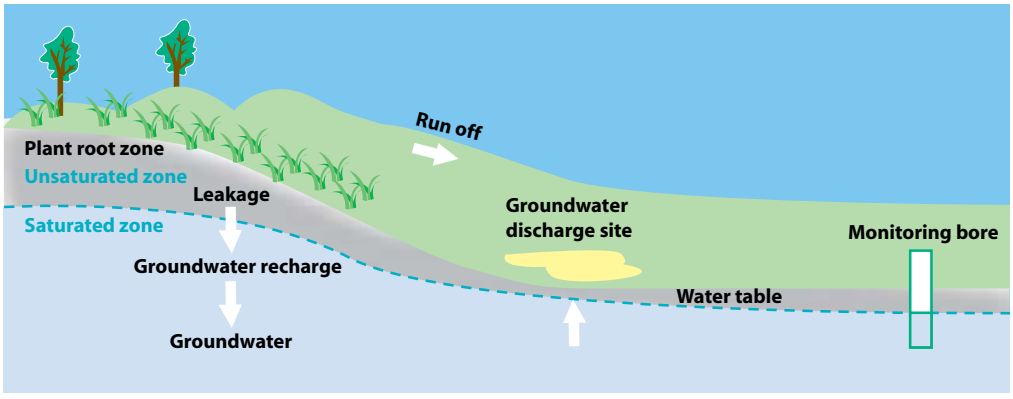

Figure 7.1: The groundwater system, demonstrating recharge and discharge. Source: NSW Department of Primary Industries Salinity Glovebox Guide (2005)

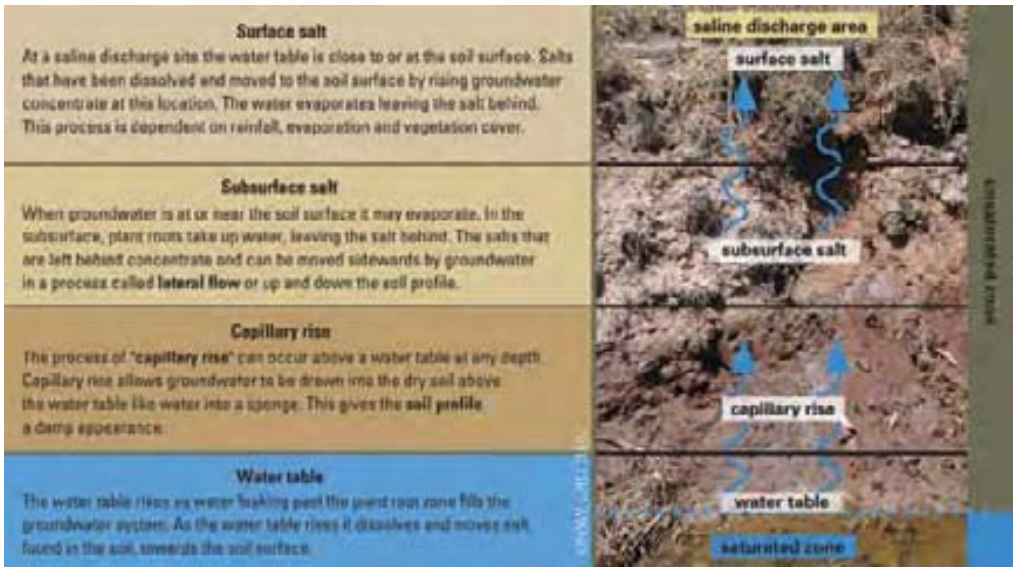

Figure 7.2: Salt movement to the soil surface. Source: NSW Department of Primary Industries Southern Salt Action Team (2003)

Salinity outbreaks may also be related to geological, topographic or engineered features such as roads or dams that restrict sub-surface water flow and drainage and subsequently cause a rise in the groundwater table. Management of salinity may need to address one or several of these issues.

Why is this important to me as a farmer?

Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth. Excess salts in the root zone hinder plant roots from withdrawing water from surrounding soil. This lowers the amount of water available to the plant, regardless of the amount of water actually in the root zone.

As a result there is:

- loss of groundcover and pasture production
- salt deposits on the soil surface and associated toxicity
- increased soil erosion
- tree death
- increased salt concentrations in dams, streams and rivers leading to decline in water quality for human consumption, irrigation, livestock and aquatic biodiversity
- damage to farm infrastructure such as roads, fences and buildings
- waterlogging.

Addressing salinity on your property will:

✓ minimise runoff and improve rainfall use
✓ increase vegetation cover
✓ increase soil organic carbon.

What is best practice?

✓ Manage saline areas and salt scalds
✓ Promote plant growth and use plant species to maximise soil water use
✓ Revegetate hills, ridge tops and other recharge areas

How can you achieve this?

To achieve best practice you should:

1. identify areas at risk of salinity
2. manage saline areas and salt scalds
3. promote groundcover with perennial species, including trees.

Identify areas at risk of salinity

✓ Look for signs of salinity:
- salt scalds - bare patches with white crusts on the surface
- invasion by salt tolerant plants such as Sea Barley Grass, Buck's Horn Plantain and Couch.
- crystal clear dam water.

✓ Conduct a soil test to measure the level of Electrical Conductivity (EC) in your soil. This is a measure of salinity. Attend a LANDSCAN™ course to learn more about soil tests and their interpretation.

Indicators of salinity: salt scald surrounded by sea barley grass. *Photo: H Warren, Industry & Investment NSW*

Even though you may not observe salinity on your property, recharge on your farm may be contributing to groundwater discharge and salinity further down your local catchment

Manage saline areas and salt scalds

- ✓ Manage saline areas and salt scalds separately from the rest of the property to lower the groundwater table below the root zone and re-establish groundcover.
- ✓ Fence out saline discharge sites to control livestock access.
- ✓ Use mulch, gypsum and/or fertilisers in saline areas where appropriate to maximise plant growth.
- ✓ Use physical structures above the discharge sites to divert excess surface water away from the site, eg contour banks, dams and subsurface drains.
- ✓ Building up mounds using non-saline topsoil on top of the salt scald may help to establish pasture.

Promote groundcover with perennial species, including trees

- ✓ Maintain more than 80 percent ground-cover with deep-rooted perennial pasture species. Include an appropriate mix of shrubs and trees.
- ✓ Sow grasses, herbs, shrubs and trees that are tolerant of salt and waterlogging on discharge areas, eg Tall Fescue, Kikuyu, Puccinellia.
- ✓ Protect native vegetation and rehabilitate degraded native vegetation, particularly in high recharge areas. High recharge areas typically occur in the upper parts of a catchment on hills and ridge-tops and with shallow soils. These areas often have low land capability and relatively low agricultural value if cleared (see Figure 7.3).
- ✓ Fence-off rocky recharge areas to encourage perennial species which include a combination of pastures, woody shrubs and trees. It is important to select appropriate species for the site conditions (locally endemic native species are ideal).
- ✓ Increase soil organic carbon by adopting reduced till cultivation practices and preserving perennial pasture cover. Organic carbon not only increases soil health but also soil water holding capacity, reducing leakage to groundwater.

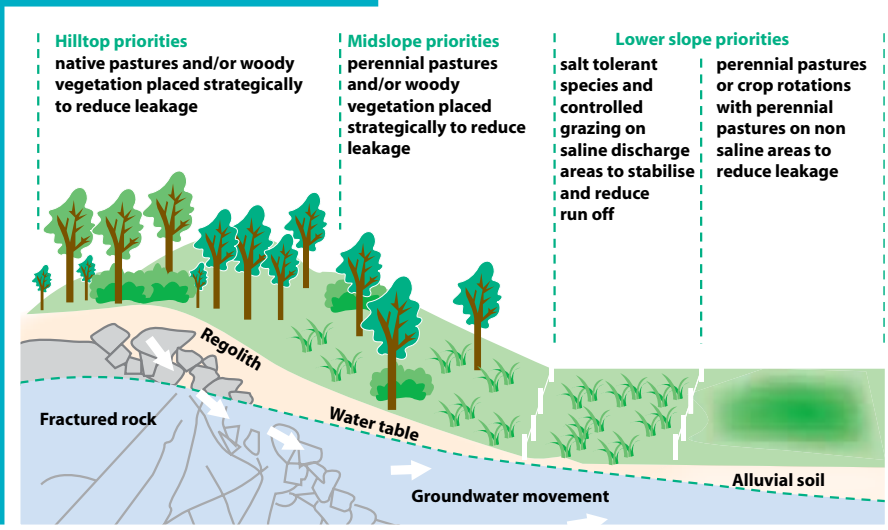

Figure 7.3: Landscape vegetation options for salinity management. Source: NSW DPI Salinity Glovebox Guide (2005)

Selected resources

Publications

Salinity Glovebox Guide. Contact your local Industry & Investment NSW office for information on how to order this publication.

NSW Department of Primary Industries Salinity Notes *How do I test water salinity?* Number 4, October 2000. Available from www.dpi.nsw.gov.au

NSW Department of Primary Industries Salinity Notes *How to Texture Soils & Test for Salinity*, Number 8, October 2000. Available from www.dpi.nsw.gov.au

Salt Magazine – The Magazine of the Cooperative Research Centre for Plant-based Management of Dryland Salinity. Available from www.crcsalinity.com to subscribe (free).

Website

More information can be found in a range of publications including the former NSW Department of Primary Industries Primefacts and the former NSW Agriculture Agfacts and Agnotes which are available through district offices or directly from the web site: www.dpi.nsw.gov.au

Course

LANDSCAN™: a course to help graziers interpret landscapes and soil tests for sustainable farm management.

8 Managing weeds in pastures

Serrated tussock *(Nassella trichotoma). Photo: B Stein, Industry & Investment NSW*

KEY THEMES

- Weeds cost landholders and communities in NSW $600 million per year
- Weeds are generally a sign of pasture decline and land degradation, not the cause
- Competition from productive perennial pastures is the most effective strategy for long term weed control

KEY ACTIONS

- Develop and implement an Integrated Weed Management Plan
- Maintain a competitive cover of desirable perennial species to restrict weed germination
- Control infestations by continuously reducing the area of land infested by weeds

Weeds are plants that are unwanted in a given situation and may be harmful, dangerous or economically and environmentally detrimental.

Weeds have traditionally been viewed as the cause of pasture decline but are now recognised as a symptom of issues relating to the interaction of management, climate and the environment. Pasture decline usually begins with a loss of desirable species, creating bare ground that is taken over by opportunistic weeds.

Good weed management should focus on early detection and intervention, controlling weed infestations using a combination of methods, and making pastures and the farm landscape resistant to weed establishment.

Why is this important to me as a farmer?

Weeds can dominate and degrade both native and introduced pastures reducing productivity, carrying capacity, biodiversity, groundcover and the property value. Once established, weeds are difficult and expensive to eradicate.

Controlling weeds improves the feed value of the pasture, increases meat and wool quality and quantity, prevents injury to stock, and lengthens the life of the pasture.

Note: There is a legal responsibility to control or eradicate noxious weeds under the *Noxious Weeds Act 1993*.

What is best practice?

- ✓ Develop and implement an Integrated Weed Management Plan
- ✓ Maintain a competitive cover of desirable perennial species to restrict weed germination
- ✓ Control infestations by continuously reducing the area of land infested by weeds

How can you achieve this?

Use an Integrated Weed Management approach with a combination of several weed control methods. Recommended activities include:

1. identify weed species
2. retain groundcover of a competitive perennial pasture
3. keep weeds out of clean areas
4. use targeted grazing pressure and rest periods
5. use herbicides strategically
6. in limited circumstances, cultivation followed by sowing a new pasture might be suitable.

KEY WORDS

- Integrated Weed Management (IWM)
- land degradation
- spray grazing
- spray topping
- tactical grazing
- weeds

Weeds are a symptom of pasture decline – not the cause! Determining the cause of pasture decline and taking action early will prevent further loss of desirable species and minimise weed invasion

At an annual cost of $600 million per year to agriculture in NSW, weeds constitute a major natural resource management issue (NSW Weed Strategy)

Serrated tussock can completely dominate degraded pastures. *Photo: L McWhirter, Industry & Investment NSW*

Identify weed species

- ✓ Learn to identify weeds at all growth stages and be familiar with their life cycles. Some weed species have a similar appearance to native plants, eg serrated tussock is sometimes confused with native poa tussock or spear grass species.
- ✓ Identify which, if any, weeds can be poisonous to stock. Contact your local Livestock Health and Pest Authority for advice.
- ✓ Attend a Paddock Plants field day to help you identify and manage common plants, including weeds. Contact your local Industry & Investment NSW office for more information.

Retain groundcover of a competitive perennial pasture

- ✓ Maintain at least 80 percent groundcover to reduce germination and establishment of weed species. This is particularly effective in reducing the germination of weed seedlings that are most susceptible to competition early in their life cycle.
- ✓ Avoid creating bare ground. Identify and address soil nutrient deficiencies or toxicities that limit productive plant growth resulting in bare ground which facilitates weed invasion. Attend a LANDSCAN™ course to help you to investigate and manage soil fertility and other soil chemical properties on your farm.

Keep weeds out of clean areas

- ✓ Early detection and control of weeds is the more cost-effective strategy.
- ✓ Identify and remove weeds before they set seed.
- ✓ Quarantine newly purchased stock, or stock returning from agistment, in a designated paddock for 21 days to reduce their weed seed burden. Monitor this paddock for new weeds and control them early.
- ✓ Watch for weeds that may have been introduced with supplementary feeding of hay or grain or by vehicles and machinery. Where infestations occur, destroy weeds before they set seed.
- ✓ Consider using small, designated areas or droughtlots to introduce supplementary feeds to limit the spread of potential weeds.
- ✓ Consider using a contained wash-down area for vehicles and machinery used in weed infested areas.

Use targeted grazing pressure and rest periods

- ✓ Apply targeted grazing pressure and periods of rest to manipulate pasture competition. Time grazing according to the life cycles of weeds and desirable species.
- ✓ Use high intensity grazing for short periods to force stock to graze weeds prior to seeding and to reduce selective grazing of desirable species. Remove stock if they are overgrazing desirable species.
- ✓ Remove stock to allow desirable species to set seed and recruit seedlings, particularly after drought conditions.
- ✓ Subdivide paddocks into manageable units to facilitate better grazing management, eg use high grazing pressure and pasture rest periods at key times (rotational grazing).
- ✓ Use animal preferences and selective grazing to target specific weeds, eg dry sheep will feed on capeweed and Paterson's curse, and goats on thistles and blackberries.
- ✓ Seek advice from a veterinarian on the risks of forced grazing of weeds to avoid incidental poisoning or other adverse effects.

Strategic use of herbicides

Herbicides are a very effective tool to control weeds. However, relying on herbicides to provide a 'quick fix' in the absence of other management inputs will not provide long term control of most weeds and could contribute to the development of herbicide resistance.

What is Integrated Weed Management?

Controlling weeds and making landscapes resistant to weed invasion requires the planned integration of control techniques, also called Integrated Weed Management (IWM). This means using a variety of control methods to target vulnerable aspects of a weed, its life cycle or its environment to achieve more effective control (eg using a combination of grazing, chemical or mechanical strategies and timing the use of these appropriately). Using a single control method will not provide long term control for all weeds in the pasture.

Example: *A landholder uses the selective herbicide flupropanate on flats to control serrated tussock, but chooses to hoe steeper areas where desirable herbicide susceptible grass species are growing. The whole paddock is then spelled to allow desirable species to thicken up and out-compete the weed. The pasture is then more vigorous for animal production, and more competitive for weed control.*

A chemical control program should aim to control weeds selectively and leave desirable pasture plants relatively unharmed and competitive.

If used inappropriately, herbicides can cause more damage than good. Many grasses, particularly valuable native species, are sensitive to herbicides, and may be lost forever if exposed to herbicides (directly or through spray-drift).

Herbicides may have a limited life before resistance develops, particularly if they are used repeatedly and as the sole method of weed control.

Broadleaf annual or short-lived weeds

(eg Paterson's curse, capeweed and thistles)

- ✓ Use a lethal dose of an appropriate herbicide to directly kill the weed. This involves spraying at the optimal time and removing stock for the specified withholding period, as per the label instruction.
- ✓ Spray grazing. This involves using a sub-lethal rate of herbicide to 'sweeten' weeds, followed by crash grazing. For winter/spring active weeds (eg thistles, capeweed, Paterson's curse), this can be anytime following the autumn break through until early spring.
  - Spray a sub-lethal rate of herbicide (MCPA or 2,4-D amine). Remember to follow herbicide label directions.
  - Withhold stock according to labelling directions then graze the wilted leaf heavily with high stocking rates (8 to 10 times the normal stocking rate).
  - Heavy stocking rates should continue until the target weed has been satisfactorily reduced, but before pasture survival is threatened.
  - Remove stock and allow the pasture to recover.
  - Spray grazing is most effective when broadleaf weeds are at the rosette stage and less than 20 centimetres in diameter.
  - Spray grazing may encourage over consumption of some plants which may have high levels of plant toxic compounds, eg Paterson's curse. Seek advice from a veterinarian when planning a spray grazing program and preferably use livestock that are not pregnant or lactating and are close to point of slaughter.
  - This method is best used when there are low levels of the weeds present and there is plenty of alternative feed available, ie sufficient perennial grass pasture.

Annual grass weeds

Annual grass weeds include barley grass, vulpia and brome grass.

Herbicides can be used to reduce the production of viable annual grass seeds, giving perennial pasture species a competitive advantage over annual grass species.

- ✓ Spray topping. This is the application of a sub-lethal dose of non-selective herbicide (typically glyphosate or paraquat) to annual grass pastures at flowering. It will reduce the formation of viable seeds without inducing a winter feed shortage.
  - Synchronise spraying with seed-head emergence of the target weed.
  - Grazing pressure in late autumn followed by rest can be used to synchronise seed head emergence prior to spray topping.
  - During a wet spring, annual grasses may be able to re-tiller and set seed after spray topping. Should this occur, integrated methods such as short-term high density grazing can be used to prevent seed-set.
  - Spray topping with non-selective herbicides can cause substantial damage to some pastures, particularly native pastures, and should be used with caution. Consult your local Agronomist for specialist advice. In new pastures it is preferable to use paraquat rather than glyphosate as the latter will significantly reduce seed-set of sub clovers.
  - Withhold livestock according to label directions.
- ✓ Mechanical topping. Slash annual grass weeds before they set seed in spring or cut for silage.

Note: Complete removal of annual grasses will often lead to less winter feed availability. Remember it's not the presence of annual species which poses a problem but dominance in pastures.

Paterson's curse *(Echium plantagineum). Photo: B Stein, Industry & Investment NSW*

There are rules under the *Pesticides Act 1999* and Quality Assurance Programs that make training and record keeping compulsory for commercial users of herbicides

Barley grass *(Hordeum leporinum). Photo: B Stein, Industry & Investment NSW*

Remember the 3 R's:

- Remove
- Replace
- Revisit

Once you have removed perennial grass weeds, remember to replace them with a competitive perennial pasture species and continually revisit paddocks to control newly emerging weeds

Spot spray serrated tussock to limit damage to non-target species.
Photo: S Taylor, ACT Parks, Conservation and Lands

Notes on using herbicides

- Always follow herbicide/pesticide label directions for the safety of you and others.
- Avoid spraying herbicides in or near streams, riparian areas or other water bodies (eg farm dams) as they can be toxic to native animals, aquatic species and domestic stock. If you must use herbicides to control weeds in riparian areas, use herbicides which have been registered for use near watercourses. Check the chemical label and Material Safety Data Sheet for more information.
- Ensure stock are kept out of sprayed areas after herbicide application and follow withholding periods as directed on the label.
- If feasible, spot spray weeds instead of boom spraying. This provides greater control and is less likely to damage useful pasture species which compete with weed seedlings.
- Herbicides may have a limited life before resistance develops, particularly if they are used repeatedly and as the only method of weed control.
- Do not spray in windy conditions or immediately before rain.
- The Pesticides Act 1999 and Quality Assurance Programs make training and record keeping compulsory for commercial users of herbicides (this applies to all pesticides). See http://www.environment.nsw.gov.au for more information and a list of accredited training providers.

Perennial grass weeds

Perennial grass weeds include serrated tussock, Chilean needle grass, African lovegrass.

The key to controlling perennial grass weeds is competition from vigorous perennial pastures, as they are difficult and expensive to control once established.

- ✓ Control perennial grass weeds before they seed.
- ✓ For small, isolated infestations, use mechanical removal (with a hoe or mattock) or spot spraying to limit damage to non-target species.
- ✓ For large infestations, boom spraying may be the only feasible option. If boom spraying, use a selective herbicide at appropriate rates to minimise damage to non-target species. If boom spraying results in the loss of non-target species re-sow a competitive perennial species.

Cultivation and re-sowing

Cultivation should only be used on land classes I – III (See Appendix 3) in cases of severe infestations and in combination with sowing a competitive perennial pasture.

Cultivation and re-sowing is effective at killing adult plants, reducing the weed seed bank in the soil, and promoting new weed germination to enable further control before sowing perennial pastures for long term weed management.

- ✓ For severely infested and/or degraded pastures, consider using a cropping phase of up to three years to reduce the level of weed infestation and seed bank in the soil before establishing a new pasture.
- ✓ Implementing a cropping phase prior to sowing can also off-set the cost of pasture establishment by providing useful fodder or returns from produce (ie grain or hay).

Selected resources

Publication

Pasture Management for Weed Control (2004) by J Burton and P Dowling. Published by NSW Department of Primary Industries

Noxious and Environmental Weed Control Handbook (3rd edition) by R Ensby and A Johnson. Published by NSW Department of Primary Industries.

Websites

For general information on weeds, see http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds and www.weeds.gov.au

For Noxious Weeds Database, see http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed

Course

Paddock Plants Field Day: a field day which teaches farmers, graziers and land managers to recognise and manage common paddock plants, including weeds.

9 Managing landscapes for biodiversity

Biodiversity in the agricultural landscape delivers useful 'ecosystem services' to farming enterprises. *Photo: B Stein, Industry & Investment NSW*

KEY THEMES

- Biodiversity provides a number of valuable 'ecosystem services' to farms
- The abundance and diversity of soil organisms are useful indicators of soil and catchment health
- Biodiversity can have benefits for both farm production and the environment

KEY ACTIONS

- Assess the biodiversity within your farm landscape and the risks facing it
- Foster and sustain a level of biodiversity that is appropriate to your farm landscape and which complements your production and environmental goals
- Improve the diversity and health of the soil ecosystem

KEY WORDS

- biodiversity
- ecosystem services
- resilience
- soil biota
- stability

Biodiversity is an abbreviation of the term 'biological diversity'. It is the variety of all life: the different plants, animals, insects, microorganisms, their genes, and the ecosystems they form. The greater the number and variety of plants, animals and other organisms on a farm, the greater its biodiversity.

The different combinations of living organisms, and the habitats they live in form part of the farm ecosystem. Each part of the farm landscape interacts with others to contribute to the overall functioning of the farm. What happens in one area can influence the productivity and/or stability of adjacent or even distant areas.

Agriculture benefits from the biodiversity of healthy ecosystems which transform natural assets, such as soil, vegetation, water, air and living organisms, into products or services, known as 'ecosystem services'. Ecosystem services are important to the productivity and sustainability of farming enterprises, and include:

- nutrient and waste recycling
- shelter for livestock
- sediment control
- flood mitigation
- water storage
- soil formation
- pollination
- pastures and native vegetation
- control of potential pests
- provision of genetic resources
- production of food and fibre
- aesthetic and cultural values.

In agriculture, managing landscapes for biodiversity is about keeping (or bringing back) a wide range of plants, animals and other organisms on your farm that contribute to its health, productivity, sustainability and value.

Why is this important to me as a farmer?

✓ Encouraging biodiversity can increase productivity by sustaining the environmental processes that help maintain soil health, perform nutrient cycling, filter and clean toxins from water, control pests and pathogens, pollinate crops and pastures, and provide shelter for livestock.

✓ Increased biodiversity provides natural checks and balances, contributing to the stability and resilience of your farm landscape. This helps to buffer your enterprise from pests and diseases as well as extremes in temperature and changes in climate, including droughts, floods and fire. For example, well managed native grasses may provide the only remaining forage and groundcover during extended drought conditions.

Remember!

Biodiversity refers to the range of organisms above AND below the ground

CSIRO have estimated that, Australia-wide, the value provided by 'ecosystems services' is $1,300 billion per year

Conserving remnant vegetation on your farm may encourage higher bird densities and predatory insect numbers, which in turn may reduce fly strike in sheep. *Photo: Industry & Investment NSW*

A woolgrower in Western Australia recorded less fly strike when sheep were grazed on a property with a significant area of remnant vegetation than when the same sheep were grazed on an adjacent property with little remnant vegetation. The site with the high level of remnant vegetation had a high bird density. Higher predatory insect numbers have also been attributed to lowering fly strike

(Land Water and Wool Native Vegetation and Biodiversity Fact Sheet)

Revegetation of ecologically sensitive areas. *Photo: G Johnson, Industry & Investment NSW*

- ✓ A diverse and healthy ecosystem, above and below the soil surface, can reduce the amount of external inputs required to maintain production, eg herbicides and some fertilisers.
- ✓ You can use the biodiversity on your farm to supply emerging markets which are demanding environmentally and socially responsible agricultural production, eg eco-labelled wool and beef.
- ✓ Healthy vegetated riparian land provides habitat for insect eating birds and insect parasites. Losing even a small number of birds can significantly increase the number of below-ground pasture grubs that survive and become adults.

What is best practice?

- ✓ Assess the biodiversity in your farm landscape and the risks facing it
- ✓ Foster and sustain a level of biodiversity that is appropriate to your farm landscape and which complements your production and environmental goals
- ✓ Improve the diversity and health of the soil ecosystem

How can you achieve this?

There are no absolute prescriptions for increasing biodiversity on a farm. The most sensible approach is to understand the variability in your farm landscape and manage different areas appropriately. Some areas will have high productivity and possibly low biodiversity. In other parts of the farm, maintaining native pastures or improving the condition of remnant vegetation may be the most appropriate action to improve biodiversity.

To achieve best practice you should:

1. identify the biodiversity features of your farm landscape
2. integrate biodiversity into farm management planning
3. conserve and manage existing remnant vegetation
4. improve the diversity and health of soil organisms
5. manage native pastures
6. develop habitat corridors.

What do we mean by resilience and stability?

The **resilience** of a system describes its ability to persist, to absorb change and disturbance and still be recognisably the same farm landscape.

The **stability** of a farming system is its ability to return to production after a temporary disturbance - the more rapidly it returns the more stable it is.

Identify the biodiversity features of your farm landscape

The first step to improving the biodiversity of your farm is to be aware of what you already have. This includes knowing the flora and fauna present together with the physical characteristics of your farm (eg soil depth, slope, fertility, aspect and hydrology).

- ✓ Use a physical plan of the farm (farm map or aerial photo) to get an overall picture. Use the aerial photo to identify:
  - existing land uses
  - land capability
  - natural resources, including remnant vegetation
  - ecologically sensitive areas, eg riparian areas
  - physical features and farm improvements including sheds, fences, windbreaks, paddock trees, laneways, farm water supplies, erosion control work
  - problems such as weeds, erosion, salinity or tree dieback.

Integrate biodiversity into farm management planning

- ✓ Focus your farm inputs (eg fertiliser inputs, improved pastures) to areas with the highest potential productivity. Marginal areas, eg class VI to VII land (see Appendix 3), may be best managed by retiring them from active grazing.

- ✓ Fence your property according to land class, soil type and aspect, or subdivide larger paddocks to facilitate improved management of high production areas and to protect ecologically sensitive areas of your property from overgrazing, eg riparian areas, areas of high conservation value, or areas prone to degradation.
- ✓ Aim to integrate biodiversity conservation with other farm objectives to provide as many benefits as possible. For example, tree plantings, or fencing to facilitate regeneration may provide multiple benefits such as shelter and shade for livestock, windbreaks, habitat for native species, prevention of salinity and soil erosion, livestock fodder, and improved aesthetic values.
- ✓ To determine the most appropriate locations for revegetation, consider landform, soil and climatic conditions across the farm, as well as how trees and/or pastures will fit into existing farm operations.
- ✓ Attend a LANDSCAN™ course to learn how to achieve sustainable productivity and improved environmental outcomes by matching production and management options to the potential of the landscape.

Conserve and manage existing remnant vegetation

- ✓ Aim to protect and enhance the existing native vegetation on your property as the first step in implementing your farm biodiversity strategy.
- ✓ Fence out remnant native vegetation to control livestock access.
- ✓ Reduce stock numbers when native grasses, forbs and shrubs are flowering and seeding. This is usually during spring and early summer.
- ✓ To facilitate the regeneration of trees, exclude livestock until young trees are out of reach of livestock (this may take 3-5 years or more).
- ✓ Plant local native trees and shrubs to link existing remnant vegetation. This not only provides corridors for wildlife movement, but if strategically placed will improve shelter for livestock and conserve soil moisture in pastures (see Figure 9.1).
- ✓ Use indigenous tree species and local provenance seed stock for revegetation initiatives to ensure seedling survival.
- ✓ Consider the following actions to preserve and enhance paddock trees for livestock shelter and shade:
  - fence the trees or clumps of trees, so that an area twice the size of their canopies is protected
  - revegetate this area with locally native shrubs or grasses. Allow the trees to regenerate from seed fall
  - if planting paddock trees for shelter, establish the trees as far away from watercourses as possible to encourage livestock to camp away from sensitive riparian areas
  - replant understorey species in areas of native vegetation that have been subjected to long term grazing.

Improve the diversity and health of soil organisms

A largely unrecognised but vitally important element of farm biodiversity exists in the soil. Healthy soil can be the most biodiverse part of the farm!

Soil biodiversity consists largely of microscopic organisms, such as bacteria and fungi, as well as earthworms and insects. These are collectively known as 'soil biota'. The abundance and diversity of soil biota are useful indicators of soil and catchment health.

There is often a close relationship between agriculture and soil biota as undisturbed soils often have a greater variety of soil biota, whereas frequently cultivated or disturbed soils contain less diversity. Soil organisms play a key role in recycling nutrients, benefiting soil fertility, structure and water holding capacity.

The following strategies encourage soil biological activity:

- ✓ Establish or maintain perennial pastures to provide habitat and an adequate supply of organic matter.
- ✓ Avoid soil cultivation, which depletes organic matter by accelerating decomposition, dries out the topsoil, and destroys fungal hyphae mats (strands of fungi that bind soil together) and macrofauna, such as earthworms.

Fence-off remnant vegetation from livestock to enable recovery and regeneration. *Photo: J Reynolds, Hawkesbury Nepean Catchment Management Authority*

Soil organisms are responsible for recycling up to 75% of the available nitrogen and 65% of available phosphorus in the soil. *Photo: S Orgill, Industry & Investment NSW*

Once lost, native pastures are particularly difficult and expensive to re-establish. Indiscriminate use of herbicides (e.g. boom spraying) may permanently destroy native pasture species

- ✓ Reduce compaction: Limit traffic from machinery and over-stocking of paddocks. Compaction reduces pore spaces in the soil causing drainage and aeration problems.
- ✓ Consider liming acidic soils to provide a soil pH_{CaCl} (more than 5.0) that is favourable for soil microbes and earthworms.
- ✓ Reduce the extent of waterlogging and salinity by fencing and protecting native trees and shrubs in recharge and discharge areas and through revegetation programs where appropriate.

Manage native pastures

Native grasses are well adapted to local climates and soil types and can play a vital role in sustainable perennial pastures. Good soil and grazing management practices can improve the productivity of these pastures while maintaining a high level of biodiversity.

- ✓ Learn to identify the native species present on your farm and monitor the effects of management changes. Attend a Paddock Plants field day to help you to identify native grasses and other plants on your property.
- ✓ Some native species will thrive under increased fertility and controlled grazing, eg *Microlaena* (Weeping Grass) and *Austrodanthonia* (Wallaby Grass), while others will decline, eg *Themeda australis* (Kangaroo Grass). Sustainable management must be based on the needs of the dominant perennial native grass species to ensure their survival.
- ✓ Only apply fertilisers to native pastures which contain a legume and are dominated by species which will respond to increased levels of fertility, eg *Microlaena*, Spear Grass, Red Grass and Wallaby Grass.
- ✓ Most native grass species are very robust, drought hardy and tolerate grazing. Graze to ensure that clover content is less than 30 percent so it does not smother native grasses in spring and deplete soil moisture for summer growing species.
- ✓ Retain habitat structure (native tussocks, rocks, logs, etc.) for biodiversity.
- ✓ Some native grasses, eg *Microlaena* and Wallaby Grass, are extremely sensitive to commonly used perennial grass weed herbicides, ie Flupropanate. Avoid boom spraying native pastures if possible, and promote pasture growth to minimise the germination of weed species. Contact your local Agronomist for advice.
- ✓ Ask your local Industry & Investment NSW office for a copy of *Managing Native Pastures for Agriculture and Conservation*.

Notes on clearing or managing native vegetation, including native grasslands

Clearing native vegetation is regulated under several pieces of local government, State and Commonwealth legislation. In most instances clearing native vegetation, including native grasslands, on rural land is covered in NSW by the Native Vegetation Act 2003. Clearing proposals must be assessed and can only proceed if they improve or maintain environmental values.

Some clearing is allowed under the legislation for regrowth and Routine Agricultural Management Activities. For more information visit www.nativevegetation.nsw.gov.au or contact your nearest catchment management authority office.

Top left: Kangaroo Grass will decline under increased soil fertility. *Photo: H Rose, Industry & Investment NSW*

Bottom left: Wallaby grass *(Austrodanthonia spp)* is extremely sensitive to most selective perennial grass weed herbicides. *Photo: B Stein, Industry & Investment NSW*

Figure 9.1: Creating wildlife corridors to link three isolated areas of habitat. Source: H Ward, Hawkesbury Nepean Catchment Management Authority

Develop habitat corridors

The aerial photograph in Figure 9.1 shows three separated areas of remnant vegetation. These are significant wildlife refuges. The farmer could link these areas, providing windbreaks and wildlife corridors between the separated 'islands' of remnant vegetation. By simply working with the farm landscape and using the lessons from LANDSCAN™, the farmer will benefit local wildlife, enhance biodiversity and improve farm health and production.

Selected resources

Publications

Managing native pastures for agriculture and conservation (2004) by CM Langford, PC Simpson, DL Garden, DA Eddy, MJ Keys, R Rehwinkel and WH Johnston. Published by NSW Department of Primary Industries.

Biodiversity in the paddock – a land managers guide (2008) by J Dorrough, J Stol and S McIntyre. Published by Future Farm industries Cooperative Research Centre. Available from www.csiro.au and www.futurefarmcrc.com.au

Wildlife on Farms: How to Conserve Native Animals (2003) by D Lindenmayer, A Claridge, D Hazell, D Michael, M Crane, C MacGregor and R Cunningham. CSIRO Publishing.

Websites

Landholders who wish to protect and enhance remnant vegetation, riparian areas or wetlands should contact their local catchment management authority for possible funding assistance.

Stewardship payments may be available for Box-Gum Woodlands and Endangered Ecological Communities. Speak to your local catchment management authority for more details.

- for landholders in the Hawkesbury Nepean Catchment visit: www.hn.cma.nsw.gov.au
- for landholders in the Southern Rivers Catchment visit: www.southern.cma.nsw.gov.au

Drought depletes the farms natural capital assets including topsoil and perennial pastures. *Photo: Industry & Investment NSW*

KEY WORDS

- containment paddock
- drought
- stocking rate
- drought plan
- droughtlot

10 Managing the impacts of drought on pastures

KEY THEMES

- Droughts affect not only the farm business, but also the farms valuable natural assets (eg soils, pastures, groundcover)
- Planning BEFORE drought will reduce the impact on your enterprise and degradation of your soils and pastures
- Native pastures can become permanently degraded if not protected from overgrazing

KEY ACTIONS

- Plan for drought
- Reduce stocking rates for pasture persistence and stock health
- Protect your pastures and soil by confining livestock to droughtlots

Seasonal feed shortages occur for short lengths of time, due to cold or dry conditions in most years. A succession of seasonal feed shortages is a drought.

Droughts are unpredictable and it is important to plan to cope with both short and long term feed shortages. Planning should include taking advantage of good seasons and/or prices, and minimising costs associated with damage to soils and pastures in poor seasons.

Why is this important to me as a farmer?

- ✓ In addition to the loss of income and increased supplementary feed expenses, soil degradation and low pasture productivity during and after drought are significant costs for livestock producers.
- ✓ One of the major consequences of drought is the degradation of pastures due to overgrazing. This results in a loss of productive perennial pastures and reduced soil fertility due to erosion.
- ✓ Native perennial pastures are very difficult to re-establish and introduced pastures are costly to sow or re-establish.
- ✓ Steep and non-trafficable land classes (see Appendix 3) are very difficult to repair if degraded during droughts.

Good planning and using best management practices during drought will ensure that farm enterprises resume production as soon as possible after drought and minimise the costs associated with repairing soils and pastures.

What is best practice?

- ✓ Have a Drought Management Plan in place before a drought
- ✓ Reduce stock numbers to preserve your farm's natural assets
- ✓ Use droughtlots to protect pasture and soil

How can you achieve this?

To achieve best practice you should:

1. plan for drought
2. reduce stocking rates for pasture persistence and stock health
3. protect your pastures and soil by confining livestock to droughtlots

Planning for drought

- ✓ Draw up a drought management plan **before** a drought to protect your farm's physical (soil, pastures and water) and financial resources.

- ✓ Use appropriate tools such as Grazfeed™ and StockPlan®. Grazfeed™ is a CSIRO decision support system that helps predict animal performance from pastures and supplements or full hand feeding. StockPlan® is a suite of computer decision support tools to help cattle and sheep producers explore cost management options in a drought and examine recovery strategies.
- ✓ Attend a one-day StockPlan® workshop to help forward planning before and during drought. Contact your local Industry & Investment NSW office for more information.
- ✓ Plan and plant shelter belts to protect soil in exposed paddocks from wind erosion and to promote the retention of limited soil moisture.
- ✓ Consider using off-farm investments in good years to spread risks, eg Farm Management Deposits.
- ✓ Identify critical dates, pasture benchmarks and trigger points for destocking and implementing management actions (eg supplementary feeding). A PROGRAZE™ course can help you determine benchmarks.

Reduce stocking rates for pasture persistence and stock health

- ✓ As the drought progresses, sell stock classes in the following order: finished young stock, then non-breeding stock, replacement stock, aged stock and older breeders, until you are left with a core of young breeding females.
- ✓ Consider agisting your livestock in districts which not have been affected by drought.
- ✓ Your enterprise mix should be flexible to include stock classes which can be readily sold in drought conditions, eg merino wethers or trader steers.
- ✓ Monitor animal health and welfare and take appropriate action to prevent stress or suffering.
- ✓ Continue to confine animals after the break in the drought to allow pasture to recover and to prevent animal health problems.

Protect your pastures and soil

- ✓ Protect perennial pastures, giving priority to native pastures on steep and/or shallow soil and non-arable areas where re-sowing is not viable. Remember that native pastures are more difficult and expensive to re-establish than introduced pastures. As the drought progresses, these areas may need to be de-stocked to prevent overgrazing and irreversible degradation.
- ✓ Implement appropriate grazing management to protect fragile, new or valuable pastures. An appropriate grazing strategy would include maintenance of adequate groundcover.
- ✓ Minimise grazing pressure and environmental damage by confining your livestock to a small portion of your property which can be managed under more intensive conditions, eg confine livestock to containment paddocks, also known as droughtlots.
- ✓ Using droughtlots is an important strategy to better manage stock during droughts and to minimise degradation of soil and pasture resources. Locking stock up in a small area will result in a faster recovery of the un-stocked areas of your property once the drought breaks as pastures return to productivity more quickly.
- ✓ After the drought breaks:
  - be vigilant for weeds that may have been introduced to your property through purchased feed
  - re-sow droughtlots with perennial pastures
  - empty or desludge settling/holding ponds installed to capture nutrient and sediment runoff from droughtlots.

Do not base management decisions (eg destocking or supplementary feeding) only on stock condition. Base decisions on a combination of an assessment of pasture quantity and quality and stock condition

Resist the temptation to return animals to paddocks too soon after the drought breaks. Instead, continue to provide supplementary feeding after the break in drought to allow pastures to recover. *Photo: D Chalker, Industry & Investment NSW*

What is a droughtlot?

An area or paddock used to confine livestock during droughts to minimise pasture and soil degredation on the rest of the farm.

What to aim for in a droughtlot

- Soils that are least vulnerable to erosion and compaction. Avoid sandy, gravel soils or sodic soils.
- A site at least 500 metres from a watercourse, or the paddock at the furthest distance from a watercourse to minimise potential contamination.
- Relatively flat land to prevent excessive runoff and erosion. A gentle slope is desirable, 3-4 percent, to help with drainage.
- Settling or holding ponds to trap sediments and nutrients if excessive runoff is likely.
- Installed contour banks above and below the droughtlot to divert water running on and off the site.
- Sheltered from wind.
- Access to good quality water in troughs.
- Good all weather access for feed-out vehicles and to stock handling facilities.
- Arable land to ensure the paddock can be re-sown after drought.

Figure 10.1: Selection of this well drained arable paddock, good shelter and supplementary feeding indicates good drought management. *Photo: Industry & Investment NSW*

Selected resources

Publications

Managing drought (2006). Sixth Edition by BJ Mackay and EMK Joshua. Published by NSW Department of Primary Industries

Managing sheep in droughtlots – a best practice guide (2006). Published by Australian Wool Innovation. Available from: http://www.woolinnovation.com.au

NSW Department of Primary Industries Primefact 554 (2007) *Confinement feeding of cattle in drought: protecting the environment.* Available from www.dpi.nsw.gov.au

NSW Department of Primary Industries Primefact 325 (2007) *Pasture sustainability and management in drought*. Available from www.dpi.nsw.gov.au

NSW Department of Primary Industries Primefact 327 (2007) *Animal welfare in drought*. Available from www.dpi.nsw.gov.au

NSW Department of Primary Industries Primefact 274 (2006) *Checklist for good beef cattle health and management in drought.* Available from www.dpi.nsw.gov.au

Course

StockPlan®: A course for graziers and agribusiness advisors interested in developing their drought management skills. Contact your local Industry & Investment NSW office for more information.

11 Rejuvenating perennial pastures

Perennial pastures are the foundation of productive and sustainable grazing enterprises in the Southern Highlands and Southern Tablelands of NSW. *Photo: S Orgill, Industry & Investment NSW*

KEY THEMES

- Perennial pastures are the cornerstone of profitable grazing enterprises and sustainable land management
- The perennial component of many pastures is low
- To increase perennial composition of degraded pastures, change management or pastures will continue to degrade and require re-sowing

KEY ACTIONS

- Assess the composition of your pastures
- Adopt management options appropriate to the composition of your pastures
- Use combinations of strategic grazing and/or herbicides, fertilisers or non-destructive over-sowing to increase perennials

KEY WORDS

- direct drilling
- legumes
- non-destructive oversowing
- pasture establishment
- pasture rejuvenation
- perennial pastures
- tactical grazing management

Perennial pastures are the foundation of productive and sustainable grazing systems. If degraded there are various options to rejuvenate perennial pastures, however, they need to be established successfully and monitored actively if they are to remain productive over the long term.

Why is this important to me as a farmer?

Perennial pastures are more sustainable and productive than annual pastures because of their deeper root system and year-round groundcover. The deep and permanent root system allows them to:

- ✓ produce more feed throughout the year
- ✓ potential to convert "out of season" rainfall into quality feed
- ✓ produce more green leaf in summer
- ✓ reduce the need for costly supplementary feeding
- ✓ provide year-round groundcover
- ✓ reduce the risk of soil erosion
- ✓ access and use more water, reducing the threat of rising water tables and salinity
- ✓ reduce nitrate leaching which will slow soil acidification
- ✓ recycle nutrients leached past the shallower root zone of annual pastures
- ✓ resist weed invasion.

The perennial grass and legume content of many pastures has become depleted, and is often less than 25 percent. This may severely reduce the productivity of grazing enterprises and can contribute to increased weed invasion, erosion, salinity, acidity and a decline in water quality.

What is best practice?

- ✓ Increase the perennial grass component of your pasture to more than 50 percent
- ✓ Maintain a legume (eg clover) component of 20-30 percent to provide highly digestible, high protein stock feed and to provide nitrogen to perennial grasses
- ✓ Minimise the amount of annual grasses and weeds

How do I achieve this?

To achieve best practice you should:

1. assess the composition of your pastures
2. adopt appropriate management options based on the composition of your pasture
3. use combinations of strategic grazing, herbicides, fertilisers and non-destructive oversowing to increase perennials
4. sow a new pasture.

Attend Paddock Plants field days to learn how to identify annual grass species such as barley grass *(Hordeum leporinum). Photo: B Stein, Industry & Investment NSW*

Assess the composition of your pastures

- ✓ Recognise and identify the important grasses, legumes and weeds in your paddocks. Attend a Paddock Plants field day to improve your pasture identification skills.
- ✓ Assess the botanical composition of your paddocks, ie the relative percentages of perennial grasses (native and sown perennial grasses), legumes, annual grasses, weeds, litter and bare ground. This is best done in early winter using the methods in Appendix 4 and recording sheet in Appendix 5
- ✓ Your assessment results will guide your choice of management options/tactics for pasture improvement which is described in Table 11.1.

Adopt appropriate management options based on the composition of your pasture

Consider the causes of your current pasture condition.

To improve degraded pastures, it is important to understand why perennial grasses and legumes became depleted in the first place. Pasture degradation can be caused by drought, overgrazing, inappropriate choice of sown species, nutrient deficiencies, adverse soil chemical properties or combinations of these factors.

- ✓ Use appropriate tools to diagnose the causes of pasture degradation:
  - Soil testing is the only way to determine if deficiencies of soil nutrients or adverse soil chemical properties are limiting perennial grass vigour. Conduct a soil test through an accredited soil testing laboratory before starting a lengthy pasture rejuvenation program or a costly pasture sowing program. See Section 3 for more information on assessing and managing soil fertility.
  - Assess your stocking rate and grazing management. Is this having an impact on the persistence of your target species? If desirable pasture species are able to persist in un-grazed or infrequently grazed areas eg tree lots, roadsides etc, then these species should also persist under appropriate grazing management.

Choose management tactics/options based on the current composition of your pasture.

Use the information in Table 11.1 to help you choose pasture management options. On most farms there will be a range of the scenarios described. You should focus on priority paddocks without targeting the whole property at once. You may need to consider temporarily de-stocking your degraded paddocks to facilitate recovery or using droughtlots as described in Section 10.

Roadsides and tree lots can be useful sites to compare the composition of grazed and ungrazed pastures. *Photo: Industry & Investment NSW*

Understanding the composition of your pasture is vital to managing your pasture. *Photo: Industry & Investment NSW*

White clover *(Trifolium repens). Photo: B Stein, Industry & Investment NSW*

What is a legume and why is it important to pasture health and animal production?

Legumes convert nitrogen from the air to a form that plants can use. Legumes 'fix' nitrogen through a relationship with special bacteria, called rhizobia, which live in nodules attached to the legume's roots. The most frequently grown legumes are clovers (eg White clover and Subterranean (Sub) clover) and medics. Legumes are more digestible and have higher protein than grasses, significantly increasing the nutritional value of the pasture.

Use combinations of strategic grazing, herbicides, fertilisers and non-destructive oversowing to increase perennials

Grazing management to manipulate pasture composition

The key to rejuvenating degraded pastures is to rest them at appropriate times. The aim is to reduce or remove grazing pressure when the perennial species could be damaged and apply grazing pressure when the least desirable species (such as annual grasses and weeds) will be most adversely affected.

- ✓ When paddocks are dominated by annual grasses (eg Barley Grass, Vulpia) graze heavily in early to mid spring (before seed head emergence) to reduce seed set and plant vigour.
- ✓ When paddocks are dominated by broadleaf weeds (eg thistles, Capeweed, Paterson's Curse) spray graze targeted paddocks or areas to reduce winter/spring active weeds. See Section 8 for details on spray grazing.
- ✓ De-stock the target paddock from mid to late spring to allow desirable perennials to recover, set seed and recruit. Leave un-grazed until perennial grass seeds have matured and begun to drop.
- ✓ Paddocks containing summer active native perennials (eg Kangaroo Grass, Red Grass) require summer rainfall to set seed. De-stock these paddocks following summer rain if you want to facilitate seeding (December to February).

A spring/summer spell will allow desirable perennial species to:

- set seed
- increase basal plant diameter
- build up root reserves and promote plant recovery from grazing

Assessment Rating*	Management Tactics/Options	Cost#
High/Good • Perennial grass composition >50% • Legumes = 20-30% • Weeds and annual grasses <20%	Well done. Your current management is achieving a productive and sustainable pasture. Continue to monitor your pasture indicators.	Nil/Low
Medium/Moderate • Perennial grass composition: 25-50% • Legumes = 5-15% • Weeds and annual grasses >20%	You need to take action to prevent further degradation of your pasture. Try one or more of the following: ✓ Test soil to investigate soil chemistry or nutrient deficiencies and address them ✓ Change grazing management from continuous to a rotational system and rest pastures to allow seeding and recruitment of desirable perennials. Attend a PROGRAZE™ course to learn more about pasture assessment and grazing strategies ✓ Manage weeds and annual grasses (either use selective herbicides and/or tactical grazing to target annual grasses and weeds, or use non-selective herbicides when useful perennial species are dormant and will not be affected) ✓ Non-destructive oversowing – either broadcast or direct drill into your degraded pasture to increase the perennial grass and legume component, or to add a new species to your pasture mix (eg ryegrass).	Medium
Low/Poor • Perennial grass composition <25% • Legumes <5% • Weeds and annual grasses >50%	Your pasture is highly degraded and requires urgent attention ✓ Use a combination of the above options but note that this may take many years to improve your pasture species composition and requires some useful species to still be present ✓ It may be necessary to sow a new pasture. This may require careful economic analysis.** Seek advice from your local agronomist.	High

Table 11.1: Management options for introduced perennial pastures

* The assessment rating assumes more than 80 percent groundcover
\# relative to the other management tactics provided
** Refer also to Managing Native Pastures for Agriculture and Conservation, Industry & Investment NSW
Note: the ideal time to perform a pasture assessment is late winter or early spring when pastures are short and there has been the maximum possible germination and establishment of both desirable pasture and weed species.

In the Tablelands, pasture availability in late winter/spring is often plentiful in a normal season when available feed is made up of a mixture of perennial and annual grass and legume species. However, feed in dry summer and early autumn periods after annual grasses and legumes have dried off consists primarily of the remaining perennial grass species. If stocking rates remain the same, the effective stocking pressure on the remaining perennial grass species can be ten fold (see Figure 11.1).

- ✓ Resume grazing the target paddock after perennial grass seeds have matured (mid to late summer), then:
  - graze heavily to reduce trash and to trample grass seeds into the soil, eg in late February or early March
  - once most trash has been removed, rotationally graze the target paddock to reduce pressure on perennial species especially when under stress from lack of moisture during the dry summer/autumn period. This is particularly important as the grazing pressure on perennial species is greater during summer when many annual species are absent from the paddock (see Figure 11.1).
- ✓ Continue to rotationally graze the target paddock through the autumn/winter period.
- ✓ If you observe germination of desirable perennial grasses after the autumn break, remove livestock to allow newly germinating plants to establish and develop until they won't be pulled out by grazing.
- ✓ Attend a PROGRAZE™ course to learn about developing grazing systems appropriate to your pastures and enterprise. PROGRAZE™ will provide you with the skills to manage your pasture composition by using grazing animals as part of your suite of pasture management tools.

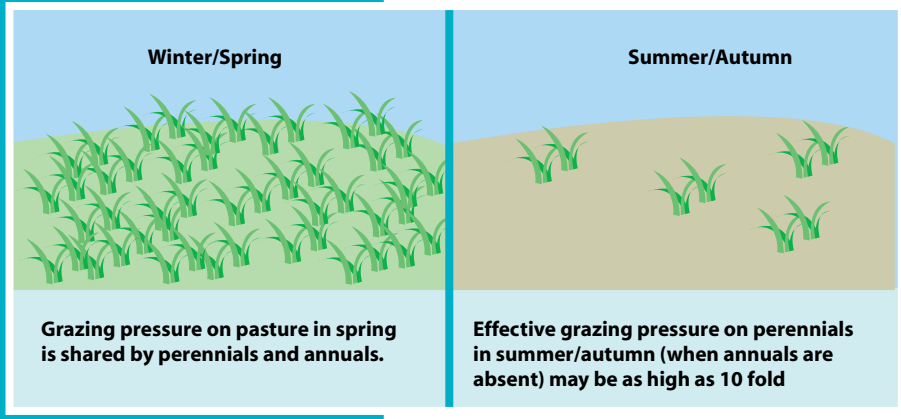

Figure 11.1: A representation of effective grazing pressure on perennial pasture over different seasons. Grazing pressure on perennial species is greater in the summer/autumn period

Non-destructive oversowing into perennial pastures

It is possible, in some circumstances, to add vigorous perennial pasture species (such as ryegrass) and legumes (clovers) to an existing pasture by broadcasting seeds or direct drilling, without having to kill the existing useful pasture plants. The aim is to thicken up the existing perennial pasture, or to add a legume or new pasture variety to the pasture mix. Non-destructive oversowing is a viable option only when competition from annual grasses and existing perennials is minimised. It is most effective in pastures with less than 30-50 percent groundcover.

- ✓ Legumes, eg sub-clover, can be oversown successfully by broadcasting seeds or by direct drilling in autumn. You should graze heavily in late summer/early autumn to remove trash before sowing using these methods.
- ✓ Direct drilling is recommended for perennial grass as broadcasting seed is less successful.
- ✓ Before direct drilling into degraded pastures, you must apply the key principles of pasture establishment:
  - Reduce competition from annual grasses, weeds and pests
  - Sow when adequate moisture is available to promote germination and persistence
  - Place seeds accurately, ie pasture seeds must not be sown too deep (only cover by 2-5 millimetres of loose soil).
  - Consider the information in **Table 11.2: Tactics for non-destructive oversowing.**
  - Consult your local agronomist to discuss options for non-destructive oversowing and appropriate rates of herbicides.

What is direct drilling?

Direct drilling is a method of sowing pasture by using specialised machinery to `directly drill' seeds into the ground instead of intense cultivation.

Direct drilling is the recommended method of sowing pastures, either into existing degraded pastures (non-destructive direct drilling) or when re-sowing paddocks. Direct drilling is as reliable and effective as sowing into ploughed ground and has a number of advantages over conventional sowings:

- more precise placement of seed
- strongly rooted seedlings
- efficient use of fertiliser
- reduced soil erosion
- use of semi-arable land
- minimum loss of grazing
- improved soil moisture by reducing moisture loss when preparing soil
- reduced run off and evaporation
- reduced labour and lower machinery investment
- trafficability both before and after sowing
- reduced weed competition.

Direct drill in operation. *Photo: D Chalker, Industry & Investment NSW*

Minimal soil disturbance from direct drilling. *Photo: D Chalker, Industry & Investment NSW*

Season	Tactic
Spring	✓ Spray top the target paddock with light rates of glyphosate or paraquat as annual grasses are coming into seed (ie at the flowering or 'milky dough' stage, before seeds mature). Light rates prevent seeding but do not kill the plants
Summer	✓ Graze hard at the end of summer to reduce litter
Autumn	✓ Kill annual grasses after they have germinated using a contact herbicide such as paraquat ✓ Use a selective broad-leaf herbicide to kill Paterson's curse, capeweed or thistles before direct drilling perennial pasture species ✓ Wait 7-10 days or after a shower of rain, then direct drill winter active perennial species, eg perennial ryegrass, cocksfoot, phalaris
Winter	✓ For summer active (C4) plants/pastures (eg kikuyu, paspalum, red grass) a non-selective herbicide (eg glyphosate) can be used to kill annual grasses in winter when the summer active pastures are dormant/frosted off (and will not be affected by the herbicide). This is not appropriate for temperate/C3 pastures (eg cocksfoot, phalaris, fescue, ryegrass)

Table 11.2: Tactics for non-destructive oversowing

Sowing pastures

Degraded pastures require attention, particularly if they are eroding or have high weed infestations. Sowing perennial pastures provides an opportunity to repair degraded paddocks or change an annual grass dominated paddock to perennial species to improve productivity, groundcover and pasture health. However, sowing perennial pastures should be regarded as an investment and careful thought should be given to determine if it is really necessary.

Consider the following:

- What pasture type is best suited to your soil and topography?
- Are there any impediments which will restrict growth and the persistence of introduced species?
- Rather than re-sowing, can the existing pasture be improved or rejuvenated by tactical grazing and/or using selective herbicides, fertilisers, etc.?
- Will the new pasture meet the livestock enterprise feed requirements and / or environmental goals?
- What will be the return on the investment?

The average cost of sowing a perennial pasture takes up to 12-15 years to recover for most grazing enterprises. Re-sowing is only recommended when cheaper alternatives such as strategic grazing management or non-destructive oversowing are not practical or feasible

Note: *The Native Vegetation Act* 2003 regulates clearing of native vegetation. This includes any type of activity that kills native groundcover.

Contact your local catchment management authority for more information

To establish summer active (C4) species: soil temperatures need to be above 18°C to facilitate germination. Autumn / winter sowings for these species are therefore not suitable.

For more information on sowing summer active (C4) pasture species ask your local Industry & Investment NSW office for a copy of Primefact 160: Pasture and winter forage crop sowing guide for Hawkesbury-Nepean, Hunter and Manning valleys or download it from www.dpi.nsw.gov.au

Pasture establishment in temperate pastures

- ✓ **Step 1**. Spray fallow using a non-selective herbicide in spring the year before sowing to kill annual grasses before they set seed (early October to early November). Add a miticide to the herbicide to simultaneously control earthmites. Note: more than one year weed control may be required.
- ✓ **Step 2**. Keep the paddock well grazed through summer and autumn or use a herbicide to control summer weeds.
- ✓ **Step 3**. Wait for a good autumn break rainfall (50-100 mm) and allow time for annual species to germinate. Once the annuals have germinated, spray again with a non-selective herbicide (eg glyphosate) and insecticide.
- ✓ **Step 4**. Wait for another rainfall event or wait 7-10 days and direct drill your pasture species, ensuring that small pasture seeds (eg cocksfoot and white clover) are not sown too deeply (only cover by 2-5 mm of loose soil). Consult your agronomist about sowing depths for your selected pasture species.
- ✓ **Step 5**. After sowing, check your paddock regularly for weeds and pests and seek advice from your agronomist if these issues arise.
- ✓ **Step 6**. Avoid grazing until the newly sown pasture has set seed in the first year.
- ✓ **Step 7**. Graze the pasture in late summer, leaving at least 1500 kg DM/ha and then lock it up through autumn.
- ✓ **Step 8**. Commence rotational grazing in winter.

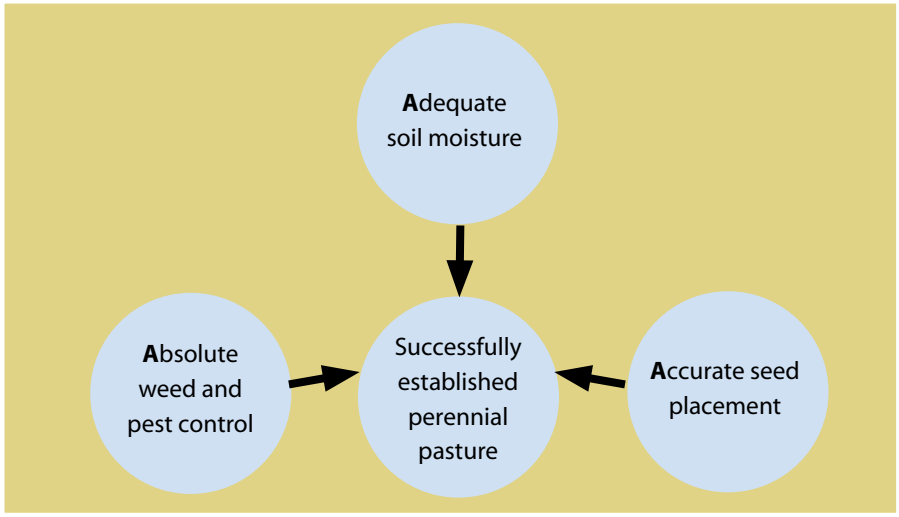

Figure 11.2: The 3 A's of successful pasture establishment

Successful perennial pasture establishment and continued persistence will depend on careful planning before sowing and appropriate grazing management after sowing to promote growth and vigour (see Temperate Pasture Establishment Checklist in Appendix 6). Start planning and preparation 1-2 years before sowing a pasture to ensure weeds and pests are properly controlled and to address soil acidity and fertility issues if necessary. Most perennial pasture species have weak, slow growing seedlings that are extremely vulnerable to weed competition and insect attack in the seedling stage. The quality and persistence of your new pasture will reflect the time and preparation devoted to establishment. Contacting your local Industry & Investment NSW agronomist to discuss planning, preparation and species selection is strongly recommended.

To achieve successful pasture establishment, three critical factors are required (the 3 A's). See Figure 11.2.

Sowing time is far less important than these three critical factors. The example provides guidelines for pasture establishment in the Tablelands of NSW to illustrate the principles associated with sowing pastures successfully.

Selected resources

Publications

NSW Department of Primary Industries Primefact 160 (2007) *Pasture and winter forage crop sowing guide - Hawkesbury-Nepean, Hunter and Manning valleys.* Available from www.dpi.nsw.gov.au

NSW Department of Primary Industries Primefact 906 (2009) *Rejuvinating perennial pastures.* Available from www.dpi.nsw.gov.au

Course

Pasture Rejuvenation Field Day: a field day designed to provide landholders with information and techniques to assess pasture composition and health and to choose appropriate strategies for rejuvenating degraded pastures. The field day advocates a hierarchy of rejuvenation techniques, with a focus on non-destructive pasture rejuvenation methods. Contact your local Industry & Investment NSW office for more information.

Appendix 1

Pasture measurements

Photos: C Langford, Industry & Investment NSW

Pasture quantity

Pasture quantity is influenced by the height and density of the pasture. Pasture quantity is usually expressed in kilograms of dry matter per hectare (kg DM/ha). It is measured by the amount of material that can be cut from a quadrat (typically a 50 by 50 centimetre square) at ground level and then dried, weighed and converted to kilograms of dry matter per hectare. It is always expressed on a dry matter basis and can be either 'green' or 'total'.

Dry Matter (DM) is the amount of feed remaining after water has been removed. As the water content of feeds can vary considerably, all analyses are expressed on a dry matter basis.

Total Dry Matter is the dried weight of all plant material in a paddock. It includes both the green and dead components, including plant litter.

Green Dry Matter is the dried weight of only the green, living parts of the plants in the paddock. It provides a better measure of how valuable the feed is for animal production.

Landholders who participate in PROGRAZE™ training courses are taught to visually estimate the quantity of feed available in a paddock in terms of kilograms of dry matter per hectare (kg DM/ha).

Groundcover assessments

Visual assessments. A simple method involves visualising a square, say 50 by 50 centimetres (18 inches by 18 inches) in front of your feet. Look vertically into the pasture to estimate the percentage of the area that is covered with plant material and litter. Do this ten times in a paddock and average out the results. Figure A1 shows some relative groundcover percentages in a pasture.

Other methods to assess groundcover include the step point or pointed stick methods. These methods also measure botanical composition of pastures and are described in Appendix 4.

Figure A.1 Visual assessment of groundcover percentages. *Photos: B Stein, Industry & Investment NSW*

Appendix 2

Pasture benchmarks for sheep and cattle

Minimum herbage mass (kg green DM/ha) to maintain satisfactory production levels in SHEEP

	Pasture digestibility (green)		
SHEEP CLASS	75%	68%	60%
Dry sheep	400	600	1200
Pregnant ewes			
- mid	500	700	1700
- last month	700	1200	ns
Lactating ewes			
- single	1000	1700	ns
- twins	1500	ns	ns
Growing stock			
% of potential growth			
30 (75 g/day)*	400	700	1700
50 (125 g/day)	600	1000	ns
70 (175 g/day)	800	1700	ns
90 (225 g/day)	1600	ns	ns

* Predicted growth rates in brackets are based on a weaned four month old crossbred lamb of approximately 32 kg from a ewe with a standard reference weight of 55 kg.

Minimum herbage mass (kg green DM/ha) to maintain satisfactory production levels in CATTLE

	Pasture digestibility (green)		
CATTLE CLASS	75%	68%	60%
Dry cow	700	1100	2600
Pregnant cow (7-8 months, not lactating)	900	1700	ns
Lactating cow (calf 2 months old)	1100	2200	ns
Growing stock (% of potential growth)			
30 (0.39 kg/day)**	600	1100	2900
50 (0.61 kg/day)	800	1600	ns
70 (0.85 kg/day)	1200	2600	ns
90 (1.12 kg/day)	2200	ns	ns

** Predicted growth rates in brackets are based on a weaned 13 month old steer of approximately 320 kg from a cow with a standard reference weight of 500 kg.

ns = not suitable. At these levels no matter how much pasture is available dry or pregnant stock are unlikely to maintain weight, lactating stock are likely to experience an unacceptable level of weight loss and growing stock will not achieve the targeted weight gain.

Note: The benchmarks relate specifically to the nutritional requirements of livestock. At lower herbage masses, particularly those indicated for sheep, there is a risk of excessive runoff and soil erosion due to lack of groundcover. Survival of perennial species is also compromised, especially in dry conditions.

Note: The predictions in these tables are based on a pasture which includes 500 kg DM/ha of dead pasture, with a digestibility of 47% and a legume content of 15%.

From: PROGRAZE™ manual, NSW Department of Primary Industries

Appendix 3

Rural land capability

Land capability is the ability of land to sustain a type of land use without causing permanent damage to the land. Land is not classified on present use, but on its potential for sustainable use if developed. There are eight classes in the land capability assessment system. The classifications are based on soil type, slope and erosion risk (see table below). These factors should guide your choice of land use as well as your subsequent management and production techniques. Farming beyond the limitations of the land, by overgrazing or cultivating on inappropriate areas, can leave soil vulnerable to erosion. It is important to identify different land classes on your property and manage them within their limitations.

Land class	Land use	Brief description	Management option	Soil conservation practices
I	Arable	Usually flat land that is suitable for a wide variety of uses.	When it is fertile it can be used for almost anything including fruit and vegetables, sugar cane, cereal crops and other grain crops.	No special soil conservation works or practices necessary.
II	Cropping or grazing	Gently sloping land suitable for many agricultural uses. Low erosion potential	Good cropping land on fertile soils.	Soil conservation practices such as strip cropping, minimum tillage and adequate crop rotations should be used if cropping.
III		Sloping country that is likely to wash and erode when cultivated.	The land is quite fertile and adequate for cropping as long as soil conservation practices such as contour banks are used.	Structural soil conservation works such as graded banks may be necessary, together with soil conservation practices as in Class II.
IV	Mainly grazing	Good grazing country but not suitable for the practices listed in I to III. Main limitations are slope, rockiness, soil fertility, and susceptibility to soil structure decline. Maintenance of good groundcover is essential.	Occasional cultivation, but better suited to grazing.	Practices such as sowing pastures, stock control, application of fertiliser, reduced cultivation or direct drilling pasture establishment and maintenance of good groundcover.
V		Not suitable for cultivation on a regular basis due to slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of all of these factors. Soil erosion problems are often severe.	Requires careful grazing management.	Structural soil conservation works (absorption banks, diversion banks and contour ripping) may be necessary in some areas, management practices as in Class IV, more emphasis on maintaining groundcover.
VI	Grazing only	Comprises the less productive grazing lands that should not be cultivated because of soils, slope, wind or water erosion hazard.	Not capable of cultivation; generally less productive grazing. Requires sound grazing management and pasture improvement.	Practices such as restricted grazing, broadcasting seed and fertiliser, native pasture enhancement, protection from fire, and destruction of weeds and pests. Preservation of native perennial grasses is vital. May include some isolated structural earthworks
VII	Tree cover	Steep country which is too fragile for grazing.	Very important habitat areas for protecting biodiversity. Critical area for minimising recharge.	Land best protected by green timber or undisturbed groundcover
VIII	Unsuitable for agriculture	Cliffs, lakes or swamps, etc. Not capable of sustaining agriculture.	Cliffs, lakes, swamps or other lands where it is impractical to grow agricultural produce or timber.	

Appendix 4

Measuring the botanical composition of pasture

Step point method. *Photo: D Doyle, Industry & Investment NSW*

Pointed stick method. *Photo: B Stein, Industry & Investment NSW*

Pointed stick method. *Photo: B Stein, Industry & Investment NSW*

Two methods for measuring the botanical composition and/or groundcover percentage of your pasture are:

Step point method

The step point method involves making observations along a straight path at specified intervals and recording plant species. Make a mark on the toe of each of your boots. You then need to step for 100 equally spaced steps throughout the pasture along a fixed bearing or towards a landmark to ensure a straight line. At each step look at what the mark on your boot is touching and record perennial grasses, legumes, annual grasses, weeds, litter, bare ground or other. A Pasture Composition Recording Sheet is provided in Appendix 5 Pasture composition recording sheet.

Pointed stick method

The pointed stick method uses a 1 centimetre thick dowel about 30 centimetres long with pointed ends – or a nail can be driven into each end of the stick. Randomly throw the stick across the paddock and record the plants that are nearest the ends of the stick. Repeat the process 50 to 100 times throughout the paddock. Fifty observations of a double ended stick will give you 100 observations (hits) and the composition can be calculated as a percentage. The total observations (hits) for each pasture component, divided by the total number of hits, indicates the percentage of each species in the pasture.

Appendix 5

Pasture composition recording sheet

Example of a recording sheet to determine pasture composition.

Use the sheet to record the number of times each plant species was encountered (see Appendix 4) by making a mark as per the example below.

Species										Total
Perennial grass (eg cocksfoot, phalaris, kangaroo grass, microlaena)	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	𝍸	||||	44
										(44%)
Legume: (Clover or medic)	𝍸	𝍸	𝍸	𝍸	||					22
					sample					22%
Annual grass	𝍸	𝍸	||||							14
										14%

Blank recording sheet to determine pasture composition.

You may want to categorise species or look at them individually. For example, all undesirable species may be called 'weeds', all perennial grasses (introduced and native species) grouped together, and annual grasses together.

Species										Total
Perennial grass (eg cocksfoot, phalaris, kangaroo grass, microlaena)										
Legume: (Clover or medic)										
Annual grass										
Weed										
Litter										
Bare ground										

Appendix 6

Temperate pasture establishment checklist

Be certain each step is completed before going to the next step

- Management issues to successfully establish perennial pastures
- Times will vary for spring and autumn sowings and with regions
- For further advice contact a Industry & Investment NSW Agronomist.

1. Assess, select and plan early (1-2 years before)	**Key check: Assess existing pasture, weeds, pests and soil fertility** ✓ Select correct pasture species and variety to suit the soil, paddock and purpose ✓ Identify weeds and pests and commence a control program ✓ Soil test for nutrient requirements and need for lime or gypsum ✓ Budget check – assess potential productivity gain, costs and returns	**Check** ✓
2. Control of weed and pests in planning years	**Key check: Prevent weeds and pests from seeding/reproducing** ✓ Control broadleaf and perennial grass weeds – spray or spray-graze ✓ Prevent annual grasses from seeding for up to 2 years ✓ Use integrated pest management (IPM) practices in the season prior to sowing ✓ Consider a cropping cycle on suitable sites ✓ Calibrate boom-sprays for accurate application	**Check**
3. Pre-sowing activities	**Key check: Remove excess plant material before sowing** ✓ Sowing method – check availability/suitability of equipment	**Check**
4. Absolute weed and pest control	**Key check: Allow full weed germination after the autumn break then graze to keep weeds small until moisture in the profile is right for sowing** ✓ Assess for the presence of pests including slugs in wet areas ✓ Either use appropriate herbicides/insecticides and label rates or cultivate to achieve a firm, fine weed-free seedbed.	**Check**
5. Adequate soil moisture and fertility	**Key check: Moist soil profile from the surface to 20 cm deep** ✓ Don't dry sow temperate pastures ✓ Don't sow on the first autumn rain – need a further 50-100 mm of rain ✓ Drill fertiliser with the seed; use starter fertilizers for direct drill sowings (< 20 kg N/ha for 15 cm row spacings)	**Check**
6. Accurate seed placement	**Key check: No more than 5mm of loose tilth over the seed** ✓ Direct drill - furrows 25 mm deep but open – do not use harrows or rollers ✓ Direct drill – preferably use inverted "T" points ✓ Direct drill - correct tyne tension is 35 kg at bolt hole for 25 mm deflection ✓ Direct drill - 5% of seed/fertilizer should still be visible in the furrow ✓ Ploughed seedbeds – aim for a firm seedbed and good seed/soil contact	**Check**
7. Monitor weeds and pests	**Key check: Look for pests and weed seedlings every 10-14 days after sowing**	**Check**
8. Grazing	**Key check: Do not graze unless the soil is moist, plants are well anchored and 15 cm tall** ✓ Graze heavily but quickly down to 5 cm, then spell ✓ Allow grasses and legumes to set seed in the first season ✓ Never make hay or silage from perennial pastures in their first year ✓ Aim for high groundcover to improve water infiltration and pasture growth	**Check**

Glossary

A

Acid soil Technically, a soil with a pH of less than 7.0. Problems usually only occur for pastures when the pH falls below 5 (1:5 soil: water test) or below 4.5 (calcium chloride test) - These problems usually relate to toxic amounts of aluminium and/or manganese, poor root growth and nodulation (also see Glossary note on pH)

Acid tolerance Ability of plants to grow at low pH and/or at high available soil aluminium

Annual grasses Grasses (mostly introduced) which are annuals - Includes many weedy species, eg Silver grass (*Vulpia* spp.), Brome grass (*Bromus* spp.), Barley grass (*Hordeum* spp.)

Arable Land that can be cultivated and sown safely to crops and pastures

Aspect Direction a slope faces

B

Bank A constructed earth embankment, incorporating a channel on the up-slope side, typically traversing a slope, to control and/or prevent erosion of that slope - This is achieved by intercepting, diverting or sorting run off instead of permitting it to flow uninterrupted down the slope

Biodiversity, or biological diversity The variety of all living life-forms including plants, animals and micro-organisms, the genes they all contain and the ecosystems of which they form a part

Biological control Control of a pest by using its natural enemies, including parasites, fungi and predators

Botanical composition The mix of plant species present in a pasture

Buffer strip A vegetated strip of land that functions to absorb/trap sediment and nutrients

C

Carrying capacity A paddock or farm's capacity to carry livestock. Usually measured in Dry Sheep Equivalents per hectare (DSE/ha) - Carrying capacity is largely influenced by pasture production which varies within and between years

Cation Exchange Capacity (CEC) The capacity of a soil to retain cations - Clay particles and soil organic matter are negatively charged and tend to attract cations - These cations, which otherwise could be leached from the soil, remain available to plant roots

Conservation value A value given to a vegetation remnant that identifies it worthy of conserving for future generations

Containment paddock *(also called droughtlots)* Small areas of your property, also known as droughtlots, that you sacrifice to ensure that the rest of your paddocks can recover quickly once drought conditions ease

Continuous stocking Pastures continuously stocked, rarely or if ever receiving a rest from grazing

Crash grazing Very heavy stocking rates (eg 100 DSE or more per hectare) used for relatively short periods to non-selectively remove weedy species from pastures

Cryptosporidium A protozoan that is an intestinal parasite of humans and other vertebrates, which can cause diarrhoea in humans and animals

D

Deep drainage Loss of water through the soil profile to beyond the root zone - This water can contribute to movement of salt in the landscape

Direct drilling Sowing crops and pastures directly into the soil without prior cultivation. Herbicides may be used to reduce competition from existing vegetation

Discharge area An area where underground water is discharged at the soil surface

Dispersible soil Soil that readily disperses into its constituent particles (clay, silt, sand) in water, often due to high levels of sodium

Disturbance Changed state of soil or pasture by external means such as cultivation, herbicides, etc.

Diversion bank An earth bank, with a graded channel on the upslope side, designed to divert water away from an actively eroding area or gully head

Drainage depression A shallow depression with smoothly concave cross-section that conveys runoff only during or immediately after periods of heavy rain. Drainage depressions may be subject to seasonal waterlogging or spring activity and vegetation type often indicates a wetter micro-environment than the surrounding country

Drainage line A channel where surface water naturally concentrates and flows, conveying water only during or immediately after (hours or days) periods of heavy rain - Drainage lines exhibit one or both of the following features which distinguish them from drainage depressions:
(a) evidence of active erosion or deposition - e.g. gravel, pebble, rock or sand bed, or
(b) an incised channel more than 30 cm deep with clearly defined bed and banks.
Landholders often refer to a drainage line as a gully or flow line

Drought A prolonged period of dryness that can damage plants

Droughtlots See containment paddock

Dryland salinity The build-up of salt in surface soil, usually due to a rising water table and subsequent groundwater seepage - Dryland salinity refers to non-irrigated areas showing a salt problem

Dry Sheep Equivalent (DSE) A standard unit used to compare the feed requirements of classes of livestock and to assess the carrying capacity of a farm or paddock - The standard DSE is the amount of feed required by a two year old 50 kg merino sheep (wether or non-lactating or non-pregnant ewe) to maintain its weight

Duplex soils One with a sharp texture contrast between topsoil and subsoil

E

Ecosystems All organisms, physical habitats and ecological processes in a location

Ecosystem services Services provided by ecosystems that benefit humans and are neccessary for a healthy planet like oxygen production, water purification, pollination, soil formation and nutrient recycling.

Electrical conductivity (EC) The ability of a substance to conduct electricity - The most common and convenient method to measure salinity of water is by electrical conductivity - The reading depends on concentration and composition of dissolved salts present

Endangered A species that is listed in legislation as at risk of extinction

Erodibility The susceptibility of soil to detachment and transportation of soil particles by erosive agents, such as water runoff - Erodibility is a function of the mechanical, chemical and physical properties of the soil - Highly erodible soils are those which detach easily

Erosion Wearing away of the land by water or wind, leading to the loss of topsoil

Exchangeable Sodium Percentage (ESP) Commonly used as a measure of soil sodicity, ESP is the proportion of sodium absorbed onto the clay mineral surfaces as a proportion of total cation exchange capacity, expressed as a percentage

F

Farm Mixed Lime Super Equal amounts of fine lime and superphosphate mixed immediately prior to sowing which provides a short-term liming effect

Fertiliser Any product applied to a paddock or crop to improve the type and amount of nutrients available

Fertiliser Strip Tests A way to visually assess a paddock's response to fertiliser. Fertiliser is broadcast in a single strip across a paddock at twice the normal spreading rate

Flowlines The natural sequence of drainage of water into a waterbody

Flume A constructed channel lined with erosion-resistant materials used to convey water on steep grades without erosion

Forbs Herbaceous broad-leafed plants (essentially non-grasses), eg legumes, native daisies

G

Giardia A parasite which is waterborne and which can cause severe diarrhoea in humans and animals

Grassland (native grassland) A natural vegetation community where native grasses dominate, and there are usually other plant species that include daisies, peas, lilies, orchids and many other species of wildflowers - Trees and shrubs may be present, but are sparse (less than 10% of projective foliage cover)

Grassy filter strip Areas of perennial grasses, adjacent to a riparian area or other inflow area, which filter surface flow, sediment and waterborne nutrients

Grazing capacity Maximum stocking rate that grazing land can support in the long term without deterioration

Grazing management The way animals are grazed on pastures, including continuous grazing, rotational grazing, and set stocking

Groundcover The proportion of the ground surface covered by plant material (including litter), which protects the soil from wind and water erosion

Groundwater Water found below the ground surface

Gully An open erosion channel more than 30 cm deep. Gullies have very gently inclined floors and precipitous walls

Gully head The upstream end of a gully where runoff from the catchment above falls to the gully floor

H

Habitat The place where a particular animal or plant normally occurs and reproduces

High-density stocking/high-intensity grazing Large numbers of animals grazed on a small area of land, generally for short periods to achieve a desired outcome

I

Indicator species A species of plant or animal used to assess landscapes, soil types or microclimates

Inflow area Areas that concentrate water flow into a farm dam

Integrated Weed Management The planned use of multiple techniques to control weeds

Introduced pastures Includes sown pasture species introduced by humans - also includes non-indigenous species introduced by other means

K

kg DM/ha Kilograms of dry matter per hectare - This is a measure of pasture productivity

L

Land capability The ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage. It is an expression of the effect of biophysical land resources, including climate, on the ability of land to sustain uses, such as crop production requiring regular tillage, grazing, woodland or wildlife

Land degradation The decline in quality of natural land resources caused by improper use of the land

Leaching The process by which soluble materials in the soil, such as salts, nutrients, pesticide chemicals, or contaminants, are washed into a lower layer of soil, or are dissolved and carried away by water

Legume A plant that converts atmospheric nitrogen into a form that other plants can use through a process of 'nitrogen fixation'

Liming The process of applying lime to a pasture

Litter Dead plant material lying on the ground (unattached to plants)

N

Native grassland See grassland

Native vegetation For the purposes of the Native Vegetation Act (2003), native vegetation means indigenous vegetation comprising any trees, understorey plants, groundcover or plants occurring in a wetland - For this Act, groundcover is defined as vegetation which occurs in an area where not less than 50% of the herbaceous vegetation covering the area comprises indigenous species - In determining that percentage, not less than 10% of the area concerned must be covered with herbaceous vegetation (whether dead or alive) - Note: Seasonal impacts (such as drought) are considered to determine the amount and type of groundcover

Natural capital The natural resources, including soil, water, plants and climate that a landholder has available to work with

Naturalised pastures Pasture species, which have been introduced, often accidentally, and which have spread extensively on their own (eg barley grass, rat tail fescue, ball clover)

Nitrogen fixation The process by which legumes convert nitrogen from the air into a form that plants can use – It relies on a relationship between the plant and a specific bacteria known as rhizobia which live in nodules on the plant's roots

Non-destructive oversowing Sowing a pasture species into an existing pasture by broadcasting seeds or direct drilling without killing the existing useful pasture plants

Non-trafficable Land which cannot be safely driven across with a wheeled tractor

Noxious weeds Plants, proclaimed by legislation, which a landowner is legally obliged to control (eg serrated tussock, blackberry, scotch thistle)

Nutrient budget Quantitative assessment of nutrients (eg nitrogen or phosphorus) moving into, being held in, and moving out of a specified area (farm or individual paddock)

O

Organic matter Generally refers to dead or decaying residues of animals and plants in the soil

Overgrazing A short-term concept describing the consumption of pastures by stock so that the growing point of the plant is injured and recovery and growth is slowed. Under certain circumstances this practice is necessary for short periods

Oversowing Sowing without prior cultivation

Overstocking A long-term concept describing a stocking rate which can lead to a detrimental change in the botanical composition of pastures

P

Pathogen A disease causing agent (eg virus, bacteria)

Perennial plant A plant whose life cycle extends for more than one year – a plant that continues to live from year to year

Pest species Harmful, destructive, nuisance or troublesome types of animals or plants

Pesticide Chemical substance used to destroy pests (ie weeds or insects)

pH A measure of the acidity or alkalinity of a soil, measured in either water or calcium chloride (the latter is preferred for acid soils) - A pH of 7.0 is neutral, higher values indicate alkalinity, and lower values indicate acidity - Soil pH in the tablelands range from 4 to 6 in calcium chloride - Most plants grow best in soils with a pHCaCl above 4.6

Photosynthesis A plant process which converts carbon dioxide and water into sugars and starch, using sunlight

R

Recharge The process that replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table

Recruitment The process of regeneration from seedlings

Remnant vegetation An isolated patch of original vegetation in a landscape that has been altered by human activity such as agriculture

Resilience The ability of a system to persist, to absorb change and disturbance and still be recognisably the same system

Revegetation The process of replanting an area, usually with locally native species

Revetment A protective layer of rip-rap or other erosion-resistant material, placed along the edge of a stream or shoreline, to stabilise the bank and protect it from erosion by water

Rill erosion Formation of shallow channels up to 30 cm deep due to channelling of water runoff, usually from initial sheet erosion

Riparian area/zone Any land which adjoins, directly influences or is influenced by a body of water such as a permanently or intermittently flowing creek, a wetland that interacts with a river only during periods of high flow, or a dam/reservoir

Riparian buffer zone The area of land surrounding the water course or drainage line which is managed to control grazing and minimise impacts to water quality

Riparian land Land that is connected to a waterway

Rotational grazing A grazing strategy that involves a period of grazing followed by a period of rest - The rest period is generally based on the pasture growth rate - May be used during or only part of the year

Runoff The portion of rainfall not immediately absorbed into or detained upon the soil which becomes surface flow

S

Salt scald An area affected by salt on the soil surface to the point that it is bare of plants

Sediment Material of varying size, both mineral and organic, that is being transported, or has been moved from its site of origin by air, water, gravity, or ice and settles in another place

Selective grazing Allowing animals to choose particular plants (or parts of plants) in preference to others, often resulting in loss of more palatable species

Set stocking A specific grazing period when stock are not moved or pastures are not spelled. For example, for lambing, calving or finishing stock

Sheet erosion Heavy rainfall dislodges soil particles from large bare areas and carries substantial volumes of sediment down the slope

Sodic soil Soil with a high proportion of sodium that often causes poor physical structure

Soil biota Micro-organisms, plants and animals that live within the soil

Soil test A combination of physical and chemical tests on a soil sample

Sown pasture Pastures sown by ground or aerial machinery into a ploughed or sprayed out (direct drill) seedbed

Spray grazing Using a sub-lethal rate of herbicide at an optimal time, and applying high density grazing to use the weed for forage

Spray topping Using a sub-lethal dose of non-selective herbicide (typically glyphosate or paraquat) on flowering annual grass pastures to reduce the formation of viable seeds without inducing a winter feed shortage

Stability The ability of a system to return to a productive state after disturbance

Stocking rate The number of livestock on a particular area (eg wethers per hectare)

Streambank A moderately inclined to precipitous slope forming the margin of a stream channel, resulting from erosion by channelled stream flow

Subsoil Part of the soil profile, typically the B and C horizons which underlays the topsoil (A horizon) - Being older than the topsoil it is generally lower in organic matter and fertility, and can be significantly different in colour and texture to the topsoil

Subsoil acidity Acidity which occurs deeper in the soil profile - Soils with subsoil acidity usually have low productivity and are very difficult to improve

T

Topsoil Part of the soil profile, typically the surface A horizon, containing material which is usually more fertile and better structured than underlying layers - It is the important part of the soil for growth of crops and pastures - Loss or degradation of topsoil is the most serious aspect of soil erosion

Tactical grazing A flexible grazing management system which sets a management objective for a paddock, implements a strategy and monitors the results, to achieve a desired outcome, eg uniformly grazing undesirable annual species during flowering or early seed growth to reduce seed production for the following growth period ie annual grasses such as barley grass

Total stocking rate Includes the stocking rate of all grazing animals including domestic (eg sheep, cattle and other domestic livestock), native (eg kangaroos, wallabies), birds (eg ducks), and noxious animals (eg rabbits, pigs)

Turbidity The cloudy appearance of water due to suspended material

W

Water balance The balance between where water comes from (rainfall) and where it ends up (evaporation, runoff, deep drainage)

Watercourse Any river, creek, stream or chain of ponds, whether artificially modified or not, where water flows, either continuously or intermittently, in a defined bed or channel

Weeds Plants that are growing where they are not wanted by humans

Water table The top level of water in the ground that occupies spaces in rock or soil and lies above a layer of impermeable (non-porous) rock. When the water table rises above ground level, a spring, lake or wetland is formed

Whole farm planning A planning process which considers the natural capital resources and features of the whole farm

Wildlife corridor An area of (generally native) vegetation which can allow movement of wildlife between larger remnant vegetation areas (eg vegetation along fences, roads, rivers)

Windbreak One or more rows or groups of shrubs and trees planted across the prevailing wind direction to reduce wind speed on the lee side

Y

Year-long green Plants that generally remain green throughout the year, when soil moisture is adequate, eg Wallaby grasses (*Austrodanthonia* spp.) and Microlaena (*Microlaena stipoides*)

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