

# A practical guide to rural land management

Course booklet



Government of  
South Australia



Natural Resources  
Adelaide and Mt Lofty Ranges

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#### Disclaimer

This booklet is intended to help you to understand the value of developing your own property plan, budgeting for future expenses and seeking out and accepting good advice. It is not a comprehensive guide to managing your land. No legal liability is accepted for the information presented in this booklet.

#### Acknowledgements

The contents were compiled as a template for landholders in the Adelaide and Mount Lofty Ranges (AMLR) natural resources management (NRM) region. It is a collaborative project built on the work of the Sustainable Agriculture Team of Natural Resources AMLR with contributions from rural land management consultants, Rural Solutions South Australia, and the Country Fire Service.

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# 1. An introduction to land management

## Background

To ensure agricultural production remains viable and sustainable for the long term, Natural Resources Adelaide and Mount Lofty Ranges offer advice, incentives and education, with the aim of assisting primary producers to develop technical skills.

The key services offered include land management courses, field days and workshops, property visits and one-on-one small property advice, the *Small Talk* newsletter and a monthly events calendar.

The objectives of these services are to:

- increase landholders' level of awareness of natural resource management (NRM) issues and solutions
- ensure that property owners are aware of the causes and effects of land degradation and have an understanding of appropriate solutions for tackling these problems
- increase the confidence and ability of landholders to construct a property management plan to enable them to successfully implement the necessary changes in land management practices.

## Land management issues in the Mount Lofty Ranges

The Mount Lofty Ranges is arguably one of the most important regions in South Australia. It is a nationally recognised biodiversity 'hotspot'. Only about 8% of pre-settlement native vegetation cover remains within the region, and 70% of that is on private land. Within the region, four ecological communities\* are listed as threatened under the federal *Environment Protection and Biodiversity Conservation Act 1999* and the region has one of the highest concentrations of threatened bird species on mainland Australia.

The quality of Adelaide's water supply is determined largely by how well the land is managed in this watershed. Agricultural production from the region benefits the state's economy. In addition, the region is an excellent tourism and recreation destination. The diverse and unique native vegetation, which includes forests, woodlands, grasslands and wetlands, provides an ideal habitat for a large variety of flora and fauna species, many of which are endangered.

The main issues addressed in this booklet include:

- environmentally sustainable land use
- property management planning
- land management and water resources legislation
- soil erosion by water and wind
- decline in soil fertility and structure
- soil acidification
- dryland salinity
- perennial pasture management
- weed control in pastures, revegetation sites and existing native vegetation
- use of chemicals
- surface and underground water – quality, quantity and management
- revegetation
- loss of biodiversity and wildlife habitat
- management of native vegetation
- bushfire prevention
- pest animal control.

\* An ecological community is a naturally occurring group of native plants, animals and other organisms that interact in a unique habitat. Its structure, composition and distribution is determined by environmental factors such as soil type, position in the landscape, altitude, climate and water availability.

## Legal responsibilities of land owners and managers

The *Natural Resources Management Act 2004* (the Act) is an amalgamation of the *Soil Conservation and Landcare Act*; the *Animal and Plant Control Act* and the *Water Resources Act*.

Under this Act it is the duty of an owner (or manager) of land to take all reasonable steps to prevent degradation of the land. Water erosion is a major issue on some properties. To prevent this, landholders should keep at least 70% ground cover of at least 3 cm in height. Landholders should also avoid overgrazing and check for the correct stocking rate for their particular district and their pasture quality (see Chapter 2).



*Figure 1: Typical scene in the Mount Lofty Ranges. Photo: Adelaide and Mount Lofty Ranges NRM Board*

The same Act imposes a duty of care on owners and occupiers of land to destroy or control pest plants and animals that have been declared for a particular region. The owner is also responsible for the cost of control of many of these pests and animals on the road verge adjoining their land.

Failure to control such pests will result in local authorised officers undertaking the work and billing the owner of the land. The local district officer can supply the landholder with a list of declared pest plants and animals for the specific area.

The water resources section of the Act states that any person will have the right to take water from any course (for example, water course, underground, or merely flowing over the land after rain) occurring on land occupied by the person for reasonable stock and domestic use. Owners of properties must obtain a permit from Natural Resources Adelaide and Mount Lofty Ranges if building a dam, as long as the dam wall is no higher than 3 m above the natural ground surface and has a volume no greater than 5 KL.

However, local council development approval is required for dam construction, as well as for enlargement or modifications of walls greater than 3 m above the natural ground surface, and/or if the dam capacity exceeds 5 KL, or if the property is located within the Hills Face Zone. An engineer's report may be required if the wall is greater than 6 m high.

Licences for irrigation are required in all prescribed areas; that is, Eastern Mount Lofty Ranges, Barossa Valley, Western

Mount Lofty Ranges, Southern Fleurieu and Northern Adelaide Plains. Those landholders whose properties are outside a prescribed area will fall within a natural resources management board area with its own water allocation plans.

A permit for sinking a bore is required from the Department of Environment, Water and Natural Resources.

Other Acts which may impact on land managers include:

- Aboriginal Heritage
- Agricultural and Veterinary Chemicals
- Animal Welfare
- Development
- Environmental Protection
- Fences
- Fire and Emergency Services
- Impounding
- Livestock
- Local Government
- Native Vegetation
- Plant Health
- Wilderness Protection.

# 2. Land capability and stocking rates

## Land capability classification

Land capability describes the ability of the land to accept a *type and intensity* of use with minimal risk of damage to the soil. Understanding land capability is at the core of responsible land use and management. Land use decisions should only be made on the basis of adequate information about the land itself.

Land capability is based on the physical attributes of the land, which is called 'land quality'.

These include:

**Slope:** the greater the slope, the less capable the land is of sustaining production.

**Soil type:** this includes the soil structure, its pH and chemical composition; wind and water erosion affect some soil types more than others.

**Water absorption:** some low-lying areas may become waterlogged in the wetter months, reducing the amount of land available to stock. Others are highly water-repellent, affecting the quality of crop and horticultural production.

**Rockiness:** the degree of stoniness will affect the purpose to which the land can be used, particularly where machinery is involved.

**Fertility:** some soils are poorer in nutrients than others. While nutrients can be added to soil, it is important to decide whether the cost of fertilisers outweighs the value of the enterprise as a whole.

An assessment of all the attributes of the land will decide its limitations. These limitations can then be used to assign the land to particular 'land classes' (see Table 1).

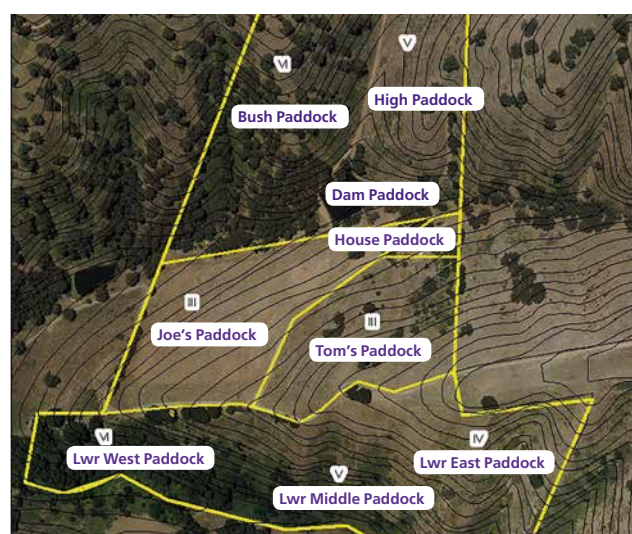


Figure 1: Example of dividing land into land classes

Table 1: Land classification

	Land classes	Description
Arable land	1	Land with little risk of degradation and able to support a wide range of uses. Suitable for all types of agricultural production on a permanent basis.
	2	Land with some risk of degradation but still able to support a wide range of uses. Some conservation practices required if used for cropping e.g. broad rotations and/or some special cultivation practices.
	3	Land with moderate risk of degradation. Special conservation practices required if used for cropping.
Semi-arable	4	Land with moderately severe risk of degradation. Regular cropping would constitute an unacceptable risk.
Non-arable	5	Land with little risk of degradation but unsuitable for cropping because of soil, topography, wetness or salinity. Suitable for cultivation associated with pasture development.
	6	Land with severe risk of degradation. Suitable for grazing but good management needed to preserve vegetative cover. Specialised equipment is necessary for establishment of improved pasture.
	7	Land with very severe risk of degradation. Suitable for controlled grazing. Good vegetative cover is essential for protection of the land.
	8	Land incapable of sustaining any form of agricultural production.

### Land classes and why we map them?

The following indicators are useful for mapping the various classifications of land type. Land classes:

- show where you can or cannot graze
- enable land to be fenced according to land type
- enable the assessment of carrying capacity by determining the area available for grazing

- show the limitations of the land for other enterprises, for example:
  - vines: well-drained soils and frost-free areas
  - farm forestry: maximum slope of 20 degrees (35%)
  - cropping: avoid land over 12-degree slope
  - grazing: avoid waterlogged soils
  - strawberries: avoid saline soils.

### Land class system for grazing

Table 2: Land classification for grazing only

<p><b>All-year access areas</b> Gentle to moderate slopes, well drained, loamy to clayey soils. All-year access except when conditions become too wet or when vegetation cover becomes sparse (cover should be &gt;70%).</p>	<p><b>Restricted access areas</b> Winter waterlogged, poorly drained, steep slopes, highly erosive and/or poorly structured soils. Access is restricted during the year when certain areas experience waterlogging or when vegetation cover is too sparse.</p>	<p><b>Prohibited areas</b> Extreme slopes, area affected by or prone to landslips, gullying, tunnelling, salinity, areas of native vegetation or highly sensitive areas.</p>
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A 3-class system can be used as an alternative to the more complex 8-class system (Table 2).

The ‘prohibited areas’ classification needs to be considered when assessing stocking rates and the type of management required.

Identifying whether a property has any limitations (such as waterlogging, extreme slopes or rockiness) will enable the property owner to achieve a more realistic assessment of the amount of grazing land available.

Allowing stock to graze on waterlogged land will damage soil and pasture.

Extreme slopes can be dangerous for stock and are best used for revegetation.

Rockiness reduces the ability to use machinery and indicates a shallow soil depth, rendering the land unsuitable for perennial horticulture.



Figure 2: Waterlogged lower pasture. Photo: A. Cole.

## Property planning

A property plan is an assessment of a landholder's property. This property assessment will help the landholder to understand the dynamics of the property, the natural resources already available and any potential or existing environmental threats. The assessment also identifies the management options and techniques available for use.

It is important to understand that the assessment of a property cannot be undertaken in a short period of time. Landholders need to observe how the property reacts to natural events over a number of weather types and seasons (dry, wet, prevailing winds, frost etc.). Moreover, the priorities and lifestyle of landholders will change over a period of time.

Thus property planning is a dynamic and fluid process and the landholder can expect their plan to change over time, as priorities, physical aspects of the property and lifestyle change. It is important that the landholder records their short-term and long-term goals for the property. These should include both personal and farm goals.

### Why write a property plan?

- It helps to focus your goals.
- It helps you to solve problems.
- It allows you to plan your budget.
- It allows you to plan your time.

To write an effective property plan, the landholder will need to gather information about the property. This includes:

- *natural resources*: soil type, rainfall, native vegetation, water quality, water quantity
- *physical geography*: slope, rocky outcrops, drainage lines
- *limitations of the property*: waterlogging, weeds, erosion, salinity
- *financial and human resources*: what are the requirements of the enterprise you wish to run? Do these match the attributes of the property?

Having a clear vision for the property is important if you are to achieve your hopes and aspirations for the property. For most small property owners lifestyle is a major consideration; however, particular enterprises can be a source of income if managed effectively. Whatever your priorities, appropriate management is critical to maximising your land's potential.

Purchasing an aerial photograph makes it possible to map the physical characteristics of your land that may limit particular activities. A series of clear overlays can then be developed to enable a realistic plan to be designed.



*Figure 3: An aerial photograph is the first step in property planning. Photo: Adelaide and Mount Lofty Ranges NRM Board.*



*Figure 4: Overlays on an aerial photograph are a useful aid to property planning. Photo: J. Kruger and McLaren Vale Grape, Wine and Tourism*

Overlay 1 includes all the physical and permanent features of the property that are likely to impact on its management (for example, saline sites, rocky areas, steep slopes, native vegetation etc.).

Overlay 2 includes the existing layout of the property (including fences, stock troughs, raceways, etc).

Overlay 3 is the realistic plan, based upon 'best practice' land management principles, and includes future plans such as new fence lines, revegetation areas or permanent structures.

The following should be considered when drawing up your realistic farm plan:

- location of the house
- location of sheds and yards
- location and types of fences
- water resources, including stock-watering points
- trees and vegetation
- surface-water management
- names or numbers of paddocks
- raceways
- number and types of enterprises
- new fencing.



## Stocking rates

The dry sheep equivalent (DSE) is a standard unit used to compare the feed requirements of different classes of livestock, or for determining the carrying capacity of an area of grazing land. The standard DSE is the amount of paddock feed required by a 2-year-old 45 kg sheep (wether or non-lactating ewe) to maintain its weight.

Calculating a suitable stocking rate will avoid overstocking. Overstocking can result in livestock death and/or land degradation.

By mapping your land classes (as described on page 3), you will be able to see which areas should be permanently excluded from grazing (watercourses, house yard etc.) and those with restricted grazing (for example, waterlogging in winter).



Figure 5: Avoiding overstocking

### What is your regional stocking rate?

Regional DSE values are predominantly calculated according to rainfall, but they should also take into account soil type and its influence on pasture growth. Generally speaking, the higher the rainfall, the higher the regional DSE value. However, steep slopes will significantly reduce stocking rate (Table 3).

Table 3: Regional dry sheep equivalents

Locality	DSE value / ha	Locality	DSE value / ha
Balaklava	3	Kersbrook	11
Birdwood	10	Lyndoch	8
Cherry Gardens	10	Mt Pleasant	8
Clarendon	9	Nuriootpa	6
Cockatoo Valley	8	One Tree Hill	6
Cudlee Creek	10	Parawa	14
Echunga	13	Port Wakefield	2
Gawler/Roseworthy	5	Woodside	10
Gumeracha	11	Yankalilla	10

Note: these figures are a guide only and will change depending upon the local climatic conditions.

## Calculating your stocking rate

Work out the area of each of your paddocks:

$$\text{Length (m) x width (m) / 10,000 = ha}$$

For example, 150 m x 200 m / 10,000 = 3 ha

Work out the total number of hectares on which you can carry stock for 12 months of the year. Do the same for 9 months and 6 months. Note 1 ha = 2.47 acres.

Use the formula to work out the maximum carrying capacity:

$$\frac{\text{Number hectares x Number months grazing}}{12 \text{ months}} \times \text{regional stocking rate (RSR)} = \text{DSE}$$

**Example:** A 6-hectare property located in Woodside where 3 hectares are being locked up for hay production for 6 months of the year.

$$\frac{3 \text{ ha x 6 months x 8 RSR}}{12 \text{ months}} = 12 \text{ DSE}$$

$$\frac{3 \text{ ha x 12 months x 8 RSR}}{12 \text{ months}} = 24 \text{ DSE}$$

The sum of the two DSEs indicates that this property can carry 36 dry sheep. Remember that this is a general annual figure. In reality your property may be able to carry more in the winter months if rain is sufficient to provide good pasture growth. Likewise, you will most likely need to de-stock in the summer months when pasture feed becomes minimal. It is imperative that the land is not grazed to the extent that paddocks start to look bare.

## Calculating stocking rates for other livestock

Of course, not every property has sheep. Some have cattle, horses, alpacas, goats or a mixture. To enable the calculation of the stocking rate for other livestock, each is given a sheep-equivalent value.

These values represent the number of dry adult sheep that can be kept on one hectare of pasture. Once you have worked out the total DSE value of your property, you *divide* the number by the DSE of the corresponding class of livestock you can keep.



Figure 7: A well-managed horse paddock. Photo: A. Cole.

Table 4: Dry sheep equivalent values for livestock

Class of livestock	Sheep – wether	Lambing ewe	Cattle – dry cow or steer	Horse	Pony	Goat	Alpaca	Deer
Values of DSE	1.0	2.0	10.0	10.0	6.0	0.6	1.0	1.0

**Example:** if you can keep one sheep, you could alternatively keep one deer, or one alpaca or one tenth of a cow.

**Or**

A property with a DSE of 30 can keep 30 sheep or 3 cows.

These figures are based on good *perennial pasture*. If pasture is not of good quality, the DSE must be reduced by at least one-third. The property owner should also take into account any paddocks requiring renovation. Renovating paddocks will reduce the amount of grazing available in the first instance, but be well worth the effort once established.

# 3. Soil management

## Role of soil

Soils are dynamic ecosystems containing vast numbers of living organisms. Soils anchor plants and provide them with water, nutrients and air.

Soils are productive when their properties are beneficial. However, there are times when the properties of soils can be detrimental to the growth of plants. Australian soils are some of the oldest in the world, having experienced severe weathering and leaching over millions of years. As a consequence, nutrient and organic matter levels can be low. The inherent features of a soil are usually determined by the type of the parent rock and the nature of environmental exposure over time. Features such as soil colour, layers, texture and, to some extent, structure, are used to describe a *soil type*.

Appropriate management of soils is critical to avoiding their degradation to the point where plant growth suffers. The continued removal of plant products without the addition of fertilisers will result in a loss of crucial soil nutrients. The physical condition of a soil, together with its chemical and biological status, is used to measure *soil health*. Nutrient levels, soil acidity and erosion can all impact on the health of a soil.

Healthy soils allow water and air to move freely through the soil profile, are easily worked and allow roots to penetrate, enabling the uptake of water and essential nutrients. Maintaining adequate levels of nutrients and available water relies on our understanding of plant-soil interactions, which in turn influences the way soils are managed.

Soil organisms play an important part in maintaining soil fertility. They recycle nutrients by breaking down plant materials, which release nutrients for plant roots. They also improve soil structure, suppress plant diseases and help to degrade pollutants such as herbicide residues. However, in order for these organisms to survive and work effectively over long periods, sufficient levels of organic matter must be retained in the soil as a source of food.

## Soil profiles

There are many different soil types, many of which have quite distinctive characteristics such as colour, texture, structure and fertility. When assessing a soil it is important to examine the soil profile, which consists of a series of layers or 'horizons'. The features of these horizons depend very much on the age of the soil, the nature of the parent material, climate, slope, vegetation and chemical reactions in the soil. Some profiles consist of quite shallow soils over parent rock. Others can be deep sands with little horizon differentiation. Knowledge of soil profiles is important when deciding what plants to grow. Most pastures have roots which only grow to a depth of approximately 10–15 cm, while perennial horticultural crops may penetrate to a depth of one metre or more. An examination of soil profiles may reveal limitations to growth such as waterlogging, salinity or acidity, and physical barriers such as hard pans, which can often inhibit the growth of plant roots.



Figure 1: Common soil profiles in the Mount Lofty Ranges region. Left: Loam over brown or dark clay. Centre: Acidic sandy loam over brown or grey clay on rock. Right: Shallow soil on rock. Photos: J. Hall, D. Maschmedt, B. Billing.

## Texture and structure

### Texture

Soil texture is the proportion of sand, silt and clay that makes up the mineral portion of soil (Table 1). The proportion of these particles influence the amount of water that can be stored in the soil, the rate of movement of water and air through the soil, the soil's nutrient supply, the ease of root growth, soil workability and resistance to erosion.

Sandy textured soils are well drained, often lack adequate levels of plant nutrients and dry out quickly. Nutrients from fertilisers are easily leached out of sandy soils. These soils are not suitable for building dam walls (a minimum of 30% clay is

needed). Provided clay is present below the soil surface, clay spreading and/or delving (deep ripping to raise sub-soil clay) are practices which increase the clay content of sandy soils, thereby improving water-holding capacity and nutrient levels. Clay soils can become waterlogged, but are quite fertile and hold water well during dry spells. As small clay particles break down they release nutrients for plant growth. Clay-textured soils require more lime to correct acidity than do sandy soils (see Table 3 for a summary of soil characteristics).

Table 1: Texture and soil particles

Texture (when wet)	Soil particles	Particle size
Gritty	Sand	2–0.02 mm
Silky	Silt	0.02–0.002 mm
Smooth and sticky	Clay	< 0.002 mm

Table 2: Textural class

Textural class	Clay %
Sand	0–5
Sandy loam	10–20
Loam	Approximately 25
Clay loam	30–35
Medium to heavy clay	> 50

## Assessing soil texture

Soil texture can be assessed in the field. Take a small sample of moist soil and knead it into a ball. Continue to add a small quantity of water and knead the soil until it just fails to stick to the fingers. Press out the soil ball between the thumb and forefinger to form a ribbon. The feel of the ball and the length of the ribbon indicate the textural grade (see Figure 2).

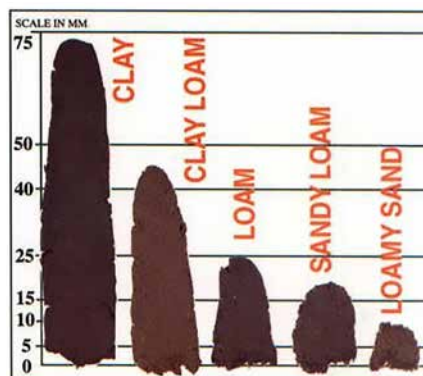


Figure 2: Field chart showing textural classes  
Source: Advisory Board of Agriculture

Table 3: Physical properties of soils in different textural classes

Property	Textural class				
	Sands	Sandy loams	Loams	Clay loams	Clays
Total available water	Very low to low	Low to medium	High to medium	Medium to high	Medium to low
Rate of water movement	Very fast	Fast to medium	Medium	Medium to slow	Slow
Air diffusion (i.e. drainage rate)	Very high	High	Medium	Medium to low	Low
Nutrient supply capacity	Low	Low to medium	Medium	Medium to high	High
Leaching of nutrients and herbicides	High	High to moderate	Moderate	Moderate to low	Low
Tendency to hard-set or surface seal	Low	High	High to medium	Medium	Medium to low
Rate of warming after watering	Rapid	Rapid	Rapid to medium	Medium	Slow
Trafficability and workability after rain or irrigation	Soon	Intermediate	Intermediate	Intermediate	Long
Susceptibility to compaction	Low	Moderate	Moderate to high	Moderate	High

Source: Advisory Board of Agriculture (1998)

## Structure

Structure refers to the way that soil particles (sand, silt and clay) clump together into aggregates. A well-structured soil relies on the formation of small soil aggregates that remain stable when wet and contain pore spaces that allow water and air to penetrate. Organic matter in the soil plays a key role in binding soil particles together.

A poorly structured soil will have aggregates which break down, or do not form, resulting in large dense impermeable clods that act as a barrier to root growth and reduce the penetration of water and air. Most soil structure is inherent to the soil; however, management can improve or decrease structure and condition to some extent.

Surface soils are poorly structured if they have one or more of the following:

- a high proportion of sand and silt – which can set hard
- dispersible clay particles (high sodium percentage)
- low organic matter levels.

Most soils will benefit from the addition of organic matter, which not only encourages good aggregation, but also releases nutrients to assist plant growth. The structure of most heavy clay soils can also be improved by the addition of gypsum, which helps soil particles to aggregate.

Gypsum (calcium sulphate) is effective on *sodic* soils. These are soils with a naturally high level of insoluble sodium. When gypsum is applied to these soils calcium displaces the sodium and the sodium is leached down the profile. The newly created calcium-based clay is much more friable, enabling greater water penetration and better growth of plant roots. The purer the gypsum applied, the more effective it will be. Gypsum is not to be confused with lime. Generally gypsum is used for sodic soils, while lime is used to alter soil pH. In clayey areas which have never seen gypsum before, initial application rates of up to 5 t/ha might be required. The need for subsequent applications depends on local conditions and are usually around 2.5 t/ha.



Figure 3: Variations in soil structure. Left: No structure; sandy soil; lacks organic matter. Centre: Good structure; allows water and air into soil. Right: Poor structure; heavy clay; needs organic matter. Photos: A. Cole.

## Soil fertility

### Soil testing

Summer is the best time to test soils – while they are dry – as this is when the nutrient levels are the most stable and the test results most reliable. Laboratory soil testing is calibrated for summer and autumn sampling.

Soil testing is critical for checking both pH (acidity) and nutrient levels. Inappropriate nutrient and pH levels can severely restrict plant growth.

Any product removal from paddocks, be it hay, milk, meat, wool etc., depletes the nutrient 'bank' in the soil. These nutrients need to be replaced, and this is best determined from the results of a soil test. However, it is also possible to estimate the nutrient levels removed from paddocks to determine how much fertiliser should be added.

A soil test is recommended prior to liming, pasture renovation or sowing a new crop. It is also important to test soils on a regular basis (every few years) to monitor the effect of management on soil fertility and pH.

Different soil types should be sampled separately. The aim should be to take a representative sample of a relatively uniform area, avoiding stock camps, tracks, headlands etc., where conditions may not be representative. If testing pasture or cropping paddocks, approximately 30 cores to a depth of 10 cm should be collected and mixed thoroughly for laboratory testing. In the laboratory only a teaspoon of soil can be tested and this has to represent the area being sampled.

Where perennial horticulture is being planned, it is advisable to engage a qualified professional to undertake a full soil survey, which involves examining the soil profile and testing soil at depth. Soils can then be ameliorated before planting.

In instances where deficiencies are identified, soil test results include recommendations, but if further assistance is required when calculating the level of fertiliser to apply, professional advice should always be sought. The results in Table 4 are from a grazing property in 750 mm rainfall area with an average stocking rate of 10 DSE/ha. No hay is cut, and the soil type is a sandy loam.

**Table 4: Soil test results displaying soil acidity and nutrient levels**

Test	Result	Interpretation	Target level pastures	Recommendation
pH (water)	5.6	acidic	6.0–6.3	
pH (CaCl <sub>2</sub> )	4.7	acidic	5.2–5.5	apply lime
Ext P	16 mg/kg	low	25–45	apply P
Ext K	150 mg/kg	adequate	120–150	
Ext S	9 mg/kg	marginal	>10	apply S
Ext Cu	1.2 mg/kg	adequate	1–2	
Ext Zn	1.0 mg/kg	low	1.2–2	apply Zn
Ext Mn	15 mg/kg	adequate	10–50	

*Note: most soil tests now include a measurement of the phosphorus buffering index (PBI) to more accurately determine phosphorus applications.*

## Nutrients

### Nitrogen (N)

Plants require nitrogen to make protein, and require large amounts for normal leaf growth. It is one of the most widespread nutrient problems in South Australia because it is easily leached from the soil. Plants which display a yellowing of older leaves and stems could be suffering from a nitrogen deficiency.

A range of fertilisers are available to improve soil nitrogen, such as urea, ammonium nitrate and various organic fertilisers. Legumes add nitrogen to soil naturally through a process known as *nitrogen fixation*. On average, lucerne can add approximately 225 kg/ha of nitrogen to the soil each year, while clover can add approximately 100 kg/ha.

### Phosphorus (P)

Most Australian soils, in their natural state, suffer from phosphorus deficiency. Having phosphorus in the soil encourages good root growth and is often incorporated at sowing time (for example, cereals). Plants suffering from stunted growth may be lacking phosphorus. Added phosphorus can be absorbed and held by clay particles and organic matter, resulting in only a fraction of phosphorus being available to plants. In soils with a high pH (alkaline) and those with high levels of iron, calcium and aluminium, phosphorus is less soluble. Phosphorus is also locked up in highly calcareous soils. Sandy soils in high rainfall areas are also prone to phosphorus deficiency due to leaching.

### Potassium (K)

Apart from sandy soils in high rainfall areas, natural potassium deficiencies are generally rare in South Australian soils. However, land management practices may induce potassium deficiencies, such as continual cutting of hay, which removes large quantities of this nutrient. Potassium is required by flowers and seeds, which in turn influence the productivity of fruit and cereals in particular.

### Sulphur (S)

Sulphur deficiencies are generally not widespread in soils containing sulphate compounds and reasonable levels of organic matter. Common high-analysis fertilisers were often low in sulphur, but this nutrient is now being added to improve soil nutrient levels. Gypsum is a good source of sulphur.

### Calcium (Ca)

Most Australian soils have sufficient calcium in the form of limestone, calccrete, and 'soft' lime. However, some soils can be low in calcium, which leads to plant disorders, especially in horticulture.

### Magnesium (Mg)

Sandy soils in high rainfall areas can be heavily leached, resulting in a deficiency of magnesium. These soils can also be quite acidic, in which case dolomite lime may be required. This type of lime will not only correct the level of the acidity, but it will also add magnesium to help correct deficiencies.

### Trace elements

Trace elements are required by plants in only small quantities, but they still have the capacity to severely impede the growth of plants. Situations where deficiencies are most likely to occur are:

<b>copper (Cu)</b>	acid and calcareous sands, alkaline sands, peats and lateritic soils
<b>manganese (Mn)</b>	highly calcareous soils
<b>zinc (Zn)</b>	all soils, especially calcareous and sandy types
<b>molybdenum (Mo)</b>	sandy, acidic soils in high rainfall areas
<b>iron (Fe)</b>	calcareous soils
<b>boron (B)</b>	leached sandy soils (toxic in some clays and saline soils if > 15ppm).



## Soil colour

Soil colour, which is valuable for classifying soils, can vary immensely. The profile of a soil can exhibit a number of layers markedly different in colour, often giving some explanation for how these soils may have originally formed. Colour may also indicate how water has impacted on a soil. Heavily leached soils can display pale sub-soils, as darker coloured organic matter and minerals are washed through the profile.

### How do soils obtain their colour?

Two critical factors which influence soil colour are:

- the nature of mineral matter
- the level of organic matter.

Climate also affects soil colour. Warm moist conditions will often accelerate weathering, creating more highly coloured soils than cooler drier climates.

### Mineral matter

The main colour group of soil is determined by the distinctive colour of the parent rock it formed from. The characteristic red soils of the Gawler Ranges are such a case. Iron compounds can also influence colour, with red, yellow, grey and bluish grey colours dominating. Yellow can also indicate iron which has partly oxidised under conditions of normal air and water. Red soils (fully oxidised) are often better drained, while waterlogged soils can be distinguished by grey or bluish-grey mottling.

### Organic matter

This material breaks down into humus, which is black and therefore impacts significantly on soil colour, particularly in the 'A' horizon (first layer below surface) of a soil profile. Soils which have high levels of organic matter are dark brown or black. Dark soil is generally a characteristic of the top 10 cm of a soil where organic matter levels are quite high. Sandy soils lacking humus will retain their typical light sandy colour.

Soil colours observed in the field are a result of both organic and mineral matter and can be assessed by comparing a broken sample with a Munsell soil-colour chart.

Table 5: Assessment of soil characteristics based on colour

Soil colour	Assessment
Dark colours	Near soil surface; indicates high levels of organic matter and high soil fertility
Reds and oranges	Iron oxides in aerobic conditions in sub-soils; indicates good drainage
Dull colours and mottles	Waterlogging
Pale colours and whites	Low organic matter and leaching

## Soil issues

### Acidity

Soils are often characterised as being acidic or alkaline and measured using the term pH. The pH scale covers a range from 0.0 to 14.0, with 7.0 being neutral (see Figure 4). If soils are measured at less than pH 7.0 (in water) they are considered to be acidic. If they are less than pH 5.0 (in water) they are considered to be strongly acidic.

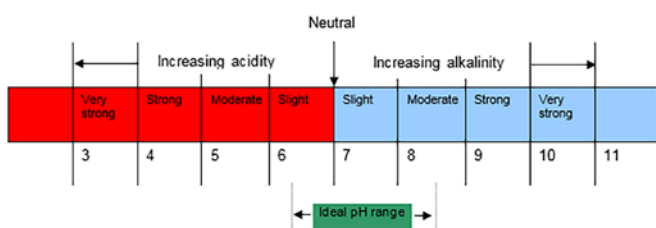


Figure 4: Soil pH scale

A field kit consisting of barium sulphate, universal indicator and a colour chart can give an indication of soil acidity; however, a laboratory soil test should be undertaken to determine the precise pH reading. This will enable the correct amount of lime to be added to neutralise the acidity.

Most laboratories measure pH by two methods pH (water) and pH (CaCl<sub>2</sub>). Typically pH (CaCl<sub>2</sub>), (that is, pH calcium chloride) is about 0.8 units lower than pH (water).

### Causes

Acidification is caused by:

- organic matter decomposing and producing organic acids
- nitrogen compounds being added to soils by fertilisers and legumes (for example, clovers, lucerne and lupins)
- removal of alkaline elements in crops.

Sandy soils in high rainfall areas are often naturally acidic; however, land management practices such as pasture production and removal of nutrients in farm products (for example, hay and silage) can also lead to acidification.

In high rainfall areas nitrogen compounds are generally leached from the soil profile, leaving acid conditions behind. Areas most affected include the Mount Lofty Ranges, South-East, Kangaroo Island and Lower Eyre Peninsula.

Soils can be naturally alkaline, with some being caused by the presence of calcium carbonate. These soils, usually referred to as 'calcareous', will not generally have pH values above 8.5. Those soils which are higher than pH 8.5 can have significant levels of exchangeable sodium (sodic soils).

### Consequences of soil acidity

Most of the detrimental effects of acidity are due to the impacts on the availability of plant nutrients (see Figure 5). In acid soils aluminium becomes available, leading to toxic conditions. Some plants, such as phalaris and lucerne, are especially susceptible to aluminium toxicity and overall production can be severely reduced. In some soils manganese toxicity can also occur where pH is low, resulting in stunted growth and leaf necrosis.

Crops such as potatoes and brassicas can be adversely affected by soil pH. 'Whip tail' in brassicas is due almost entirely to a molybdenum deficiency, which is pH-related, while discoloured curds in cauliflowers are due to a boron deficiency, which can occur at high pH. High soil pH can also lead to powdery scab in potatoes.

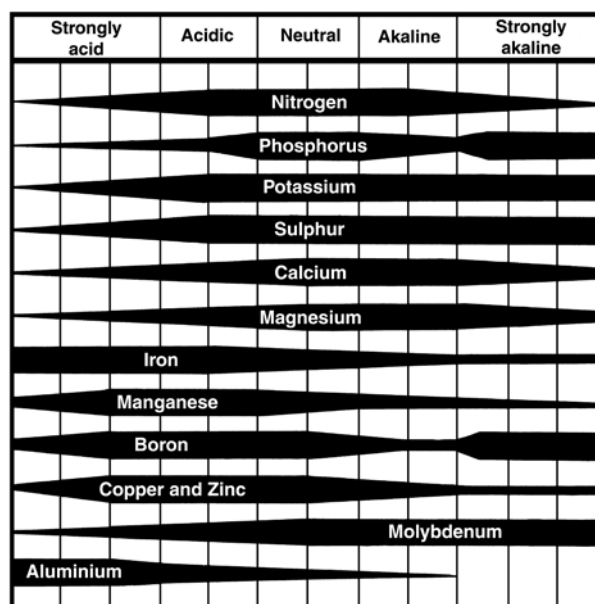


Figure 5: Nutrient availability

### Correcting acid soils

Acid soils can be corrected by the addition of lime. The lime neutralises the acid and raises the pH. When lime (calcium carbonate) is added to soil, the carbonate fraction combines with the acid (H<sup>+</sup> ions) to form water and carbon dioxide.

Conducting a soil test once every 4–5 years is the best way to determine when lime needs to be applied, unless soils are very sandy, in which case every 2 years is more appropriate.

A number of different lime materials are available and include calcium carbonate, hydrated lime, burnt lime and various other materials. The neutralising value of different types of lime is expressed as an index relative to pure calcium carbonate (Table 6). *Dolomite lime* (calcium magnesium carbonate) should only be used where a soil test indicates a deficiency in magnesium.



Table 6: Relative neutralising values of liming materials

Liming material	Relative neutralising value
Calcium carbonate	100
Dolomite lime	95–108
Agricultural lime	85–100
Burnt lime	150–175
Hydrated lime	120–135
Gypsum	Nil
Basic slag	50–70

Source: Price (2006)

### Lime requirements

The amount of lime required to raise the pH of a soil (that is, reduce acidity) will depend on the soil texture, the initial pH and the target pH. Soils with a high proportion of clay and organic matter will have a high capacity to ‘buffer’ and therefore resist changes to pH. These soils require more lime to correct acidity than those with a lower buffering capacity, such as sandy soils with low organic matter (Table 7).

Table 7: Lime requirements to raise soil pH by approximately 1 unit

Soil texture	Lime application rate (t/ha pure fine lime)	Mean (t/ha)
Sand, loamy sand	1.5–2.5	2.0
Sandy loam	2.5–4.0	3.25
Loam, sandy clay loam	4.0–5.0	4.5
Loamy clay	4.0–6.0	5.0

Table 8: Target pH for different land uses

Land use	Target pH (CaCl <sub>2</sub> )	Target pH (water)
Extensive grazing	5.0–5.5	5.8–6.3
Intensive cropping and grazing	5.5	6.3
Most horticultural crops	5.5–6.5	6.0–7.0

For grazing properties, if pH (CaCl<sub>2</sub>) is < 4.5, lime should be added as soon as possible. In all situations lime should be added to prevent the pH from falling below 5.0 (CaCl<sub>2</sub>) Refer to Table 8.

**Example:** Consider an extensive grazing property with perennial pasture (rye/clover) and a 'sandy loam' soil texture. Good lime is to be incorporated to 10 cm depth. Current soil pH (CaCl<sub>2</sub>) = 4.6.

$$\begin{aligned} \text{Lime required} &= (\text{target pH} - \text{current pH}) \\ &\times \text{soil texture factor (Table 7)} \\ &= (5.5 - 4.6) \times 3.25 = 2.9 \text{ t/ha} \end{aligned}$$

In this case 3.0 t/ha per hectare should be applied.

Lime is generally surface-applied and most commonly works its way into the soil over 3–5 years, depending on texture and rainfall. Only if application rates are high (>5 t/ha) will lime be incorporated at depth. This would generally coincide with crop/orchard establishment.

### Salinity

Saline soils are those with levels of soluble salts high enough to impede the healthy growth of plants. Different species will have varying tolerances to salt, but where concentrations are high, plants may not grow at all. Salts can consist of the cations of sodium, potassium, calcium and magnesium and ions of chloride, sulphate, carbonate and bicarbonate. However, in South Australia most of the salts are sodium chloride. Measuring soil salinity is based upon a process of electrical conductivity. The higher the salt concentration, the easier an electric current will pass through the solution. Salinity meters are available for measuring soil salinity; however, an accurate measurement can be obtained when a full laboratory soil test is conducted.

Dryland salinity is caused when water tables rise and bring salts to the soil surface, having an adverse effect on plant growth. Clearance of trees and deep-rooted perennials, which historically have kept the water table below the root zone of plants, has played a major part in this form of degradation.

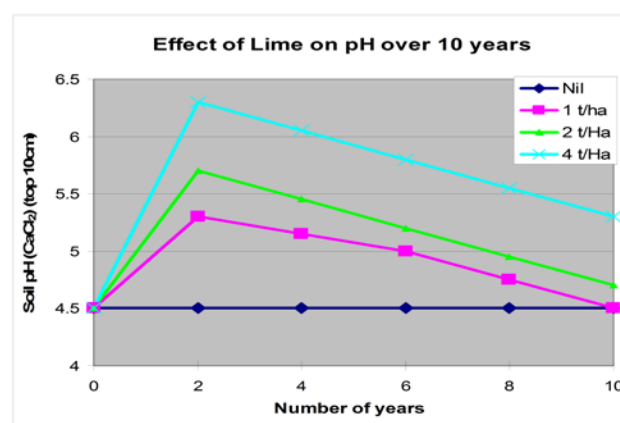


Figure 6: Effect of lime over time  
Source: MacKinnon, Evans & Scott (undated)

### Sodicity

Sodicity occurs when soils contain excessive amounts of sodium. These soils are said to be sodic and can occur in soil where the pH is acidic, alkaline or neutral. The sodium impacts on the behaviour of clay particles, resulting in poor soil aggregation (that is, poor structure) and reduced penetration by water and air. Water tends to pond in sodic soils. The use of gypsum (calcium sulphate) is widely used to reclaim these soils, by replacing the sodium with calcium, which allows aggregation of clay particles and improved soil structure. Where acidic soils exist, a combination of lime and gypsum may be used to address the problem. Sodic soils are susceptible to water erosion and need to be managed carefully to reduce the risk of soil loss.

### Waterlogging

Waterlogging is a product of the amount of water entering the soil and the rate at which water leaves the soil. The loss of water can be from evapotranspiration, percolation and lateral seepage. Due to oxygen starvation in the root zone, waterlogged soils may cause poor plant growth. They can also be detrimental for plant growth because waterlogged soils tend to lose nitrogen and may produce plant toxins. In addition they are prone to compaction by livestock and farm machinery.

Where sub-soil clay layers of low permeability exist, waterlogging is common. Water tends to accumulate above the clay, often resulting in a white bleached layer above a mottled yellow-grey clay horizon. Low-lying areas can often become waterlogged as water runs off due to poor infiltration on hillsides. These areas may benefit from not being grazed during winter to avoid 'pugging'. As soil dries out in spring, livestock can be reintroduced.

### Water repellence

Some soils, particularly sandy soils, are known as 'non-wetting' and display poor infiltration due to water 'beading' on the surface and penetrating very slowly. This problem tends to be worse on sandy soils. Paddocks can show uneven wetting, resulting in patchy germination and establishment of crops and pastures. The cause of this problem is not fully understood; however, organic matter which contains waxes capable of repelling water can form a film over sand particles, creating a barrier to water absorption. These soils can be susceptible to water erosion, especially during intense summer storms. Various furrow-sowing techniques, along with clay spreading or 'delving' (deep ripping to raise sub-soil clay) are common management techniques.

### Soil erosion

Erosion by wind and water can severely degrade land. Soil loss from erosion events can be significant, with a loss of one millimetre of top soil representing 10–12 t/ha, and the loss of approximately 10 kg/ha of nitrogen and 2 kg/ha of phosphorus. Large tracks of primary production land can be lost due to gully erosion, while silt in watercourses and dams can damage aquatic habitats and interfere with the respiration of fish and other biota.

Light sandy soils are very susceptible to wind erosion once the surface is loose, whether by cultivation or grazing animals. The keys to minimising wind erosion risks are:

- maintaining adequate vegetation or stubble cover, especially when the soil surface is loose; grazing animals tend to loosen and bare the soil surface
- minimising the time between the first cultivation and early crop emergence
- using low-intensity tillage practices (for example, direct drill, no till)

- managing sand hills and other very sandy soils separately from less erodible soils; ultimately they should be fenced off and permanently stabilised by planting perennial vegetation

- establishing windbreaks to reduce surface velocity and combat the erosive forces of the wind.

There are a number of factors which contribute to water-erosion risk. These include soil characteristics (that is, texture, depth and the nature of sub-soil clay horizons), steepness and length of slopes, surface disturbance and, in particular, the amount of soil surface cover and rainfall intensity. Cropping land with slopes of 4% to 12% is likely to exhibit medium-to-high risk of water erosion. On these slopes contour banks have been constructed to reduce run-off and erosion.

In high rainfall areas with steep slopes, the cultivation of land can lead to serious water erosion; consequently, direct drilling of pastures is recommended. Maintaining good surface cover throughout the year is the key to reducing the risk of soil erosion (see Figure 7). As a general rule landholders should always maintain a minimum of 70% ground cover. Appropriate grazing-management practices need to be adopted for annual and perennial pastures.

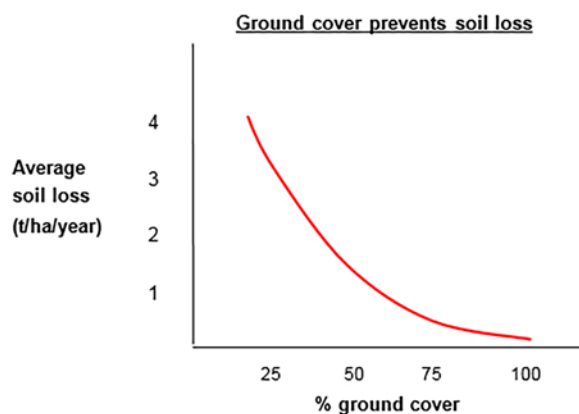


Figure 7: Ground cover and soil loss  
Source: Mount Lofty Ranges soil conservation boards

# 4. Pasture management

## The role of pasture

The concept of an ideal pasture varies between regions. Seasonal variations, soil type and the purpose for which it is being used will determine what is suitable. However, pastures should:

- be productive and meet the nutritional needs of stock
- withstand grazing and persist
- resist disease and weed invasion
- provide good ground cover throughout the year
- not cause any livestock health problems.

Most pastures are made up of grasses and legumes. Common legumes include clovers and medics, which have high levels of digestible protein and also greater concentrations of calcium compared with grasses. Grasses produce the bulk of pasture growth during the year and have a greater tolerance to grazing than legumes.

Pasture plants can be described as either *annual* or *perennial*. Annual plants survive for only one year. They germinate in autumn following the opening rains and grow strongly in spring. In late spring they set seed, which remains dormant over summer until autumn rains promote germination and the cycle begins again, for example, Subterranean Clover (*Trifolium subterraneum*). Perennial plants live for more than 2 years and generally have deeper root systems than annuals. They are highly productive and have the capacity to grow all year if water is available. Phalaris (*Phalaris aquatica*) and Cocksfoot (*Dactylis glomerata*) are common perennial pasture grasses. Rainfall and soil type will play an important part in determining whether perennial or annual pastures are sown (or a mixture of both).

## Identification of common pasture plants

### Perennial Ryegrass (*Lolium perenne*)

A perennial grass native to Europe, Asia and North Africa, ryegrass was brought to Australia on the First Fleet and remains one of the country's most important grasses in high rainfall and irrigation areas. It is easy to establish, has good nutritional value and is highly digestible. Unfortunately, some cultivars contain an endophyte fungus which can affect the nervous systems of animals, causing 'grass staggers'. Horses and alpacas are particularly susceptible and can display symptoms of trembling, staggering and loss of balance. It is not usually fatal, although animals can be severely injured as a result of falling. They will generally recover quickly if removed

from those paddocks and fed non-toxic feed. Low endophyte cultivars can be planted for animals that may suffer from this condition. Cultivars available differ greatly in maturity, growth habit, and resistance to disease and moisture requirements. The minimum rainfall required is approximately 600 mm per annum for dryland pasture cultivars (for example, Avalon, Victorian and Ellett). Perennial Ryegrass is also ideal under irrigation, where it can be sown with White Clover. Sowing rates range from 8 to 30 kg/ha, depending on seed size, rainfall and irrigation.



Figure 1: Perennial Ryegrass. Photo: A. Cole.

### Phalaris (*Phalaris aquatica*)

Phalaris is a deep-rooted perennial grass native to the Mediterranean region and requires at least 450 mm rainfall per year. It is relatively drought-tolerant and should persist, provided pastures are not overgrazed during spring. Phalaris has very low seedling vigour so care should be taken at establishment. It will persist on a wide range of soil types, including heavy waterlogged soils, but of the temperate grasses it is the most sensitive to acid soils, where aluminium toxicity can severely reduce growth. It performs best on neutral soils. Although the risk is small, livestock may experience staggers when grazing phalaris-dominant pastures, which are low in cobalt. In some cases sudden death may occur during autumn and early winter. Animals should be moved to a non-toxic pasture and veterinary advice sought. Sowing rates are generally 2–4 kg/ha when mixed with other cultivars, or 4–6 kg/ha when sown as a sole grass. Cultivars include Holdfast, Siroso and Sirolan.



Figure 2: Phalaris. Photo: A. Cole.

### Italian/Annual Ryegrass (*Lolium multiflorum*)

This pasture is suited to lower rainfall areas where Perennial Ryegrass will not survive. It is native to Europe and comprises both biennial and annual cultivars. Italian ryegrasses are generally used in short-term pastures for the production of high-quality hay or silage, but are sometimes used as a minor component of a perennial pasture. They are quick to establish and are of high nutritional value. The minimum rainfall requirement is 450 mm, unless irrigated cultivars are being used. The sowing rate is generally 15–30 kg/ha depending on seed size, rainfall or irrigation. Cultivars include New Tetila, Tetrone and Dargo.

### Cocksfoot (*Dactylis glomerata*)

Cocksfoot is a deep-rooted perennial grass of high-to-moderate drought tolerance (depending on the cultivar). Native to Northern Europe and the Mediterranean region, it requires a minimum of 450 mm rainfall. Cocksfoot will not tolerate waterlogged soils, but does grow well on slightly acidic soils. The quality, or perceived lack of quality, of cocksfoot has for some time been an issue; however, new cultivars are of a higher quality. Its persistence and quality can be further improved by attention to grazing management. Cocksfoot does not contain animal toxins and is often recommended as a suitable pasture for alpacas and horses. Cultivars include Currie and Porto.

### White Clover (*Trifolium repens*)

White Clover is a perennial clover, native to Europe and is suited to regions with at least 750 mm rainfall per year or where irrigation is available. It is easy to establish and produces surface runners which form roots at the nodes. It will grow on a wide range of soil types, but is most highly productive on fertile soils. One method of differentiating White Clover is by its large leaf size, another by stolon density. Persistence in pasture is usually in those cultivars whose stolon density is



Figure 3: Cocksfoot. Photo: A. Cole.

highest, although some persistence can be attributed to seed set. When sowing irrigated pastures White Clover is often mixed with Perennial Ryegrass or Tall Fescue. Sowing rates vary from 1–2 kg/ha for Dryland conditions, and 3–5 kg/ha in high rainfall areas or where irrigation is available. Cultivars include NuSiral, Demand and Haifa.

### Subterranean Clover (*Trifolium subterraneum*)

Native to the Mediterranean region, Subterranean Clovers grow on a wide range of soil types. Rainfall requirements vary from 250 mm per year to in excess of 750 mm, depending on the variety. Subterranean Clover is a self-regenerating annual which buries its seed in the ground. It adds considerable quantities of nitrogen to the soil, which benefits the growth of pasture grasses. Sowing rates are generally 4–12 kg/ha when mixed with perennial grasses. If irrigated, the rates may be as high as 15 to 25 kg/ha. Cultivars include Nugarin, Trikkala, Gosse and Leura.



Figure 4: Subterranean Clover. Photo: A. Cole.

Table 1: Characteristics of some Subterranean Clover varieties

Cultivar	Rainfall (mm)	Days to flowering	Hard seed	Characteristics
Nungarin	275-450	77	10	Very early
Dalkeith	350-600	97	9	High hard seed levels
Seaton Park	400-600	110	6	Persistent, moderate production
Trikkala	450+	112	2	Tolerates waterlogging
Karidale	550+	139	2	Low hard seed levels

Source: Seed Distributors

### Lucerne (*Medicago sativa*)

Lucerne is a deep tap-rooted perennial legume. It is one of the oldest cultivated plants in the world and is prized for its drought-tolerance and high quality as an animal feed. With proper establishment and management Lucerne has the ability to survive for over 20 years. It requires well-drained fertile soils with a pH ranging from neutral to alkaline. All lucernes are summer-active, but are rated on a scale of 1 to 10 by their winter activity (1 is winter-dormant, 10 is highly winter-active). The choice of cultivar should, as a general rule, depend on its intended use and the area where it will be sown. Lucerne is most productive under irrigation where it can be rotationally grazed or cut for hay. It can also be sown into a dryland pasture mix but requires at least 250 mm of rain during the growing season. Sowing rates vary from 6–10 kg/ha for dryland production, and 8–15 kg/ha under irrigation. Cultivars include Trifecta, Aurora, SARDI 5, SARDI 7 and SARDI 10.



Figure 5: Lucerne. Photo: A. Cole.

### Tall Fescue (*Festuca arundinacea*)

Tall Fescue is a deep-rooted perennial grass native to Europe, the Mediterranean region, and Asia. Tall Fescue is suited to soils of medium-to-high fertility and will tolerate some waterlogging and moderately saline conditions. There are now two distinctively different types, summer-active and summer-dormant. Summer-active Tall Fescues have the ability to out-produce Perennial Ryegrass during summer and require periodic summer rainfall or irrigation. Summer-dormant types have the ability to persist in areas of very low rainfall. Tall Fescue is most productive under irrigation, but can be included in dryland pasture mixes where the rainfall is at least 450 mm per year. The sowing rate is generally 10–20 kg/ha. Cultivars include Advance, Typhoon and Prosper.



Figure 6: Tall Fescue. Photo: A. Cole.



## Medics (*Medicago* spp.)

The term Medics describes a particular group of annual legumes. They are predominantly suited to alkaline soils in medium-to-low rainfall areas. Medic species originated in Europe and are generally yellow-flowered, and named according to pod appearance (that is, Snail, Barrel, and Burr). The pods of most medics generally hold between 4 and 10 seeds per pod. Persistence and resistance to pests and diseases make them ideally suited to many areas. Generally sown in autumn, the seed should be sown to a depth of no more than 10 mm. The sowing rate, when blended with selected grass species, is usually between 5 kg and 10 kg/ha, depending on the variety.

## Salt-tolerant pastures

A soil test may reveal salinity levels which preclude the sowing of many pasture species. In this case, the use of salt-tolerant plant species is advised. Puccinellia (*Puccinellia ciliata*) and Tall Wheat Grass (*Thinopyrum ponticum*) are suitable perennial grasses, while Strawberry Clover (*Trifolium fragiferum*) and Balansa Clover (*Trifolium michelianum*) are both tolerant of moderately saline soils.

## Examples of pasture mixes

When choosing a particular pasture mix it is important to acknowledge the purpose for which the pasture is being planted. Other considerations include the nature of the grazing livestock, soil properties, rainfall and other climatic factors. The characteristics of pasture species can then be selected to best match these conditions.

Legumes are particularly important because they can improve soil nitrogen levels. They contain rhizobia bacteria in their roots, which convert nitrogen gas from air pockets in the soil into a usable form of nitrogen for plants.

The following examples represent only a handful of suitable mixes which could be used in particular circumstances. Professional advice should always be sought before decisions are made on what pastures to sow.

## Horse pasture for Northern Adelaide Plains (375–450 mm per annum)

On a neutral-to-alkaline red-brown earth with moderate stocking rate, a mixture of Annual Ryegrass and legumes (mainly medics) would be suitable. The following mixture could be sown as an annual pasture, which would require careful grazing over summer and autumn to maintain at least 70% cover.

Safeguard Annual Ryegrass	@ 10 kg/ha
Barrel Medics (Mogul, Caliph, Paraggio, and Sephi)	@ 5 kg/ha
Balansa Clover (Paradana)	@ 1 kg/ha

Safeguard Annual Ryegrass has resistance to the nematode associated with Annual Ryegrass toxicity (ARGT). This toxicity can lead to stock losses and has been associated with the use of Wimmera Ryegrass.

## Irrigated perennial pasture

A mixture of Perennial Ryegrass and White Clover is commonly used to produce high-quality feed for dairy cattle grazing. This pasture is ideal for hay and silage production.

Perennial Ryegrass (Bronsyn 20%, Samson 20%, Avalon 20% and Dobson 20%)	@ 20 kg/ha
White Clover (Nusiral 5%, Demand 5% and Haifa 10%)	@ 5 kg/ha

## Non-irrigated perennial pasture (650+ mm per annum)

On heavier soils such as loams or clay loams, a mixture of Perennial Ryegrass and Subterranean Clover is traditionally used to produce high-quality feed for grazing livestock. The following pasture is suitable for high rainfall areas of the Mount Lofty Ranges.

Perennial Ryegrass (Ausvic 20%, Skippy 20%, Avalon 20%)	@ 15 kg/ha
Subterranean Clover (Goulburn 10%, Trikkala 10%, Denmark 10% and Gosse 10%)	@ 10 kg/ha

### Non-irrigated perennial pasture (450–600 mm per annum)

On lighter sandy loams in lower rainfall areas, Cocksfoot and Phalaris can be considered as a substitute for Perennial Ryegrass, which will struggle to persist. The following pasture mix is often sown in the Mount Lofty Ranges.

Cocksfoot (Porto or Currie)	@ 3 kg/ha
Phalaris (Holdfast or Sirosa)	@ 4 kg/ha
Subterranean Clover (Denmark 15%, Riverina 15%, Seaton Park 15% and Trikkala 15%)	@ 10 kg/ha

The use of Cocksfoot and Phalaris can be influenced by soil pH (acidity), so professional advice should be sought before sowing.

### Assessment of pasture quality

Good-quality pastures should provide livestock with appropriate amounts of energy, protein and fibre for continued growth. If pastures are weedy and dominated by plants with low digestibility, livestock productivity may decline, while the risk of soil degradation, such as erosion, may increase.

It is important to adopt good grazing strategies to ensure maximum pasture utilisation and improve productivity on both dryland and irrigated pastures (Table 2).

**Table 2: Utilisation for irrigated and non-irrigated perennial pastures in the Mount Lofty Ranges**

Quality	Non-irrigated (dryland) pasture, tonnes dry matter/ha/per annum.	Irrigated pasture, tonnes dry matter/ha/per annum
Poor	< 3	< 9
Average	3–4.5	9–12
Good	4.5–8	12–18

*Note: pasture 'utilised' includes all pasture eaten by stock or preserved as hay or silage, and excludes plant material which naturally decomposes during the season*  
 Source: Herrmann & Mitchell (2002)

### Pasture benchmarks for pasture sustainability and persistence (rainfall > 500 mm per annum)

As a general rule, pastures in high rainfall areas (> 500 mm) should have a balance of perennial grasses and legumes. As a minimum, 20 perennial grass plants and 60 clover plants per square metre will avoid the necessity to re-seed the pasture. Using fertiliser, adopting good grazing practices and applying selective herbicides for weed control should improve a pasture of this quality. However, to maximise carrying capacity, and, hence, productivity pastures should contain the following plant densities.

#### Late summer

- Perennial Ryegrass: 60 plants/m<sup>2</sup> (minimum) and 100 plants/m<sup>2</sup> (ideal)
- Phalaris, Tall Fescue and Cocksfoot: at least 20 plants/m<sup>2</sup>
- Lucerne and Chicory: at least 30 plants/m<sup>2</sup>
- Subterranean Clover seed reserves: 50 kg/ha (minimum) and 300+ kg/ha (ideal)

#### After the break (May/June)

- Subterranean Clover plants: 50 plants/m<sup>2</sup> (minimum) and 150 plants/m<sup>2</sup> (ideal)

#### Late spring

- legume percentage (as dry matter): 30% (minimum) and 50% (ideal)

#### Summer

- remove livestock when there are fewer than 600 kg of dry matter/ha on offer (approximately 2 cm pasture height), and or less than 70% ground cover of any dry matter.

### Feed quality

It is important to understand that the nutritional value of pasture plants will vary. Selecting the correct pastures can impact on livestock productivity. As a general rule, legumes are high in protein, while grasses provide fibre and energy.

Table 3: Nutritional values of pasture and grain

Feed	Dry matter % (excl water)	Energy (MJ/kg DM)	Protein % (of dry matter)
Barley grain	90	12.5	10
Oats grain	90	10.0	8
Lupins grain	90	12.5	30
Beans grain	90	12.5	23
Pasture hay			
- Good quality	90	9.8	18
- Average quality	90	9.0	12
- Poor quality	90	7.8	8
Silage (good)	40	10.0	18
Lucerne hay	90	9.3	20
Green pasture			
- Young, lush	15	11.5	25
- Flowering	25	10.0	15
- Mature	50	6.0	5–10
Dry pasture	90	5-6	5–8

Source: Ellis (2006)

The quality and quantity of a pasture change during the growing season. Once perennial grasses begin flowering in spring, pastures are generally at their optimum for quality and quantity. If insufficient livestock are available to consume the pasture, it should be preserved as hay (or in some cases silage).

*Silage* is made from green pasture or fodder crops and is cut earlier than normal hay. The plant material is preserved by a process of bacterial fermentation, whereby sugars are converted to lactic acid. This usually takes about 2 weeks. Traditionally, silage was placed in large heaps on the ground and rolled by a tractor to push out all the air, then covered by a plastic sheet held down by recycled tyres. However, storing silage as individual bales has become more popular. In this situation pastures are cut when plant dry matter is around 60–70%. The bales are wrapped tightly in plastic to exclude oxygen, and the material then goes through a limited fermentation.

Late October to early November is usually the time for most pastures to be cut for hay. The volume of feed, together with the balance of digestible dry matter and crude protein percentage, is optimum at this time (see Figure 7).

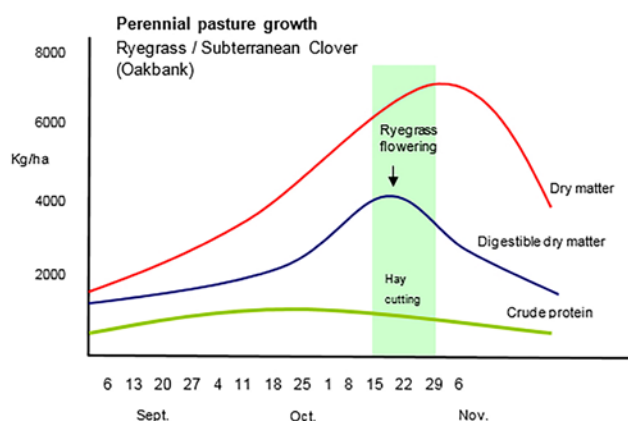


Figure 7: Growth of perennial pasture, Mount Lofty Ranges > 600 mm

Table 4: Nutritional values of hay

Hay type	Dry matter %	Energy Mj/kg	Protein %	Fibre %
Oaten – early-cut	90	9.8	6	29
Oaten – late-cut	90	9	6	33
Grass/clover (medium-quality)	90	8	12	28
Grass/clover (good-quality)	90	9	14	24
Lucerne (half-flowering)	90	7	20	29
Lucerne (full-flowering)	90	7	15	32

Source: Foyel (1994)

Oaten hay generally contains a lower percentage of protein than grass/legume hay (Table 4); however, it does contain high energy levels compared with Lucerne hay, which is very high in protein, and can contain up to 24% crude protein.

## Soil fertility

For maximum pasture growth soils need to be healthy and provide the right environment for plants to grow. Soil testing should be conducted to determine nutrient imbalances and to identify the pH (acidity) of the soil (refer to Chapter 3 Soil management). When growing grass-dominant pastures in high rainfall areas, plants are unlikely to receive adequate levels of nitrogen, which are normally provided by legumes such as clovers and medics. In these circumstances 15 to 25 kg/ha of nitrogen fertiliser may have to be added to maximise pasture growth, depending on the amount of legume present.

In a typical perennial grass/clover pasture where rainfall is > 500 mm, landholders who are considering cutting pasture for hay may benefit from adding fertiliser in August that contains nitrogen, phosphorus and potassium. Livestock should be removed from paddocks at this time to ensure maximum paddock growth.

## Grazing management

### Rotational grazing

Pasture productivity and weed control depend to a large extent on how well pastures are grazed. If continuous grazing (or set stocking) is adopted, paddocks are not rested and livestock selectively graze. This will result in more unpalatable pasture and weed species setting seed, which leads to poorer pastures over time. Pastures are often unevenly grazed and stock camps can create bare areas, which may increase the risk of soil erosion.

Rotational grazing is recommended for most circumstances, and is best described as a period of grazing followed by a period of rest. This system is regarded as a very efficient way to utilise pasture throughout the year. Strip grazing and cell grazing are both forms of rotational grazing, the aim being to enable the plants to recover quickly from being grazed, after which they grow to a height suitable to be grazed again. This will keep the plants in a productive vegetative state. Plants which are continuously grazed often struggle to recover and may die in hot dry conditions during summer. If plants are allowed to grow too tall, the lower leaves can become shaded, brown off and rot with a loss of productivity.



Figure 8: Estimations of pasture ground cover. Left: 10% cover. Centre: 70% cover. Right: 100% cover. Photos: A. Cole.

There is no set figure for how frequently stock should be moved on from a paddock. Times could vary between 3 days and a month, depending on the number of livestock and the size of the paddock. Assessing the state of the pasture is the critical factor in determining when to rotate stock. Pastures should not be grazed lower than 3 cm and ground cover should always be 70% or more (see Figure 8).

### Grazing pressure

The higher the grazing pressure, the more efficiently pasture feed is utilised, resulting in less waste. Grazing pressure can be increased in a property by increasing the number of paddocks, while the overall stocking rate remains constant. On small properties livestock should be rotated through at least 4 paddocks; however, if more paddocks are available even better control of stock is possible, resulting in higher grazing pressures.

A 48-hectare property carrying 40 cows, according to the recommended stocking rate, will have a grazing pressure of 0.83 cows/ha if the property has only one paddock (that is, 40 cows divided by 48 ha). If the property is divided into 4 paddocks the grazing pressure can be 3.3 cows/ha (that is, 40 cows divided by 12 ha). If 6 paddocks are available, the grazing pressure can be 5 cows per hectare. The time spent grazing each paddock becomes less, and the pasture is rested for longer, giving plants more time to recover.

Cattle and horses usually respond well to electric fencing, which will help to lower costs when increasing paddock numbers.

### Establishing new pastures

Many landholders may consider re-seeding pastures to provide better feed for livestock and to control weeds. Degraded pastures containing very few good pasture species and dominated by weeds may need to be re-sown. However, it is important to ensure that clear benefits will be realised, because the process can be expensive and is not without risks. The presence of weeds alone is not necessarily a sufficient reason to start again with a new pasture. Pastures may contain a minimum number of pasture species that would benefit simply from good weed control, the addition of appropriate fertilisers and strategic grazing. Some pastures may only require additional seed to be 'oversown' to improve the density. If unsure, the landholder should seek professional advice before embarking on the process of 'pasture renovation' (that is, sowing a new pasture).

If new pastures need to be sown, good weed control undertaken in the year prior to seeding is an important preliminary step. Many failures can be attributed to pasture seedlings unable to compete with stronger more vigorous weed seedlings during autumn.

Landholders should also be aware that no grazing will be possible during the first 3 months of a newly sown pasture and that only limited grazing will be available for the following 9 months, meaning that the feed requirements of all livestock on the property will need to be considered for that year.

Unless paddocks need to be levelled (that is, the surface smoothed), the recommended technique for re-seeding is direct drilling (see Figure 9). This involves the use of non-selective herbicides to control weed growth during autumn, after which the pasture seed is drilled into the soil with minimum soil disturbance.

### Checklist

It is important for landholders to recognise the need to follow a 2-year plan to establish a new pasture and not to omit any steps in the process. The following checklist is suitable for establishing pastures in high rainfall areas of the Mount Lofty Ranges.

#### Assess, select and plan early:

- Assess existing pasture, weeds and soil fertility.
- Seek professional advice if unsure whether to resow.
- Check on the availability of equipment and/or contractors.

#### Control weeds/pests the year before sowing:

- Spray or spray-graze to control broadleaf weeds.
- Spray metsulfuron methyl to control Guilford Grass or Dock (late July).
- Spray-top, slash or graze to control annual pasture weeds.

#### Check soil fertility:

- Test soil over summer to check fertility levels.
- Apply lime (if required) any time up to sowing.
- Seek advice on a suitable fertiliser program.

#### Graze prior to sowing:

- Graze well over summer to remove residues.

#### Control weeds and pests in autumn:

- Allow a full weed germination after the autumn break (normally 3 weeks after opening rains).
- Spray appropriate herbicides/insecticides to control weeds and pests (for example, Redlegged Earth Mite).
- Cultivate only if paddock has to be levelled. Cultivate to achieve a firm, fine weed-free seedbed.

#### Ensure adequate soil moisture:

- Don't sow on the first autumn rains.
- Sow into moist soil after weeds have been controlled.
- Sowing can commence if significant rain (>12 mm) is likely soon afterwards.

#### Place seeds accurately when sowing:

- Direct-seed to achieve 5–10 mm soil cover over seed.
- As a guide, around 5% of the seed should be visible after sowing.

#### Monitor weeds and pests:

- Check weekly for any pasture pests.
- Treat problems promptly.

#### Strategically graze new pastures:

- First graze when plants are 10 cm tall and well anchored.
- Graze heavily but quickly down to around 3 cm.
- Re-graze when plants again reach 10 cm tall.
- Reduce grazing pressure in the first spring.
- Do not graze horses in the first year of a new pasture.
- Do not cut hay in the first year of a new pasture.



Figure 9: Disk drill for seeding perennial pastures. Photo: A. Cole.

## High rainfall pasture management calendar

The following calendar is a guide only, since pasture management will vary according to average rainfall, seasonal conditions, soil types, slopes, aspects, pasture species and the type of stock grazing. On small lifestyle properties, hay cutting will depend upon the availability of machinery and/

or contractors. If it is not possible to cut hay, overgrown paddocks may need to be slashed or grazed by additional livestock brought into the property. If left untouched during late spring and summer, overgrown pastures may become rank and unpalatable to livestock and also become a fire hazard.

Table 5: Pasture management calendar

Month	Activity
January to March	Graze down dry residues to 3 cm; do not overgraze, and maintain 70% cover Supplementary-feed livestock Soil test on paddocks to determine fertiliser and lime application rates Lime paddocks in March, if necessary
April	Fertilise according to soil test reports If fertilising close to watercourses, split applications are recommended (half in autumn and the remainder in late winter) Control Redlegged Earth Mite, Lucerne Flea and Pasture Cockchafer, if present
May	Inspect for weeds, spray early for broadleaf weeds, if necessary Control insect pests, if necessary Graze paddocks in rotation
June and July	Inspect for weeds, spray for broadleaf weeds, if necessary, and follow instructions for safe applications and livestock withholding periods Spray for Guildford grass in late July if dense infestations present (if spraying for Guildford grass in late July with metsulfuron methyl, pastures may need to be re-sown the following year) Apply 25 kg/ha of nitrogen to grass-dominant pastures
August	Apply NPK fertiliser in late August to hay paddocks Close these paddocks off in early to mid August if cutting hay
September and October	Watch for insect pests (e.g. Lucerne Flea and Redlegged Earth Mite) and control if there is a problem Spray-top annual grasses in weedy paddocks (seek professional advice) Hard-graze paddocks not cut for hay, especially if weedy
October and November	Cut pasture for hay or silage (it is important not to cut hay off the same paddock year after year since this will encourage the build-up of annual weeds and reduce the quality of pasture; hay paddocks should be rotated over a 3–4 year cycle) Continue to rotationally graze Aim to have 10 cm of pasture cover by the end of December
December	Continue to rotationally graze; always keep 70% cover

Source: Prance & Fairbrother (2003)

## Identification and management of pasture weeds

Good land management remains the key to controlling most weeds in pastures. If chemical use is necessary, the application of low-toxicity herbicides at the correct time of the year will be better for the environment, be more effective and help to reduce costs.

There are a number of pasture-management techniques that will help to keep weeds from becoming a serious problem.

These include:





- soil testing and adding appropriate fertilisers
- liming acid soils
- rotational grazing
- keeping good ground cover

- oversowing with perennial grass and clover
- hard-grazing in spring to reduce seed set of annual grasses
- rotating hay paddocks to avoid a build-up of annual grasses
- using low-toxicity herbicides, if necessary
- integrating biological control measures where possible.

If the use of chemicals is necessary, the timing of applications is important to ensure that the control of weeds is effective. This will avoid the necessity to apply more chemicals at a later stage to eradicate larger plants. The following chart outlines the most appropriate times to control weeds.

Table 6: Calendar for chemical control of weeds

Weeds	Months											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Blackberry, Broom	Optimum	Optimum	Suitable	Suitable	Seek advice	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Optimum	Optimum
Gorse	Optimum	Optimum	Suitable	Suitable	Seek advice	Seek advice	Seek advice	Seek advice	Seek advice	Seek advice	Optimum	Optimum
Boneseed	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Seek advice	Optimum	Optimum	Optimum
Hawthorn	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Optimum	Optimum	Optimum
Olive (wild)	Optimum	Optimum	Suitable	Suitable	Seek advice	Seek advice	Seek advice	Suitable	Suitable	Suitable	Optimum	Optimum
Salvation Jane and Thistles	Not suitable	Not suitable	Not suitable	Optimum	Optimum	Optimum	Optimum	Suitable	Suitable	Suitable	Suitable	Not suitable
Broadleaf pasture weeds	Not suitable	Not suitable	Not suitable	Optimum	Optimum	Optimum	Optimum	Suitable	Not suitable	Not suitable	Not suitable	Not suitable
Cape Tulip	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Optimum	Optimum	Optimum	Optimum	Suitable	Not suitable	Not suitable
Bridal Creeper	Not suitable	Not suitable	Not suitable	Not suitable	Suitable	Suitable	Optimum	Optimum	Optimum	Suitable	Suitable	Not suitable
Watsonia	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Optimum	Optimum	Optimum	Not suitable
Water Dropwort	Not suitable	Not suitable	Not suitable	Not suitable	Suitable	Suitable	Suitable	Suitable	Optimum	Optimum	Optimum	Optimum

Legend      Optimum       Suitable       Seek advice       Not suitable 

Source: Macspred Pty Ltd (undated)



### Annual broadleaf weeds (Capeweed, Geranium and Salvation Jane)

Most landholders think of using herbicides when confronted with paddocks full of Capeweed (*Arctotheca calendula*), Storksbill (*Erodium* spp.) or Salvation Jane (*Echium plantagineum*). While herbicide use is an important tool for controlling these plants, it is only one of the management options available.

If paddocks become bare, weed seeds present in the soil are likely to germinate – especially in autumn. Establishing and maintaining a perennial pasture in high rainfall areas will help to combat this problem. Perennial pastures consisting of Cocksfoot, Phalaris, ryegrass and clover will allow grazing and provide competition for germinating broadleaf weeds, as well as reduce the reliance on herbicide use.

If using herbicides to control annual broadleaf weeds, spraying should occur early in the season when plants are small and lower rates can be applied. Early spraying encourages more desirable plants to grow without competition from aggressive weeds.

Selective herbicides such as Agtryne MA® and Tigrex®, which contain MCPA, are available for use in pastures. MCPA can be used on its own, but is most effective if cattle or sheep are grazed after spraying. The use of MCPA in paddocks where horses are grazing is not recommended because it can be detrimental to the health of these animals. Jaguar® is available but this chemical is very expensive and is only effective on very small rosettes. Metsulfuron methyl can be used to control flowering Salvation Jane in early spring.

**\*Warning: do not use products with MCPA (or similar volatile chemicals) before mid-May or after the end of August within 1 km of vineyards or horticultural crops etc. Damage to these crops could result.**

Biological control can be used as part of an integrated weed management program. In the case of Salvation Jane effective control can take up to 10 years. There are four main insects that are the focus of Salvation Jane biological control. The *Crown Weevil* larvae attack the growing crown of the plant, while the *Root Weevil* larvae feed on the taproot, effectively ring-barking the root. The *Flea Beetle* larvae also attack the primary and secondary roots. The impact of the *Pollen Beetle* is to reduce the amount of seed set.

### Bulbous weeds (Guildford Grass, Watsonia and Cape Tulip)

Despite its name, Guildford Grass is not a grass. It belongs to the family Iridaceae and is a bulb. Guildford Grass (*Romulea rosea*), sometimes referred to as Onion Grass, has long tough leaves, of up to 12.5 cm in length, and thrives in the low-fertility soils found throughout the high rainfall areas of the Mount Lofty Ranges. Landholders may also encounter Lesser Guildford Grass (*Romulea minutiflora*), which has a similar distribution.

Guildford Grass has been known to create problems for livestock (especially horses and cattle) when it forms a tough fibrous ball, blocking the animal's digestive tract. In some cases this can be fatal.

Poor pasture management, coupled with low-fertility soils, encourages the spread of this allopathic weed, and as a result, pasture growth is suppressed. Studies in Victoria have shown that adding 10–15 kg/ha of phosphorus, depending on soil type, can prevent it from invading perennial grass/ subterranean clover pastures.



Figure 10: Common annual broadleaf pasture weeds. Left: Capeweed. Centre: Storksbill. Right: Salvation Jane  
Photos: L. Hyde and A. Cole

Where this weed has become dominant, herbicide applications may be necessary. Metsulfuron methyl applied at 15 gm/ha is effective in controlling Guildford Grass, provided it is applied in late July. It may be necessary to re-seed pastures in autumn if applying metsulfuron methyl because it will kill Subterranean Clover and can damage or kill Perennial Ryegrass. Professional advice should be sought for particular situations.

Other bulb weeds include Watsonia (*Watsonia bulbifera*) and Cape Tulip (*Homeria* spp.), both of which can become quite invasive. Digging out the bulbs before they have time to flower can be effective for small patches; however, if landholders need to rely on chemical control, metsulfuron methyl is effective against both weeds. Glyphosate is also effective against Watsonia but is non-selective and may render the ground bare, encouraging the establishment of further weeds.



Figure 11: Guildford Grass (*Romulea rosea*). Left: Seedpod. Centre: Bulb. Right: Flower (pale to bright pink).  
Photos: B. Kinsey, A. Cole and A. Chapman



Figure 12: Cape Tulip (*Homeria* spp.) flower and bulbs  
Photo: K. Warner and M. Bullers



Figure 13: Watsonia (*Watsonia bulbifera*) leaves and flower  
Photo: A. Cole and K. Blood

### Perennial broadleaf weeds (Catsear and Dock)

Perennial broadleaf weeds can be difficult to control once they are established in a pasture. They often have well-established root systems and very effective seed-dispersal mechanisms. The light seeds of Catsear (*Hypochoeris radicata*), which are distributed by wind, make this a very common weed in high rainfall areas. Dock plants (*Rumex* spp.) generally have a very deep taproot, which seeks out sub-soil moisture at

depth, while the Variegated Thistle (*Silybum marianum*) is unlikely to be eaten by stock so freely sets seed. Good pasture management and improved soil fertility will help to keep these weeds under control, but if herbicides are required, Dicamba/MCPA and metsulfuron methyl are effective if sprayed when plants are small and actively growing. It is important to seek professional advice before selecting and using chemicals, and to ensure label directions are followed.



Figure 14: Common perennial broadleaf weeds. Left: Dock. Centre and right: Catsear flower and leaves. Photos: A. Cole.

## Pasture pests and diseases

Highly productive and persistent pastures can be severely damaged by pests and diseases unless land managers are able to recognise the symptoms and deal with them before they become a problem. Carrying capacity, and ultimately profitability, can be reduced when pastures lose vigour.

### Pests

The most common pasture pests include Redlegged Earth Mite, Lucerne Flea and Blackheaded Pasture Cockchafer. Severe damage can result from large infestations.

### Redlegged Earth Mite

The Redlegged Earth Mite (*Halotydeus destructor*) is a major pest of pastures, especially Subterranean Clover, annual medics and Lucerne. It thrives in the Adelaide and Mount Lofty Ranges region with its cool wet winters and hot dry summers. The use of pesticides is a common method of control. However, alternative non-chemical options are being embraced as evidence emerges that mites are exhibiting resistance to chemical sprays. Typical damage from these mites is seen as 'silvering' or 'whitening' of leaves (see Figure 15). It is important to kill adult mites before they are able to lay eggs



Figure 15: Lucerne Flea damage. Source: Roberts & Umina (2008).

in spring, which hatch in autumn. The optimum dates can be predicted by accessing the TIMERITE website program ([www.timerite.com.au](http://www.timerite.com.au)). Systemic pesticides can be applied to the seed coat when sowing a new pasture. However, it is still necessary to check young pastures to determine the extent of any infestations as these mites have the capacity to destroy the legume component of any pasture. Biological control can play a part in reducing mite numbers. They have a number of predators, in particular a predatory mite (*Anystis wallacei*); however, the dispersal rate for this mite is slow. Controlling weeds, such as thistles and Capeweed, which act as host plants for Redlegged Earth Mites, will reduce breeding sites.

### Lucerne Flea

Adult Lucerne Fleas (*Sminthurus viridis*) are approximately 3 mm long, wingless (see Figure 16) and lay eggs which remain dormant over summer and hatch during April and March. They can inflict considerable damage on clovers, lucerne and Capeweed. They tend to be a problem on loam/ clay soils, but generally not on sandy soils. Monitoring the development and spread of these pests is important so that chemical applications can be timed to act on young fleas which have not had a chance to breed. Systemic sprays can be used when damage is first detected. Predators of this pest are known, but these are unlikely to be an effective control measure on their own. A good grazing regime, coupled with sound weed control of host plants, should be adopted to avoid total reliance on chemicals.



Figure 16: Adult Lucerne Flea  
Source: Roberts & Umina (2008)

### Blackheaded Pasture Cockchafer

The larval stage of this insect pest (*Aphodius tasmaniae*) is responsible for damaging pasture. Clovers and ryegrass are particularly susceptible. Larvae can reach 15–20 mm in length (see Figure 17), while the adult beetles are generally 10–11 mm. Eggs are laid in soil and when larvae emerge they feed on pasture plants, resulting in bare patches and exposed soil. The eggs hatch in early November, with larvae causing considerable damage during April to early August. May and June is the optimum feeding time of larvae. In severe cases insecticides can be used as these insects are surface feeders. The best time to spray is just before rain or when heavy dew is expected. Avoid spraying after July as larvae will be difficult to eradicate. To confirm that bare patches are the result of the Pasture Cockchafer, holes need to be dug to a depth of 150 mm to identify the insect larvae and determine the density of the infestation.

### Diseases

Pasture plants are subject to a number of diseases, including rust, leaf spot, blight and a range of viruses. Young seedlings can also suffer from 'damping off', which occurs when a fungus attacks the stems of newly emerged seedlings. Soil conditions contribute significantly to this problem. It is important to use clean certified seed when sowing new pastures and to ensure that pastures are selected for their resistance to known diseases of the area. Appropriate management of soils and pastures will help to reduce the likelihood of disease becoming a problem. If disease is suspected, seek professional advice.



Figure 17: Blackheaded Pasture Cockchafer (20 mm long)  
Source: Mickan (2008)

# 5. Environmental weeds

## What is a weed?

A weed has been defined in many ways. One of the simplest definitions is 'a plant growing where it is not wanted'. For example, in drier areas Salvation Jane (*Echium plantagineum*) can be used as stock feed for sheep and as a good source of honey, while in wetter areas it is not a desirable plant and can compete with perennial pastures and cereal crops. Whether a plant is a weed or not depends on who is looking at it and the situation in which it is growing. To help in the management and prioritisation of pest plants, some have been declared as weeds by legislation. For environmental purposes, a weed is any non-indigenous plant species that threatens the natural biodiversity of the environment.

## Weeds of national significance

From 3,000 non-native naturalised plants in the Australian environment, a list of 32 'weeds of national significance' has been determined by the Australian Government. A weed risk assessment process assessed the weeds' invasiveness and impact characteristics, potential and current area of spread, the primary production industries affected, and environmental and socio-economic impacts. Of the highest scoring weeds, 14 are in South Australia. These are: African Boxthorn, Bridal Creeper, Bridal Veil, Blackberry, English Broom, Cape Broom, Gorse, Salvinia, Prickly Mimosa, Chilean Needle Grass, Boneseed/Bitou Bush, Athel Pine, Mesquite and Serrated Tussock. They are a high priority for control throughout South Australia.

Currently a total of 140 plant species are 'declared' as weeds by state legislation in the Adelaide and Mount Lofty Ranges. Declared means that they are restricted for sale, movement, possession or cultivation and in most cases owners have a legal obligation to remove these plants from their properties and landowners may, if required, be responsible for the cost of their control on adjacent roadsides. A list of declared pest plants can be found on Natural Resources AMLR's website by searching for 'pest plants'.

## Annuals, biennials and perennials

**Annual** weeds germinate, grow, set seed and die all in one year. They are quite easy to control with cultivation or herbicides, especially as seedlings. Long-term control can be achieved by preventing them from setting seed, since all annuals reproduce by seed only. Seed set can be prevented by mowing, cultivation or herbicide use. Examples of annual weeds include Cape Weed, Caltrop and Innocent Weed.



Figure 1: Capeweed. Photo: L. Hyde.

**Biennials** germinate and grow in one year, then set seed and die in the following year. They have taproots, which store food from the first growing season to the next. As seedlings they can be controlled in the same way as annuals. Once biennials are established, cultivation has limited value because new shoots may grow from the remaining taproot. Similarly, contact herbicides will only burn off the top growth, and the plant may grow from the taproot. Translocated herbicides, applied while the weed is actively growing, will move throughout the plant and kill the taproot and the top growth. Examples of biennial weeds include Scotch Thistle and Spear Thistle.



Figure 2: Thistle. Photo: A.Cole.



*Figure 3: Broom. Photo: K.Blood.*

**Perennials** live longer than 2 years, and may start producing seed in their first year of growth. Seedlings can be controlled in the same way as annuals, but thereafter control becomes more difficult, especially if they produce bulbs or rhizomes, since cultivation will spread the weed. Translocated herbicides are effective at post-seedling stages of growth. Examples of perennial weeds include Blackberry, English Broom, Gorse, Cape Tulip and Bridal Creeper.

## Integrated weed management

Integrated weed management (IWM) combines the use of complementary weed control methods, such that all weeds are controlled by one or more components of the weed management system.

Three main approaches can be adopted in the development of an IWM program:

- Prevent weed problems before they start (by limiting their introduction and spread).
- Restrict weed growth (by helping your crops or pastures to compete).
- Undertake control (by using a method that kills them and prevents further propagation).

Weed management approaches that rely on a single or limited number of strategies often end up with an ineffective and potentially expensive program with poor results. For example, the repeated reliance on one or two groups of herbicides to control a target weed population can lead to an increased resistance to these herbicides.

## Chemical control

Chemical control is not the only option but it is definitely very effective when used as part of an integrated weed management plan. There is a herbicide suitable for almost all weed situations and new herbicides are continually being developed. In some situations herbicides offer the only practical, cost-effective and selective method of controlling certain weeds. Because herbicides reduce the need for cultivation, they can prevent soil erosion and water loss, and are widely used in conservation farming.

In some cases, a weed is only susceptible to one specific herbicide and as a result it is important to use the correct herbicide and application rate for the target weed and situation in order to avoid herbicide resistance.

## Foliar spraying

Foliar spraying is the application of herbicides, usually diluted with water, at a specific rate, as directed by the label. Spray equipment is used to apply the herbicide mixture onto the foliage of plants until every leaf is wetted, but not to run-off. Spray equipment may vary from a simple garden sprayer or a knapsack sprayer, to boom sprays operated from vehicles, including aircraft. All other options should be considered before using foliar spraying, particularly in bushland applications, because of the increased potential for off-target damage.

When herbicides are used there is always some potential to damage plants and animals other than those to be controlled, resulting in off-target damage. The potential for off-target damage depends on the herbicide used, soil type and landform, weather, application method used and the experience of the operator.

When using foliar spraying as an application method it is important to be acutely aware of the risk of spray drift. The person spraying has an obligation to prevent the drift of herbicide onto non-target vegetation and beyond the boundaries of the site or property being worked on.

The use of herbicides and herbicide additives near waterways, or in situations where herbicides may eventually enter waterways, requires careful consideration. It is best to avoid using herbicides in these instances because of the potential risk to aquatic life and down-stream users. If herbicides are to be used they must be registered for use near waterways or aquatic situations and label instructions must be strictly followed.

## Timing of spray programs

### Annuals

Annual weeds are sprayed early in their growth, when foliage and roots are small. They are most susceptible at this stage and less herbicide is needed to control them. Early spraying also allows desirable pasture plants to develop before winter without competition from weeds.

### Herbaceous and bulbous perennials

Herbaceous and bulbous perennials are sprayed when large amounts of foliage are present to absorb the maximum amount of herbicide but before flowering.

### Woody perennials

Woody perennials are best sprayed at a time of active growth in spring but can be sprayed in summer and autumn as long as they are not showing signs of stress from dry conditions. Blackberry plants growing in situations with low water tables can often be showing signs of stress from late January in the absence of summer rains.

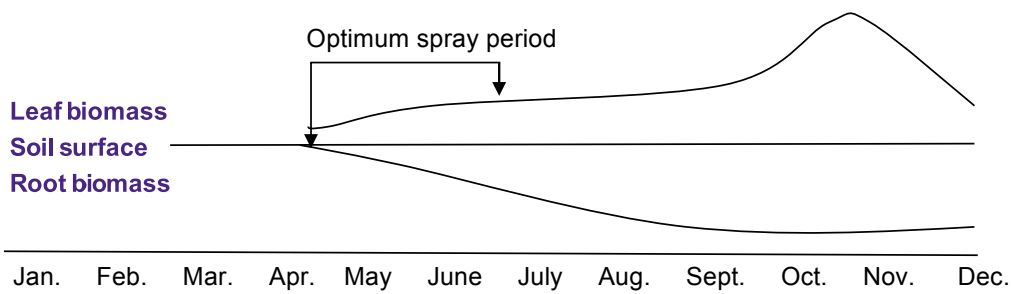


Figure 4: Leaf and root growth of annual weeds

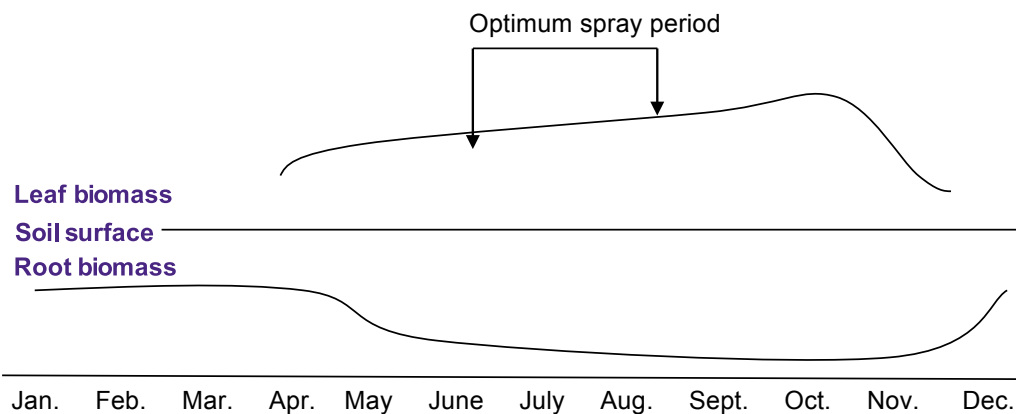


Figure 5: Leaf and root growth of herbaceous and bulbous perennials

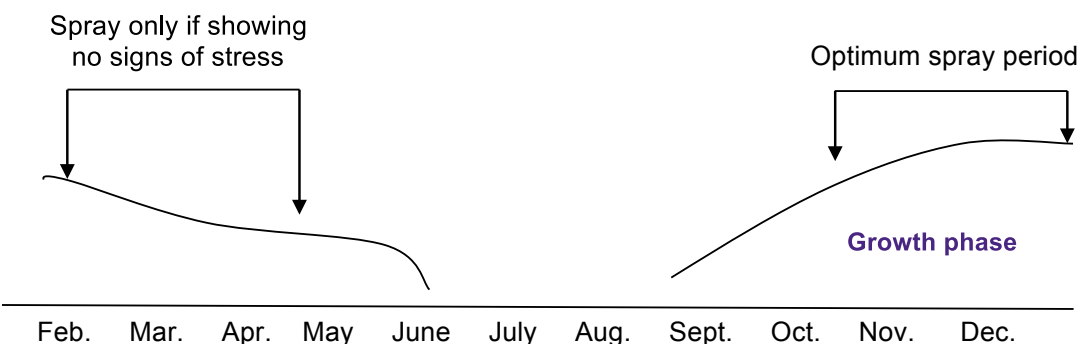


Figure 6: Growth phase of woody perennials

## Other application methods

### Cut and swab

The cut and swab method uses less herbicide, reduces the risk of off-target damage and reduces the debris left behind after spraying. To achieve the most effective outcome using this method it is advisable to clear the immediate area around the stem of the plant, cutting horizontally using secateurs, loppers, hand saw or chain saw below any nodes of growth at the base of the plant. Cut as low to the ground as possible to prevent regrowth. Herbicide is then applied quickly (preferably within 10 seconds) to the exposed surface, before the plants cells close up and inhibit the entry of herbicide. Having two people for this process, one to cut and the other ready to apply the herbicide, is the best approach. This is an effective method for woody weeds including Gorse and Broom.

### Drill and fill (and axe frilling)

The aim of the drill and fill method is to get the herbicide into the sapwood tissue (cambium layer) of woody weeds and weed trees so that it will be transported throughout the plant. This method targets individual plants and significantly reduces the risk of off-target damage. Drill holes at an angle of 45° and no more than 50 mm apart, right around the trunk. This angle will aid herbicide retention in the hole, increased absorption by the plant and a reduced risk of spillage. Similar to the cut-and-swab method, the herbicide must be applied within 10 seconds of the hole being drilled. Again, the best approach will be to have two people on hand for this task, one to drill and the other to fill with herbicide.

An alternative method is to use a chisel or tomahawk to make angled cuts into the sapwood around the base of the stem/trunk. These cuts are filled with herbicide immediately. It is important not to ringbark the plant since this will kill vegetation above the ringbark but will prevent transportation of the herbicide through the plant's entire system and allow trees to re-sprout below ringbark lines. This method is commonly used on Willows, Olives, Ash, Poplars etc.

### Stem and leaf wiping

This method is useful for leafy herbaceous plants and involves the use of a wick or rope applicator to apply the herbicide directly to the leaves and stems of the plant, thus reducing the risk of off-target damage. This method employs vehicle-mounted or hand-held equipment to wipe or brush herbicide onto weeds. The herbicide is applied from wicks, sponges or other material saturated with herbicide. The level of application can be adjusted such that only species growing

above a certain height will receive herbicide. This is therefore a highly selective method and problems with spray drift can be avoided. In a pasture situation more desirable species can be grazed down so that they are below the height of the wick wiper prior to using this method.

In bushland situations a similar method can be used with a sponge tied to a pair of tongs, aptly named the 'tongs of death'. These can be dipped in herbicide and used to wipe the weed's foliage and stem. This method can be effective for controlling strappy weeds and weedy grasses, such as Watsonia.

## Read and heed the label!

The product label, and any leaflet, pamphlet or booklet included with the product provides the necessary information on safety, use and disposal of the product. Read the label and follow the instructions. All label directions should be followed but some label instructions are mandatory. The most important few minutes in pest control is the time spent reading the label!

Information that is given on the label includes but is not limited to:

- the active constituent and its concentration
- claims for use
- directions for use, including application rates, methods and target weeds
- herbicide resistance information
- protective clothing and safety equipment
- minimum withholding periods
- storage and disposal
- first aid.

Note: adding a coloured dye to your herbicide mix can help you to identify spots you have missed.



## Herbicide resistance

In any weed population there is likely to be a small number of individual plants that are naturally resistant to any single herbicide. Repeated exposure of the weed population to a limited range of herbicides results in these resistant individuals being selected out, so that eventually a large proportion of the population is resistant to the herbicides. Eventually herbicide resistance develops and the herbicide no longer controls the target weed.

Resistance is not necessarily developed; rather their resistance is encouraged by the landholder by:

- using the same chemical year after year on the same weed or weeds
- using lower rates than recommended, thereby encouraging the selection of more tolerant types; these multiply rapidly because the more susceptible types have been killed
- the progressive increase in the rate of herbicide each year, which in turn only selects out the types with the most tolerance/resistance.

In order to minimise herbicide resistance in weed populations, an IWM approach is recommended. Land management with this focus uses complementary weed control methods such as:

- grazing
- slashing
- cultivation
- revegetation, re-seeding or pasture renovation
- manual removal
- herbicide application
- land fallowing
- biological control.

The aim of any IWM program is to control weeds and prevent them reproducing, so that eventually there is a reduction in the weed population and the amount of seed which is produced, thus improving the integrity of the ecosystem.

## Control techniques

### Manual removal

This technique is quite effective in controlling small infestations and isolated plants. Manual removal is selective, minimises risk to the local flora, reduces the need for herbicide application and develops plant identification skills and familiarity with sites.

Although a physically intensive operation, it is simpler, easier, more cost-effective and potentially less damaging in a bushland, pasture or crop situation. It is best undertaken when the soil is moist and loose so that you have a greater chance of removing the entire plant while minimising soil disturbance. Manual removal of plants often requires complete removal of root systems; that is, taproots, bulbs and tubers and can be done by hand or through the use of a tree popper.

### Mowing or slashing

These methods can be used in conjunction with grazing for pasture weed control. Mowing after grazing ensures that all plants, including less edible weeds, are cut off close to the ground, thus reducing the dominance and competitiveness of weeds in the pasture. In addition, if not enough stock are available for quick heavy grazing, mowing can make up the deficiency. Mowing is also useful for topping annual weeds to prevent seeding.

### Grazing

Grazing can be used in a variety of ways to control weed growth, but it can also encourage weed invasion if not managed well. For example, weed invasion will result if an area is grazed too heavily. Beneficial and desirable plants may not recover and weeds will take their place. Heavy stocking rates can force stock to eat most plants even though stock may dislike some of them. Light stocking rates encourage stock to selectively graze; that is, to eat palatable plants and leave behind unpalatable plants, which then thrive and set seed.

### Spray-topping

Light applications of certain herbicides will make some plants more palatable to stock, which can then be heavily grazed, thus combining the use of herbicides and stock to improve weed control outcomes.

## Fire

Fire can be a useful tool in weed control. It can stimulate different responses from different weed species. Burning woody weeds very seldom results in the plant's death but often germinates weed seeds in the soil and stimulates new and fresh growth to allow for effective spraying. When respraying weeds it is important to ensure that there is enough new foliage to translocate enough herbicide into the entire root system of the plant. The advantage of germinating the seed is to reduce the overall time (in years) needed to exhaust the seed bed and achieve complete control. Fire can also be effective in reducing the biomass and allowing access for other weed control methods. It is essential in this approach that follow-up controls are implemented. Also important is ensuring that all regulations have been followed, including council and CFS permits (See Chapter 8 Bushfire prevention, for further information).

## Biological control (biocontrol)

Biocontrol involves using biological control agents (bio-agents) from the weed's country of origin to assist in the control and ongoing management of the weed species. As part of an integrated control program, biocontrol can offer a realistic solution to some weed issues. Some examples of bio-agents include the Gorse Spider Mite and Gorse Thrip to control Gorse (*Ulex europaeus*), Rust fungus to control Bridal Creeper (*Asparagus asparagoides*) and the Horehound Plume Moth to control Horehound (*Marrubium vulgare*).

Biocontrol by its nature is never 100% effective. Good-to-excellent control can be achieved but rarely eradication. Where biocontrol is not particularly effective used in isolation, it can sometimes be effective when used in conjunction with other control measures. Successful bio-agents are self-generating and capable of spreading throughout the infested weed areas without assistance. The costs associated with controlling weeds can consequently be greatly reduced by using less herbicide.

Unfortunately with the advantages come some disadvantages. There are extremely high costs in researching and establishing a biological control program. The continued use of a bio-agent may require restricted use of sprays that are used to control other pests. And in order for the bio-agent to survive, a small population of the weed species must remain to provide food for the agent, or a place for the bio-agent to reproduce.

## Minimal-disturbance weed control

These techniques should be implemented in areas where the aim is to encourage regeneration of native plant species and manage existing remnant vegetation. Weed control techniques include hand weeding, slashing (annual grasses), drill and fill, frill, cut and swab, wiping and careful spot spraying.

Minimum disturbance bushcare relies on several principles for success, including:

- Always work from good to bad areas (that is, work from the small, isolated infestations to the larger ones).
- Disturb the soil as little as possible and restore it to its natural condition.

Allow the rate of regeneration to dictate the rate of clearing.

Minimal-disturbance weed control requires skills in plant identification and bushcare techniques and an understanding of bushland ecology and bush regeneration principles. See Chapter 7 – Native vegetation and biodiversity.



**Figure 7: The Gorse Thrip is used to control Gorse**  
Photo: Tasmanian Institute of Agricultural Research

## Key steps to a successful weed control program

### Prevention

Prevention is the key to a successful weed control program. Significant time and money can be saved through the implementation of preventative measures as part of everyday property management. The importance of weed spread prevention has grown with the recognition that the spread of most weeds occurs through similar pathways, such as the movement of goods, animals and vehicles contaminated with weed seeds.

There are many ways to prevent weeds entering your property, including restricting the opportunity for new weeds to invade and spread:

- Be vigilant about introducing stock, fodder, soil or seed onto your property.
- When buying stock, find out where the stock has come from and what weeds infest that area; buy certified weed-free fodder and seed where possible.
- Restrict the movement of vehicles and machinery on your property in periods when seeds are likely to spread.
- Establish tracks and laneways along which vehicle movement can be concentrated.
- Wash down vehicles which have been in known infested areas.
- Do not allow machinery or vehicles to enter your property unless they are clean.

Restrict the spread of existing weed infestations by:

- carrying out control works prior to other works
- slashing and cultivating when weeds are outside the seeding period
- working in the clean area first and the infested area last. Work from the outside in and clean down equipment prior to moving into a clean area.

### Quarantine

Hold livestock that may be infested with seed in a single location until they are shorn or until weed seeds have had the chance to pass through their digestive system.

Feed infested fodder in a feed lot situation only.

### Monitor

Continually monitor weed infestations and carry out control works. Taking regular photographs in the same spot can be a good way of monitoring progress.

### Early detection and eradication

Even the best weed prevention methods cannot prevent all potential weed introductions. Early detection of new weed infestations, combined with a targeted and coordinated control response, will ensure either eradication or containment of the weed. Weed populations that are not detected early may result in high future time and money costs.

Once the initial control has been undertaken, the source of the weed seed still poses a risk for future weed infestations. It is important to identify this risk, which could be a weed infestation adjacent to your property, brought-in hay, your front garden or in a conservation park 10 km away. Then the weed needs to be managed accordingly. This could mean contacting your local Natural Resources Centre to report a new weed infestation, knocking on the neighbour's door for a chat about the problem or changing management aspects of your property.

## Develop a weed action plan

IWM is an integral part of achieving successful control of any weed on any scale. The development of an action plan will ensure that the control program is integrated, delivered in a timely manner and achieves successful control.

The following actions could be included in a weed action plan:

- develop distinct aims and objectives for the control program
- identify the weed(s)
- map the weed(s); a mud map is fine
- prioritise weed(s) for control
- determine management options
- develop a realistic weed control timetable with management options
- develop monitoring measures.

Perhaps the most important aspect of implementing a weed control program is the ongoing monitoring. As mentioned earlier, monitoring assists in the detection of new weed infestations and is also important in reviewing the landowner's weed control program. Surveying the property on a regular basis and observing how your weed control program is progressing is a worthwhile approach. It might be discovered that one control technique is not as successful as was first hoped.

Now would be an ideal time to ask some important questions:

- Is this control method working?
- How could I improve?
- That worked really well, but I've noticed this?
- Perhaps I could save time and money by implementing a different strategy?

Use the knowledge learned to achieve successful control of a weed sooner or in a more economical way.

Ongoing monitoring enables the landholder to plan for follow-up works after the initial weed control has been undertaken. It is important to monitor the site and control weeds as they appear. The lack of ongoing maintenance works will result the weeds becoming as much of a problem as they were prior to the initial control.

# 6. Water resources

## Watercourses

### Regulations

In South Australia all persons have a general statutory duty of care under the *Natural Resource Management Act 2004* (the Act) to act reasonably and responsibly in relation to the management of natural resources.

Landholders need to be aware of the following key elements of the Act:

- Unless a water resource has been prescribed, a person who has legal access to the water resource has a general right to take water for stock and domestic purposes without any specific approval. They can also take water for other purposes provided their taking does not detrimentally impact on the ability of someone else to take water from that resource (Section 124).
- Where a water resource is prescribed (Section 125), a licence is required to take water for irrigation and other commercial purposes. However, stock and domestic use is generally exempt from this requirement. An exception to this in the Adelaide and Mount Lofty Ranges region is in the Western Mount Lofty Ranges prescribed area. Taking water for stock and domestic purposes from a dam greater than 5 ML is not exempt in this area, and does require a licence. Contact the Department of Environment, Water and Natural Resources' Water Licensing Group on 08 8463 6876 for further advice on water licence requirements.
- While the owner of land can take water from a watercourse, lake or well and collect surface water in dams as described above, the owner will need a permit to construct or install any new dams, wells or structures such as pumps that will take water from a watercourse.
- The owner of land cannot place or build any structure in a watercourse, or remove any sand, soil or rock without the approval of a water-affecting activity (WAA) permit.
- It is the duty of the owner of land on which a watercourse is situated to take all reasonable steps to prevent damage to the bed and banks and to the ecosystem that depends on the watercourse.

The hydrology of the Mount Lofty Ranges area has been drastically altered due to the high level of dam construction. One of the impacts of this has been to change flow regimes, resulting in watercourses not flowing until every dam upstream of the catchment has been filled. This delay places a high level of stress on many water-dependent ecosystems and native fauna, and impacts on downstream neighbours.

The Adelaide and Mount Lofty Ranges Natural Resources Management Board has developed plans that aim to strike a balance to ensure that the region's water resources are allocated fairly, taking into account the needs of all water users and the environment. This involves placing limits on how much water can be taken from each groundwater aquifer and river system.

### What are water-affecting activities?

Water-affecting activities are activities that potentially have adverse impacts on the health and condition of water resources, other water uses and ecosystems that depend on water resources. These water resources include watercourses, lakes and their floodplains, groundwater, springs, wetlands, waterholes and catchment landscapes, among others. Managing these activities helps to protect our natural systems and water-dependent ecosystems, maintain water quality and minimise impacts on other water users.

### Activities requiring a WAA permit in the AMLR region

The Act and *Volume 2, Business and operational plan* of the *AMLR NRM Plan* outlines water-affecting activities which require a permit approval.

These include, but are not limited to:

- constructing or enlarging dams or structures to collect or divert water
- building structures, obstructing or depositing solid materials in a watercourse, lake or floodplain, for example, erosion control, construction of water crossings or dumping material
- excavating material from a watercourse, lake or floodplain, for example, excavating or cleaning soaks, waterholes and sand mining
- destroying vegetation in a watercourse, lake or floodplain, for example, removal of reeds
- draining or discharging water or brine into a watercourse or lake, for example, desalination waste, stormwater, including urban discharge, drainage and salinity control
- using effluent or water imported to an area for commercial activities, for example, irrigation.

Applications for permits must be lodged with Natural Resources AMLR and can be downloaded from [www.naturalresources.sa.gov.au/adelaidentloftyranges](http://www.naturalresources.sa.gov.au/adelaidentloftyranges). It is best to apply for a permit at least 2 months before intending to undertake the activity. If planning to drill, deepen or backfill wells, bores or groundwater access trenches, landholders should contact the Department of Environment, Water and Natural Resources on 08 8463 6876 or visit [www.environment.sa.gov.au](http://www.environment.sa.gov.au) for a permit application.

Landholders should also note that in prescribed water resource areas, a water licence is required to irrigate an area greater than 0.4 ha and a water licence may be required to use water for other commercial uses.

The rules regarding water usage vary for different prescribed areas, so it is important to contact the department's Water Licensing Group on 08 8463 6876 to clarify requirements.

## Riparian zone

### How to recognise stream orders

Stream ordering is a widely applied method for classifying streams. Stream orders provide a way of ranking the relative sizes of streams within a drainage basin. Its use in classification is based on the premise that the order number has some relationship to the size of the contributing area, to channel dimensions and to stream discharge. The smaller stream tributaries are first-order streams and where two first-order streams meet a second-order stream is formed. A third-order stream is formed by the junction of two second-order streams, and so on down the catchment (Figure 1).

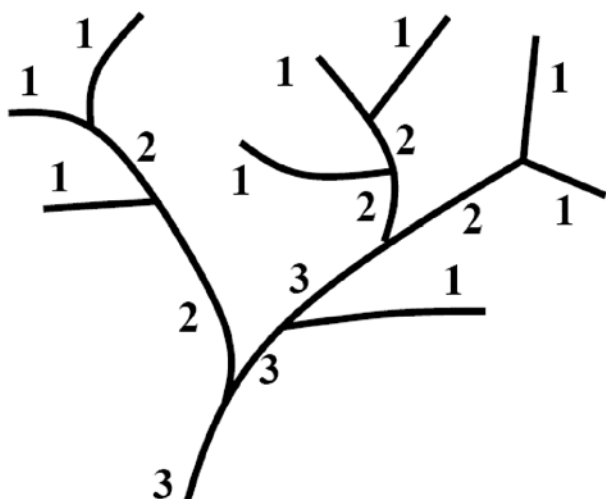


Figure 1: Strahler stream order

### Benefits of riparian zones

The area beside watercourses that forms the boundary between water and land is called the riparian zone. The riparian zone is a crucial buffer between land-use activities and the natural watercourse and plays a critical role in supporting biota and therefore improving the biodiversity of the region. The first step when improving a riparian zone is to fence off the creek line so that stock are prevented from entering the watercourse.

The larger the riparian zone, the more effective it will be; a minimum distance of 3 m is recommended. Once the riparian zone is fenced off, replanting the area with native vegetation will enhance the ability of the riparian zone to improve and protect water quality.

A well-managed riparian zone improves and protects water quality by:

- filtering nutrients from surface run-off
- slowing down flows, which reduces erosion
- controlling soil erosion and salinity
- shading the watercourse, which reduces the water temperature and prevents algae blooms
- preventing direct stock access to watercourses.

A well-managed riparian zone also provides habitat and food for wildlife and improves biodiversity. Riparian zones serve as vital habitat corridors, allowing the movement of flora and fauna between remnant vegetation zones as well as being diverse habitat areas in their own right, supporting abundant communities. Figures 2 and 3 illustrate the differences between a poorly managed and a well-managed watercourse.



Figure 2: A severely eroded watercourse. Photo: J. Evans.



*Figure 3: A well-managed, fenced and revegetated watercourse  
Photo: A. Cole*



*Figure 4: Correctly designed stock crossing point. Photo: A. Cole.*

## Erosion

### Stream-bank and stream-bed stabilisation

Riparian and aquatic vegetation is highly valuable as it reduces the risk of stream-bank and stream-bed erosion. Revegetation must be a major component of any erosion-control program and without revegetation almost all erosion control works are likely to fail in the long term.

Riparian vegetation reduces the risk of erosion in the following ways:

- Roots provide reinforcement and stability to watercourse bed and banks.
- Ground-hugging vegetation provides direct protection from the erosive action of high-velocity water.
- The drainage of the soil along the stream banks is improved by trees utilising this water and thus reduces the risk of bank failure due to heavy saturated soils.
- Vegetation can considerably reduce water velocity by contributing to the roughness of a stream.

Consult your local Natural Resources AMLR staff for options on structures that can be implemented to control severe stream-bank erosion.

### Stock-crossing points

Uncontrolled stock access to creek lines and poorly constructed creek crossings contribute to reduced water quality and creek line erosion, leading to increased turbidity and a greater decrease in water quality. In addition, poorly constructed crossings impede water flows, adversely affecting water biota, and can further contribute to creek line erosion, waterlogging and rising groundwater tables.



*Figure 5: Correctly designed and installed culvert creek crossing  
Photo: A. Cole*

The type of stock crossing to be installed will depend on the depth and width of the watercourse, the use of the crossing and the likely water flow. Stock-crossing options can include culverts, bridges and low-level crossings (fords) (see Figure 5). Stock-crossing points should be located on a non-eroding straight stretch of the watercourse and preferably where the channel has a hard bottom and the banks are not too steep (see Figure 4). Fencing should be located along the crossing to prevent animals from moving along the watercourse.

### Flood control

A well-vegetated or forested catchment will produce much less run-off than a bare, overgrazed catchment, as rainfall is trapped by vegetation, surface run-off is slowed and the rate of infiltration into the ground is greater. For the same rainfall, a bare catchment will often experience much more severe flooding than a forested catchment or a catchment with good grass cover.

Table 1: Common watercourse weeds

Common name	Botanical name	Identification
Blackberry	<i>Rubus fruticosus</i> agg	Extremely thorny shrub, stems entangled, sometimes semi-prostrate or almost erect. Flowers white to pink. Berries are green-red-black and ripen in late summer. Many very closely related introduced plants are grouped under one name.
Gorse (Figure 6)	<i>Ulex europaeus</i>	Shrub, to 2 m high, densely branched in younger parts, eventually bare at base. Leaves very prickly, yellow flowers.
Periwinkle	<i>Vinca major</i>	A low-growing perennial, shrubby herb. Shiny green oval-shaped leaves in opposite pairs. Flowers tubular and flat-lobed at mouth to 50 mm diameter, bluish purple.
Three-cornered garlic (Figure 7)	<i>Allium triquetrum</i>	A garlic-like herb with small white underground bulbs and 3-sided leaves. Snowdrop-like white flowers.
Watsonia (Figure 8)	<i>Watsonia bulbifera</i>	An erect perennial herb up to 2 m high. Leaves basal and linear and flowers curved trumpet-shaped, salmon pink to red.
Willows	<i>Salix</i> spp.	Willows are deciduous trees or shrubs. They have small seeds with long, silky hairs attached to one end like a parachute, which helps them spread. The seeds are usually short-lived, from days to a few weeks.

Source: Auld & Medd (1999)

## Common weeds of watercourses

### Identification

Weeds in watercourses are a major threat to all landholders because they choke watercourses, destroy native vegetation, decrease water quality and provide shelter for feral animals such as rabbits and foxes. A large number of weeds are particularly problematic in watercourses in the region.

### Control of weeds and the use of herbicides in watercourses

In general, herbicides are a short-term solution to managing weeds. Repeated applications are often required until the primary cause of the weed infestation is addressed, that is, increased nutrient loads entering the watercourse. Wherever feasible, weed control should be carried out using non-herbicide methods, such as biological control, slashing, mulching, physical removal and controlled grazing. Often the best approach is one of integrated control, where combinations of the above methods are used.

The use of herbicides and herbicide additives near waterways, or in situations where herbicides may eventually enter waterways, requires careful consideration. It is best to avoid using herbicides in these instances because of the potential risk to aquatic life and downstream users. If herbicides are to be used they must be registered for use near waterways or aquatic situations and label instructions must be strictly followed.



Figure 6: Gorse. Photo: M. Seiler.



Figure 7: Three-cornered Garlic. Photo: A. Dean.





Figure 8: *Watsonia*. Photo: C. Wilson.

### Willows along watercourses

When willows were first introduced to Australia they were used extensively for watercourse erosion control. Unfortunately in Australia, willows have few insect pests or diseases, can be spread by water and out-compete our native riparian plant species. For this reason they have spread extensively in Australia.

The planting of willows along watercourses leads to a significant improvement in stream-bank stabilisation in the short-term; however, willow-dominated watercourses are severely altered from their 'natural state'.

The environmental issues associated with willows include:

#### **Reduction in diversity of indigenous plants and animals:**

The dense shade provided by willow trees and mat-forming roots suppress and kill the indigenous understorey, which means there is little protection provided for native fauna. Willows shed few large branches and are deciduous, with the majority of leaves falling in autumn. This autumn leaf drop smothers aquatic habitat, increases nutrients and reduces oxygen levels in the water as a result of the breakdown of organic matter. This results in unsuitable water quality and habitat for native aquatic plants and animals. Large branches are important in watercourses as they provide important habitat for native fish and water insects.

**Displacements of indigenous plants:** Willows have the capacity to spread extensively and pose a major risk to the regeneration of native plants. Consequently, willows have been labelled an 'environmental weed' since they have the ability to out-compete and replace native vegetation.

**Changes in watercourse behaviour:** Large and strong fibrous willow roots can trap foliage and silt, decrease channel capacity, exacerbate flooding and change flood patterns.



Figure 9: Parrot's Feather (*Myriophyllum aquaticum*) weed present in a farm dam. Photo: AMLR NRM Board.

Staged or gradual removal of willows, in conjunction with revegetation using indigenous plants is the best option for maintaining stream stability and improving environmental outcomes. Widespread rapid removal of willows is not recommended since this can create further problems, such as exposing watercourse banks, leading to erosion. Drill-and-fill control techniques are particularly effective when controlling willows, as chips and broken branches, which can reshoot, are less likely to occur. It is essential that the impacts of willow removal on the stream are considered.

### Aquatic plants

Some species of aquatic plants (native and non-native) have a tendency to grow profusely and can at times become invasive. This is likely to occur where run-off water contains high levels of nutrients, which are a source of plant food. Under these circumstances they are often regarded as weeds and need to be controlled.

Aquatic plants can be divided into three main groups:

**submerged weeds** – Ribbon Weed (*Vallisneria gigantea*) and Elodea (*Elodea canadensis*)

**emergent weeds** – Parrot's Feather (*Myriophyllum aquaticum*; Figure 9), Common Reed (*Phragmites australis*), pondweeds, sedges and rushes

**free-floating weeds** – Salvinia (*Salvinia molesta*), Water Hyacinth (*Eichhornia crassipes*; Figure 10), Duckweed (*Spirodela* spp.) and Red Azolla (*Azolla filiculoides*).



*Figure 10: Water Hyacinth (Eichhornia crassipes)  
Photo: A. Cole*

The control of weeds in farm dams can be difficult because often dams have multiple uses, for example, stock water and household needs. There are a number of options available for the control of aquatic weeds, but often the best approach is integrated control, using a range of options. An integrated control program usually provides more efficient and stable control in the long term with fewer undesirable side effects.

Below is a brief summary of the types of control options:

**Mechanical control:** physical removal of plant material; this is a safer method than chemical control and does not threaten fish life. However, weeds that are anchored to the banks are difficult to control by mechanical means.

**Environmental control:** limit the amount of nutrients entering the dam by providing effective buffering zones and applying only the required amount of nutrients (fertilisers) to the land to match pasture/crop requirements.

**Chemical control:** generally only suitable where the weed infestation is small and the water is not for stock or domestic purposes. Where the water is used for these purposes it is imperative that the withholding period for the particular chemical and the regulations regarding chemical use in or near waterways are observed.

**Biological control:** uses the natural enemies of the problem weed. It is a non-polluting and usually self-sustaining form of control. Before biological control agents are released, a large amount of research is necessary to ensure that the agent does not attack crops or native plants.

## Dams and bores

### Regulations

The Act provides for the control of various activities that affect water, including farm dams (refer to the regulation section at the beginning of this chapter).

The construction of a dam, or the enlargement or modification of an existing dam, requires the landholder to apply for one of two authorisations, depending on the size of the dam:

- Dam construction, enlargement or modifications to a volume of 5,000 kilolitres (< 5 ML) or less, and/or with walls of 3 m or less above the natural ground surface can only be undertaken with a WAA permit. For permit-application forms landholders should refer to [www.naturalresources.sa.gov.au/adelaidemtloftyranges](http://www.naturalresources.sa.gov.au/adelaidemtloftyranges).

Dam construction, enlargement or modifications of a volume greater than 5,000 kilolitres (> 5 ML) and/or with walls greater than 3 m above the natural ground surface can only be undertaken with development approval. To seek development approval, landholders must contact their local council.

- All dams within the Hills Face Zone (from Sellicks Beach in the south to Gawler in the north) require development approval from the relevant local council.

*Please note: If development approval is granted, a WAA permit is not required.*

### Construction

A good farm dam is a valuable asset, one that will service your water requirements in most seasons with minimum maintenance costs. Proper planning will ensure that the construction and operation of the dam will be a success. The main consideration is the provision of enough water for the required farming operations at an economical cost.

### Size

Before beginning construction of the dam, the landholder should ask themselves the following questions to help determine the size of your dam: Why do I want the water? When is it needed? How long do I want the water to last? How much is needed?

Evaporation losses must be taken into consideration. A shallow storage (less than 4 m deep) will suffer larger evaporation losses than a deeper one with a similar volume. Refer to the last section of this chapter, "How much water is needed?", for guidelines on livestock and horticulture needs.

## Location

Once the storage capacity required for the dam has been determined, the next step is to find a site that can successfully collect and hold the required volume of water. The location of the dam will greatly depend on the specific property. A gully is often a good place to build a dam, since this will reduce the amount of earthworks required and hence the overall cost of the dam. However, not everyone has the benefit of a gully on their property.

A number of factors should be considered when determining dam location, including:

- selection of a location that will allow the construction of an economic and safe dam of appropriate size
- appropriate redirecting of excess water flows
- the avoidance of steep sites (> 15% slope) because there is not usually enough suitable soil material to build a satisfactory wall
- the meeting of legal requirements
- the soil type of the area (clay soil is structurally stable and able to hold water)
- the size of the catchment to adequately and reliably fill the dam.

The catchment of the dam is defined as the area that collects rainfall run-off and directs it to the dam. This catchment area can be natural, such as paddocks, or artificial, such as roads and roofs.

The amount of run-off a dam receives from the catchment is dependent on several factors, including:

- rainfall intensity
- slope of the catchment
- groundcover: pasture vs vegetative areas
- soil type.

Estimating the precise annual yield of the catchment area is difficult, but a useful rule of thumb is that approximately 10% to 15% of the rain that falls is natural run-off, which can be captured in dams. The total water stored on a property cannot exceed 50% of the total run-off for that property.

If small flows consistently travel down the spillway (trickle flows) in the winter or spring months the vegetative cover on the spillway will be modified. Vegetative loss and soil erosion may then occur when flood flows occur. Consider the installation of a trickle-flow pipe to intercept such flows and divert them down a PVC pipe back into the watercourse.

*Table 2: Calculating dam volume entitlement*

### Example of how to calculate your dam volume entitlement in the AMLR region for stock and domestic purposes

Average annual rainfall = 800 mm  
 Depth of run-off = 80 mm (assuming run-off is 10% of rainfall)  
 Area of property = 20 ha  
 Volume of run-off = catchment area (square metres) (cubic metres) × run-off from catchment (metres)  
 = 20 ha x 80 mm  
 = 200,000 square metres x 0.08 m  
 = 16,000 m<sup>3</sup>  
 Converting to megalitres = 16,000 m<sup>3</sup>/1,000 litres  
 = 16 ML

Since the total volume of water on the property cannot exceed 50% of 16 ML, the maximum property allowance is 8 ML in total.

### The following example outlines the relationship between catchment size and dam capacity

Average annual rainfall = 500 mm  
 Depth of run-off = 50 mm (assuming run-off is 10% of rainfall)  
 Run-off per hectare (m<sup>3</sup>) = 1 hectare (10,000 square metres) x 50 mm/1,000  
 = 500 m<sup>3</sup>

So total run-off is 500,000 litres (i.e. 500 m<sup>3</sup> x 1,000) = 0.5 ML.

If a 4 ML dam is required a catchment of 8 hectares would be needed.

#### Note

1 cubic metre = 1,000 litres  
 1,000,000 litres = 1 ML  
 1 ha = 10,000 square metres

## Low-flow bypasses

The diversion of stream flows into dams interrupts the natural flow regime of a stream. The effect of this interrupted flow regime is most noticeable during times of low and medium flow. A relatively simple way of reducing the delay in flows in a watercourse is to install a low-flow bypass, which prevents low flows from being diverted into dams. This retains a natural flow regime in the stream since the dam will only be allowed to fill when there is sufficient flow in the stream such that the flow pattern will not be interrupted. When the flow increases to greater than the predetermined minimum flow the diversion pipe will flow at maximum capacity and the bypass will act as a weir, allowing water to pass over the top of the structure and into the dam (Figure 12). The minimum flow will continue to flow around the dam. During high-flow events the dam will overflow, with the excess flowing downstream.

A low-flow bypass is relatively simple to build and many aspects of the device can be designed and constructed according to local conditions and available materials. Contact local Natural Resources AMLR staff for assistance with the planning of a low-flow bypass.

The *Adelaide and Mount Lofty Ranges Natural Resources Management Plan* requires low-flow bypasses to be installed on all new dams that are to be located on a watercourse.

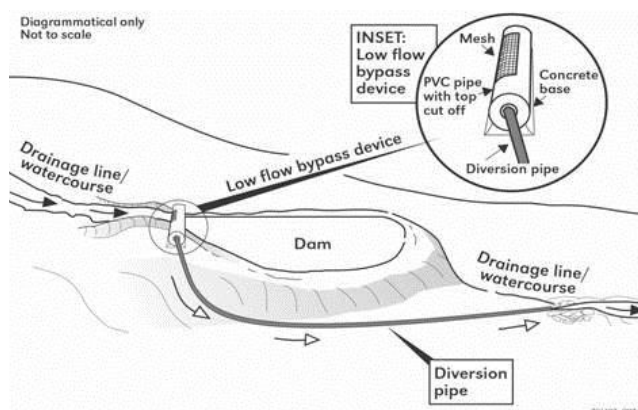


Figure 11: Low-flow bypass

Photo: Department of Water, Land and Biodiversity Conservation

## Management

The first step in improving a farm dam is to exclude stock. This will allow the establishment of native vegetation and also prevent erosion and a decline in water quality. A fenced dam can also offer an excellent wildlife habitat. When fencing off a farm dam it is important to allow access for fire-fighting equipment. Ensure that gates function properly and vegetation is kept clear of the best access point.

### Siltation

Fencing a dam and a section of the main waterway leading to it will improve water quality and reduce siltation. The installation of silt traps can be effective in catchments where erosion and siltation are a problem. Silt traps will prevent degradation of water quality by preventing nutrients from entering the dam and they will also ensure that your dam capacity is maintained. It is recommended that your silt trap should be about one-tenth the size of the dam.

### Erosion prevention

For the same reason that stock should be excluded from watercourses, stock should have restricted access to dams. By fencing out stock, or just allowing stock access to a small area of the dam for watering, the landholder can establish vegetation around the dam. This will have numerous benefits apart from erosion control, such as shading the water to prevent increases in dam water temperature, improving water quality and providing a wildlife habitat.

To protect the dam wall against erosion, grasses and groundcovers can be planted. Sedges which are mat-forming and low-spreading (for example, *Carex gaudichaudiana*) rather than species which form tussocks with bare earth in between are most suitable. Stock may damage or destroy the dam wall, and therefore ideally should not have access to it.

**Trees and shrubs should not be planted on the dam wall as their deep roots may cause cracks, leaks and ultimately will cause the dam wall to collapse.**



Figure 12: Seepage through the dam wall creates erosion  
Photo: A. Cole



Figure 13: A correctly constructed spillway. Photo: A. Cole.

## Seepage

Wet spots in the dam wall or at the toe of the wall indicate that water is leaking through the wall. To prevent seepage from occurring, encourage the pasture cover to grow to the water level. Do not allow trees to grow on the dam wall. Tree roots expand and shrink making minute channels through the soil. Water will find these channels. Roots are a major cause of dam wall leakage. However, if a large tree (or trees) is already on the wall, more damage will be caused by removing them than leaving them alone. Landholders are also subject to laws regarding the removal of significant trees.

## Spillway

The spillway has to be capable of carrying flood flows of water from the full supply level of the dam back to the natural drainage line. A good vegetative cover along the spillway is essential for this. This vegetation needs to be actively growing, robust and relatively uniform. To prevent blockages keep the spillway clear of debris and tall grass. As a general rule, the dam wall should be at least one metre above the height of the spillway.

Table 3: Recommended upper salinity levels for a range of different farm activities

Usage	Upper salinity (ppm or mg/L)
<b>Crops and pastures</b>	
Field peas and beans	850
Clover	1,200
Corn, lucerne, millet, safflower, soybean	2,000
Phalaris, sorghum, sunflower	2,800
Fescue, perennial rye grass	3,200
Barley, wheat	3,700
<b>Flowers and shrubs</b>	
Violets	300
Aster, azalea, begonia, camellia, dahlia	700
Fuchsia, gladiolus, poinsettia, rose, zinnia	1,000
Chrysanthemum, oleander, stock	1,350
<b>Fruit</b>	
Avocado, strawberry, walnut	700
Apple, almond, apricot, grapefruit, lemon, orange	1,000
Peach, pear, plum, olive, raspberry, fig, grape,	1,350
<b>Lawn grasses</b>	
Fescue, ryegrass	1,200
Santa Anna couch	5,000
Kikuyu	25,000
<b>Vegetables</b>	
French beans, peas	700
Capsicum, celery, lettuce	1,000
Broccoli, carrot, cauliflower, cucumber	1,350
Onion, potato, sweet corn, tomato	1,750
Asparagus, beetroot, cabbage, spinach	2,100
<b>Livestock</b>	
Poultry	3,500
Pigs	4,000
Horses	7,000
Dairy cattle	6,000
Beef cattle	10,000
Sheep	13,000
<b>Human consumption</b>	
Sea water	30,000

## Salinity

The quality of water can restrict its use for farm enterprises. While livestock are fairly tolerant of moderately saline water, production from horticultural crops and pastures can be severely affected. See Table 3 for the upper salinity levels tolerated by a variety of usages.

## Algae and aquatic plants

Algae have an extremely important role in the ecology of waterways. Without algae our waterways would be deprived of oxygen and food. However, algae in waterways become a problem when they are present in excess quantities, known as algae blooms (Figure 14). Excessive algae growth often results from a combination of warm water, high concentrations of nutrients and sunlight. Algae in the water may block pump filters and create odours and bad-tasting water. Some algae can even poison stock. If poisoning occurs, animals may exhibit a variety of symptoms. Typically these can include muscle weakness, lethargy, reduced or no feeding, mental derangement and diarrhoea.

Strategies to prevent algae blooms should focus on reducing the amount of nutrients entering the dam water.

This can be achieved by:

### Planting native vegetation around the dam edge:

this can play an important role in preventing algae growth by filtering out nutrients and soil particles from water entering the dam. Native vegetation can also provide shade and lower the water temperature, which can reduce algae growth, which is promoted by sunlight (Figure 15).

### Establishing or improving the growth of aquatic plants:

aquatic plants compete with the algae for nutrients, including nitrogen and phosphorus. Some aquatic plants suitable for farm dams include Aquatic Fern (*Marsilea drummondii*), Native Waterlily (*Villarsia reniformis*), Water Ribbons (*Triglochin procerum*), Tall Spike Rush and Phragmites.



Figure 14: A severe blue-green algae bloom  
Photo: W. Hannaford

## How much water is needed?

### Domestic requirements

Table 4: Average daily domestic water requirements

Types of use	Average daily requirement (litres)
Household with septic system	180 per person
Household without septic system	135 per person
Home garden	3,000 per 0.1 ha (for summer months only)



Figure 15: Native vegetation planted around a dam's edge  
Photo: A. Cole

## Livestock needs

Drinking water requirements for stock will vary according to the type of stock (Table 5), weather, quality and nature of food, water quality and age and condition of the animal. During the summer months use will be about 125% of the average daily requirements; winter use is usually 75% of average daily requirements.

*Table 5: Annual livestock water requirements*

Types of use	Average annual requirement (litres)
Ewes on dry feed	3,600
Ewes on green feed	2,700
Lambs on dry feed	900
Lambs on irrigation	450
Dairy cows in milk	22,500
Dairy cows dry	17,000
Beef cattle	17,000
Calves	8,200
Horses – working	20,000
Horses – grazing	13,500
Alpacas – grazing	2,000



*Figure 16: Use of mulch in orchards. Photo: AMLR NRM Board.*

## Horticulture needs

The amount of water required by horticultural crops or viticulture will depend upon the type of crop, the growing season, soil type and climatic factors such as rainfall and temperature. Water conservation measures should be implemented when planning or running a horticultural enterprise.

These include:

- the installation of the most efficient irrigation system for the type of enterprise
- the use of mulch and/or groundcovers
- selection of species and variety most suitable for the climatic and soil conditions in the region
- consideration of irrigation scheduling (timing)
- continual monitoring of the amount of water available to the plant to avoid under- or over-watering.

<b>Case study: water resources and requirements on a small property (Mount Barker)</b>	
Average annual rainfall	= 772 mm
<b>Livestock needs</b>	
Maximum livestock-carrying capacity for the property	= 14 wethers
Water requirements on dry feed/sheep	= 3,600 L per annum
Water requirements on green feed/sheep	= 2,700 L per annum
14 animals on dry feed for 6 months	= 1,800 L × 14 = 25,200 L (4,200 L per month)
14 animals on green feed for 6 months	= 1,350 L × 14 = 18,900 L (3,150 L per month)
<b>Total</b>	<b>= 44,100 L per year needed from dam</b>
<b>Domestic requirements</b> - Assume 4 people plus septic system	
180 L per person per day × 4	= 720 L per day
<b>Total = 720 L × 365</b>	<b>= 262,800 L per year from rainwater</b>
<b>Garden/orchard requirements</b> - Assume an area of 1,500 m <sup>2</sup> (0.15 ha) irrigating at 1.5 ML per ha (1,500,000 L)	
0.15 × 1,500,000 L	= 225,000 L
<b>Total</b>	<b>= 225,000 L per year needed from dam</b>
<b>Total requirements</b>	
Domestic (rainfall)	= 262,800 L
Orchard and livestock (dam)	= 225,000 + 44,100 = 306,900 L
<b>Total</b>	<b>= 569,700 L</b>



### Case study continued

Dam size is 2.5 ML (2,500,000 litres)

Collection off roof areas (every mm of rain falling on each square metre produces 1 litre of water)

Month	Rainfall (mm)	House roof collection (litres) 22 m × 16 m	Shed roof collection (litres) 15 m × 6 m	Domestic use (litres)	Livestock needs (14 sheep)
January	27	9,504	2,430	21,900	4,200
February	26	9,152	2,340	21,900	4,200
March	32	11,264	2,880	21,900	4,200
April	61	21,472	5,490	21,900	4,200
May	90	31,680	8,100	21,900	3,150
June	100	35,200	9,000	21,900	3,150
July	106	37,312	9,540	21,900	3,150
August	103	36,256	9,270	21,900	3,150
September	85	29,920	7,650	21,900	3,150
October	68	23,936	6,120	21,900	3,150
November	40	14,080	3,600	21,900	4,200
December	34	11,968	3,060	21,900	4,200
<b>Total</b>	<b>772</b>	<b>271,744</b>	<b>69,480</b>	<b>262,800</b>	<b>44,100</b>

### Conclusion

The landholder can collect a total of 341,224 litres off roof areas and has 2.5 ML (2,500,000 litres) of dam water. Therefore ample water supplies are available on the property to provide for all the stock (44,100 L), garden/orchard (225,000 L) and domestic needs (262,800 L).

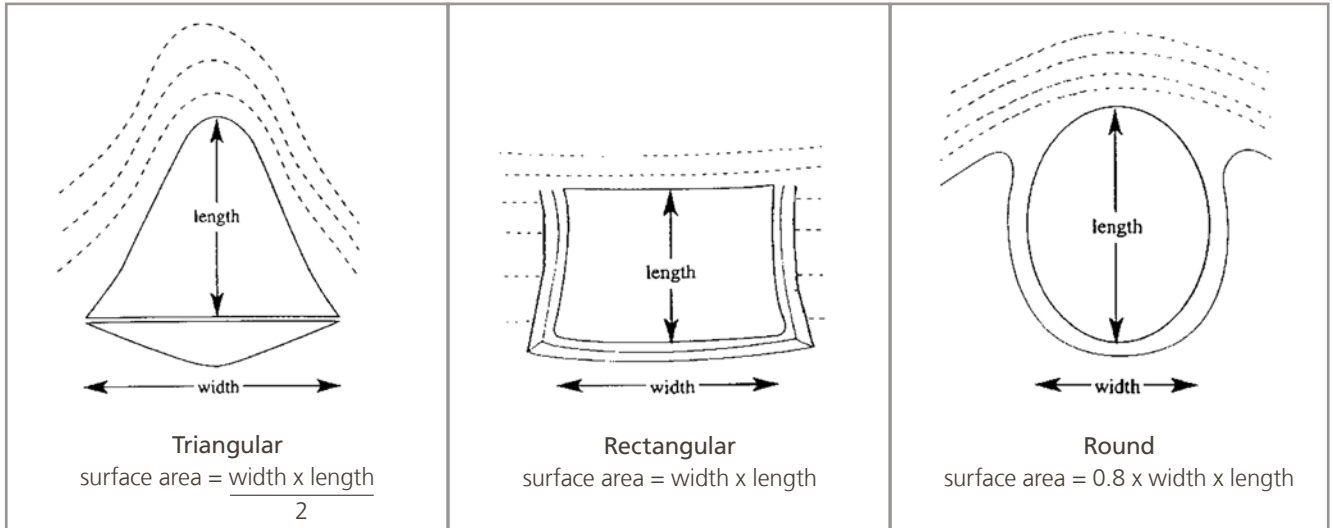


Figure 17: Dam shapes for volume calculation

### Calculating the volume of a farm dam

To calculate the volume of a farm dam you will need to measure the surface area and the maximum depth of the dam in metres. To calculate the surface area of your dam you will need to decide the shape of the dam from the options in Figure 17.

**Step 1:** Decide on the shape of your dam from the options above.

**Step 2:** Measure the relevant width and length at top water level and enter those on the recording sheet.

*All dimensions need to be recorded in metres.*

**Step 3:** Measure the maximum depth of the dam and enter on the recording sheet.

**Step 4:** Use the formula relevant to the dam shape above to calculate surface area (SA) in square metres of each dam and enter the SA on the recording sheet.

**Step 5:** Using the following formula, calculate the volume in cubic metres.

#### All shapes

$$\text{Volume} = 0.4 \times \text{surface area} \times \text{depth}$$

Enter the results on the recording sheet.

Note: The conversion factor 0.4 takes into account the slope of the sides of the dams.

**Step 6:** Divide this volume by 1,000 to convert cubic metres to megalitres and enter on the recording sheet.

This is the dam capacity in megalitres (ML).

#### Recording sheet

Width (m)	
Length (m)	
Depth (m)	
Surface area	
Volume (cubic metres)	
Volume (ML)	

# 7. Native vegetation and biodiversity

## Purpose of conserving remnant native vegetation and revegetating

### Biodiversity and habitats

The term 'biodiversity' covers the variety of life on earth. It is the variety within and between all species of plants, animals and micro-organisms and the ecosystems in which they live and interact. At the property level, landholders can conserve biodiversity through the management of native vegetation.

Native vegetation has been extensively cleared in the Adelaide and Mount Lofty Ranges (AMLR) region, with most of the remaining vegetation occurring as patches on hilltops, steep slopes, roadsides and watercourses. These plant communities generally grow on non-arable land, with few good examples remaining on productive soils, which have been extensively cropped and/or grazed for many years.

Many patches of remnant vegetation are too small, in poor condition or too far from other patches to provide adequate habitat for the fauna that were once common in the region. Consequently, many of the region's native fauna species are now extinct or rare. Protecting and restoring native vegetation is essential for the long-term survival of the remaining species.

The following priorities will assist in making decisions if conserving biodiversity is one of your goals.

### Priority 1: Protect remnant native vegetation

- Keep stock away from remnant native vegetation by establishing good fences. If no stock are grazing on the property, ensure that boundary fences will effectively exclude stock from neighbouring properties.
- Control feral animals such as rabbits, foxes, cats and deer.
- Consider if and how the scrub can be protected from over-abundant native grazing animals (for example, kangaroos).
- Control weeds using the following principles:
  - Identify plants accurately so no natives are accidentally removed or damaged.
  - Use only minimal disturbance techniques.
  - Work outwards from the best bits of bushland.
  - Concentrate on high-threat weeds first.

*Table 1: Examples of high threat bushland (or environmental) weeds in the AMLR region*

- |  |                                   |
|--|-----------------------------------|
| • African Boxthorn                     | • Gorse                           |
| • Boneseed                             | • Monadenia (African Weed Orchid) |
| • Bridal Creeper and Bridal Veil       | • Olive                           |
| • Bulbil Watsonia                      | • Periwinkle                      |
| • Cape, Montpellier and English brooms | • Radiata Pine                    |
| • English Ivy and Cape Ivy             | • Sweet Pittosporum               |
| • Erica                                | • Sydney Wattle                   |

*Note: for a full list refer to Croft, Pedler & Milne (2005)*

### Further information

For control techniques see the Natural Resources AMLR's *Weed management techniques* fact sheet at: [www.naturalresources.sa.gov.au/adelaidemtloftyranges](http://www.naturalresources.sa.gov.au/adelaidemtloftyranges)

### Priority 2: Encourage natural regeneration

Many areas have the capacity to naturally regenerate, provided they are carefully managed. Regeneration is far cheaper than active revegetation and is more likely to represent the original genetic and species diversity of the site. How to recognise those areas most likely to regenerate naturally is further explained on page 64.

Encouraging natural regeneration generally requires the same management activities as for conserving remnants. However, a higher level of weed control will usually be required and carefully managed grazing is sometimes useful in promoting native grasses over introduced pastures and pasture weeds.

### Priority 3: Revegetate

Revegetate using local native species, with the range and ratio of species selected representing the original vegetation association, including a variety of 'layers' or plant life forms such as trees, shrubs, ground covers, grasses, herbs, twiners and climbers, as appropriate.

## Improving water quality

Native vegetation along watercourses is important to:

- protect and improve the *quality of water* for human consumption, stock and the environment
- protect the bed and banks from *erosion*
- provide habitat for *aquatic animals* such as fish, frogs, insects (for example, dragonflies) and yabbies that rely on watercourses.

The width of the watercourse to be protected and revegetated (the buffer) determines the effectiveness of the work. Some guidelines are provided on page 43. However, site constraints and funding requirements will also need to be considered.

### Further information

See Staton and O'Sullivan (2006).

## Tackling land degradation

### Mass erosion

Revegetation can fulfil an important role in reducing mass erosion, but it is important to understand that this approach also has limitations. Seeking expert advice and fencing off the area to exclude stock are the first steps in reducing erosion. In many cases, enabling perennial grass to cover over the eroded area is just as effective, if not more so, than revegetation with trees and shrubs.

### Salinity

Carefully sited revegetation can be used to combat salinity by the uptake of excess soil moisture, which would otherwise cause saline groundwater to rise.



Figure 1: Mass erosion at Upper Hermitage  
Photo: AMLR NRM Board

## Waterlogging

Widely spaced trees can be used to dry out mildly waterlogged soils as well as provide shade. Soils prone to moderate to very high waterlogging may have been swamps or localised wetlands in the past. Swamps are important habitat for many species and are protected on the Fleurieu Peninsula under the *Commonwealth Environment Protection and Biodiversity Act 1999*; therefore, they are best managed as conservation areas.

### Wind erosion

Windbreaks can be planted in areas where soil types (that is, sand) are susceptible to wind erosion. Slowing wind speeds reduces the likelihood of wind erosion. Sandy rises and sand dunes can also be planted with vegetation to provide year-round soil protection as well as habitat and wind protection to surrounding areas.

## Benefits for production

### Wind shelter

Shelterbelts are used by many farmers to provide protection for their stock and crops from wind, especially in the cold months. They provide shade relief in summer and protection from winds and frosts in winter.

### Shade

Shade trees are used by stock in the warmer months. The number of shade trees in a paddock should be enough to provide shade for all stock.



Figure 2: Wind erosion in Strathalbyn  
Photo: AMLR NRM Board



*Figure 3: Shade will be appreciated by stock*  
 Photo: J. Pain

### Buffers and screens

Vegetation buffers are being increasingly used to separate conventionally farmed properties from organic and biodynamic farms. A buffer of trees and shrubs can help to prevent the accidental movement of chemicals between properties. They are also used to screen views of roads, industrial areas and houses.

### Farm forestry

In South Australia, remnant native vegetation is protected and cannot be cleared without prior approval; however, planted native trees can be harvested provided they are not protected by a legal agreement. Species used for most commercial plantations are not native to SA, but many local natives are suitable for firewood. Some landholders decide to retain their plantations once they are established, in which case it is best to select local native species. A development application is required for establishing a large-scale plantation.

### Carbon sequestration

Native vegetation planted since 1990 can be used to offset carbon emissions and there is an increasing number of schemes which pay landholders for the carbon sequestered in their revegetation. Various schemes have different ways of operating, payment rates and minimum requirements. Landholders considering such a scheme should investigate a few to determine the most suitable. Revegetation that is subject to a carbon agreement cannot be cleared and this will be registered on the property title through a covenant or similar instrument.



*Figure 4: An arid land native garden*  
 Photo: AMLR NRM Board

### Landscaping and amenity

Many local native plant species make excellent garden plants. They respond well to pruning and mulching and have adapted to local rainfall and therefore do not rely on hand watering. There are a number of native nurseries in South Australia that can provide advice on the most suitable species for your area.

### Recognise remnant areas

#### What is remnant vegetation?

While most people would tend to think of remnant native vegetation as relatively intact blocks of native scrub such as those found in national parks, remnant native vegetation also includes, but is not limited to:

- scattered native trees in paddocks and on roadsides with little or no native understorey
- native understorey species such as native grasses where the overstorey has been removed
- areas that have been cleared and then naturally regenerated.

#### Recognising native species from weeds

To recognise, assess and manage native vegetation it is important to be able to determine what is native and what has been introduced.

**Table 2: Examples of native plants that look similar to introduced plants**

Native species	Not to be confused with these introduced species
Kangaroo Thorn ( <i>Acacia paradoxa</i> )	Gorse ( <i>Ulex europaeus</i> )
Large-leaf Bush Pea ( <i>Pultenaea daphnoides</i> )	Montpellier Broom ( <i>Genista monspessulana</i> )
Old Man's Beard ( <i>Clematis microphylla</i> )	Bridal Creeper ( <i>Asparagus asparagoides</i> )
Wallaby Grasses ( <i>Rytidosperma</i> spp.)	Pussy Tail ( <i>Pentameris pallida</i> )
Sea Rush ( <i>Juncus kraussii</i> )	Spiny Rush ( <i>Juncus acutus</i> )
Native Cherry ( <i>Exocarpus cupressiformis</i> ) and Southern Cypress Pine ( <i>Callitris gracilis</i> )	Conifers/Pines

Note: See Robertson (2005) for more examples

Many plants from other regions and states have also naturalised in the AMLR region and are considered bushland weeds, such as:

- Several wattles including Cootamundra Wattle (*Acacia baileyana*), Western Coast Wattle (*A. cyclops*), Early Black Wattle (*A. decurrens*), Flinders Ranges Wattle (*A. iteaphylla*), Sallow Wattle (*A. longifolia* ssp. *longifolia*) and Golden Wreath Wattle (*A. saligna*)
- Sweet Pittosporum (*Pittosporum undulatum*)
- Rosemary Grevillea (*Grevillea rosmarinifolia*).

### Assessing the quality of remnant vegetation

Assessing the quality of remnant native vegetation is useful for, firstly, prioritising work (with better remnants receiving a higher priority) and secondly, determining which, if any, management techniques to adopt.

Features of good-quality remnant vegetation include:

- high numbers of a variety of native plant species
- low cover and threat from weeds
- minimal bare ground
- a range of different plant life forms
- natural regeneration
- healthy trees, including large, hollow-bearing trees and fallen logs present in the site
- few feral animals
- low grazing pressure
- high numbers of a variety of native fauna species
- large size, minimal 'edge effects' and connected with other remnants nearby.

### Further information

See Clarke, Stokes and Wallace (2010); Croft, Pedler and Milne (2005.); Robertson (2005).

## Regulations

The following pieces of legislation relate to native vegetation and biodiversity.

### **Native Vegetation Act 1999**

In South Australia remnant native vegetation is protected from clearance under this Act. Strict exemptions (or Regulations) exist for certain situations such as for maintaining roadsides, fencelines, firebreaks and developments.

### **Environment Protection and Biodiversity Conservation Act 1999**

This Commonwealth Act is designed to protect nationally threatened species and ecological communities from direct and indirect threats. Four ecological communities that occur in the AMLR region are protected under this Act:

- Fleurieu Peninsula swamps
- Grey Box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of south-eastern Australia
- Peppermint Box (*Eucalyptus odorata*) grassy woodland
- Iron-grass natural temperate grassland.

### **Development Act 1993 (Regulated and significant trees)**

Under the Development Act there are controls in place to protect mature trees (both native and non-native) of a certain size in metropolitan Adelaide and some Adelaide Hills areas. Regulated trees are trees with a trunk circumference of 2 m or more measured at a point one metre above natural ground level. Significant trees have a trunk circumference of 3 m.

### **Further information**

- [www.environment.sa.gov.au/managing-natural-resources/Native\\_vegetation](http://www.environment.sa.gov.au/managing-natural-resources/Native_vegetation)
- [www.environment.gov.au/epbc](http://www.environment.gov.au/epbc)
- Protecting regulated and significant trees - a brief overview of the legislative controls in place to protect trees in metropolitan Adelaide and some Adelaide Hills areas. [www.sa.gov.au/\\_\\_data/assets/pdf\\_file/0003/17571/Protecting\\_Reg\\_and\\_Sig\\_Trees\\_Comm\\_Info.pdf](http://www.sa.gov.au/__data/assets/pdf_file/0003/17571/Protecting_Reg_and_Sig_Trees_Comm_Info.pdf)

## Where to undertake revegetation

Where revegetation works should be established, and how they are designed, depends on the purpose for which they are being undertaken. Revegetation is an expensive activity, requiring a commitment to maintenance over many years, and therefore it should be carefully planned. Most landholders undertake revegetation in stages over a number of years, learning as they go. Half a hectare of revegetation is a good size for first-timers doing most of the work on their own.

Fencing is often the biggest cost of revegetation, so a layout that minimises the amount of fencing and results in multiple benefits should be selected. For example, a biodiversity corridor can also act as a shelterbelt. It may seem extreme, but returning an entire paddock to native vegetation may be more beneficial and less costly than having small patches of vegetation across the property. For example, a single paddock could incorporate remnant vegetation protection, buffer revegetation for biodiversity, watercourse revegetation for improved water quality, and a firewood plantation, with no fencing required.

Table 3: Revegetation location and design features to meet different purposes

Revegetation purpose	Suitable locations	Design features
Biodiversity and habitat	<p>Adjacent to existing remnants in order to buffer them, increase their size and encourage natural regeneration</p> <p>Connecting corridors between remnants; (wider and shorter corridors are better than long thin ones)</p> <p>Large blocks (bigger is better); try coordinating with neighbouring properties</p> <p>Incorporate existing habitats such as standing and dead trees, rocky outcrops and watercourses</p>	<p>High diversity of species (30+)</p> <p>Species diversity and density replicate the original vegetation association for the site</p> <p>Create 'patchiness' with a variety of dense and open areas across</p>
Improving water quality	<p>At least 5 m either side of a minor watercourse and 20 m or more each side of a major watercourse</p> <p>The wider the buffer, the less likely the fence is to be damaged during floods and the better the habitat that will be provided</p>	<p>Plant different species on the toe, middle and upper banks and floodplain based on their water requirements</p>
Landslip control	<p>Revegetate above, on and below the landslip</p>	<p>Use deep-rooted trees and shrubs</p>
Gully, tunnel and watercourse erosion control	<p>Fencing the areas off and planting sedges, small shrubs, and grasses may be of assistance</p> <p>Revegetation with a mix of species above the eroding area may help to reduce the flow of surface and sub-soil moisture to the eroding area</p> <p>Have the site assessed by an expert to determine if revegetation will be of further assistance</p>	<p>Do not plant trees on the erosion site</p> <p>Seek expert advice</p>
Salinity mitigation	<p>Focus revegetation on recharge areas in the catchment</p> <p>Fence off and revegetate salt-affected areas</p>	<p>Select salt-tolerant native species for salt-affected areas</p>
Windbreaks and shelterbelts	<p>Site at right angles to the direction of the most damaging winds, usually on the north-western side for wind erosion control, and southern sides for stock shelter in winter</p> <p>Protection is provided for a distance 12–15 times the height of the windbreak</p>	<p>Minimum 3 rows (10 m) wide</p> <p>Plant the tallest species in the centre row</p>
Waterlogging	<p>Mildly waterlogging-prone soils</p> <p>Plant in rows to make working the paddock easier</p>	<p>Plant waterlogging-tolerant trees 20–30 m apart</p> <p>Use sturdy, stock-proof guards</p>
Shade	<p>Site shade trees either along the northern or western boundary of a paddock and protect with temporary fencing, or scattered around paddock protected by stock-proof guards</p>	<p>If planting a single row, space trees 5–10 m apart</p> <p>If scattered, minimum 30 m apart</p>
Buffers and screens	<p>Dependent on what is being buffered or screened</p>	<p>As for windbreaks and shelterbelts</p>
Timber – small scale	<p>Most locations are suitable; plant either blocks or in rows along fencelines</p>	<p>Plant single species blocks</p> <p>Close spacings (2–5 m)</p>
Timber – commercial scale	<p>Seek advice; sites need to be large enough to be commercially viable, and should not be too steep for harvesting operations</p>	<p>Select species according to the desired product</p> <p>Pruning or thinning may be required</p>



## Planning revegetation works

### Site preparation

#### Site assessment

A thorough assessment of the site should be carried out before commencing any works, preferably with advice from an expert who can recognise both native and weed species.

Some issues that should be noted during the assessment include:

**Mature remnant trees:** tree species should not be planted underneath the canopy of existing trees. Use tubestock planting or hand direct seeding to establish middle and ground-layer species beneath existing trees.

**Weeds:** woody weeds and exotic trees are best removed before revegetation begins. However, if they are providing habitat for native fauna, staged removal and replacement with native species might be more suitable. Perennial pasture grasses and weeds should be removed 2–4 weeks before planting and will require ongoing monitoring and follow-up control.

**Power lines:** SA Power Networks has strict guidelines about what can or cannot be planted underneath power lines, and they can (and have) removed unsuitable revegetation. Tree trimming can be reduced by calling SA Power Networks for recommended 'clear zones' before new vegetation is planted near a power line on your property. SA Power Networks also publish lists of the most appropriate species to plant around power lines. (See [www.sapowernetworks.com.au](http://www.sapowernetworks.com.au))

**Native grasses and herbs:** areas dominated by native grasses, herbs, lilies and other ground layer species should be avoided when undertaking weed control and should only be planted into with tubestock for missing life forms at appropriate densities. Assess the site in the springtime (September–November) when these species are actively growing and/or flowering to identify their presence.

**Land form:** the slope and rockiness of the site affect the suitability for different planting methods; susceptibility to waterlogging affects when the site can be planted; aspect and soil type determine the range of species that can be planted.

#### Weed control

Existing pasture as well as grassy and herbaceous weeds will compete with revegetation for space, moisture and light and therefore should be controlled before planting. These weeds should be monitored and controlled as necessary for one or two years after planting. Each planted seedling should have a weed-free area of at least 0.5 m in radius. Depending on the

planting method to be used, control weeds in spots, patches or rows, or blanket spray the area prior to revegetating if planting densely.

A non-selective herbicide (applied according to the label instructions) is usually used. It is important to apply it when the plants are actively growing. If a large amount of dead matter is attached to weedy grasses, control will be more effective if the grass is slashed or grazed first and the regrowth sprayed 2–3 weeks after slashing. Herbicides are often applied once or twice before planting, and again once or twice afterwards, as required.

Non-herbicide methods of weed control include physical removal by hand-pulling, hand-digging or grubbing, which are easiest to do when the soil is moist and soft, generally from winter to early spring. Weeds can also be smothered by laying materials such as old carpet or cardboard, held down with rocks or temporarily placed tyres. Commercial mat and mulch products are available but are expensive for large sites.

#### Further information

See Chapter 5 – Environmental weeds.

#### Fencing

Revegetation areas should not be grazed and may require fencing to keep stock out. The type of fencing used will depend on the type of stock, but in most cases electric fencing is suitable and cheaper, although it requires some maintenance to prevent short-circuiting the current; for example, by tree branches falling across the fence. If the revegetation area is to be expanded over time, temporary electric fencing can be used and relocated as required. If the revegetation area is large, consideration should be given to the number and placement of gates for access.

There should be a gap of at least 2 m between the edge of the revegetation and the fence line so that the revegetation area can be accessed around the boundaries for maintenance work such as weed control. This buffer zone may require regular slashing to control weeds.

#### Fire breaks

Fire breaks, access tracks and fuel-reduction areas should be incorporated into large revegetation sites, as required.

## Species selection and seed provenance

For most revegetation, except forestry, only species that are native to the area should be planted because many non-native species can spread and become weeds. Local native species are best adapted to the conditions in the area and will also provide suitable food and habitat for native birds, mammals, reptiles, insects and micro-organisms.

Seed and cutting material should also be collected from as close to the site as is feasible to take advantage of, and protect, local plant genetic diversity. This is commonly referred to as 'local provenance seed.' Where the amount of seed available in the local area is scarce, a purpose-designed seed orchard may be required to create a central site where seed collection can occur. By way of example, the City of Playford has developed its own seed orchard for revegetation projects in the council area. For more information see [www.playford.sa.gov.au/littleparaseedorchard](http://www.playford.sa.gov.au/littleparaseedorchard).

## Establishing plant communities

For biodiversity revegetation, the species selected for the site and numbers for each species should be based on the type of plant community being established, rather than simply selecting a range of species that are tolerant of the conditions on the site. Determining what vegetation community should be established on the site should be based on the location, aspect and soil type, while noting what scattered or paddock trees and remnant roadside vegetation are present at or adjacent to the site. However, the nearest intact remnant vegetation does not always represent what would have grown on your site; for example, it may have been left uncleared because it was on a less productive soil type.

Visiting a good remnant example of the vegetation community natural to your site may help you plan your revegetation species list and planting design. Information on plant species, diversity, densities and structure is also available from the Nature Conservation Society of South Australia's (NCSA) bushland condition monitoring manuals, which describe benchmark vegetation communities (what a community should look like in its natural, undisturbed or pre-European state). Go to [www.ncssa.asn.au](http://www.ncssa.asn.au) for more information.

In particular take note of:

**The density and diversity of trees:** pace out the distance between trees to work an idea of the average number per hectare (for example, an average spacing of 10 m = 100 trees/ha, average spacing of 30 m = 9 trees/ha). In South Australia the number of different tree species within a vegetation community is often only one or two, although it can be up to five or six.

**The density of the middle layer:** in some vegetation communities, the shrub layer is thick and dense, while in others it is open, resulting in a 'see-through' vegetation type. Shrubs often occur in dense, unevenly spaced and sized clumps with open spaces between rather than being uniformly distributed.

**The range of ground layer species:** typically the diversity and abundance of species in most vegetation communities is highest in the ground layer and decreases towards the canopy. Unfortunately, only a few ground layer species are available for revegetation, and often in relatively small numbers; however, they should still be included in revegetation and can naturally reproduce quickly.

If a site is particularly weedy, it may be beneficial to plant a high density of fast-growing, 'coloniser' species such as wattles (*Acacia* spp.) to out-compete grassy and herbaceous weeds. Wattles are usually short-lived (10–15 years on average). Therefore it is important to plan a range of other longer-lived species to take their place.

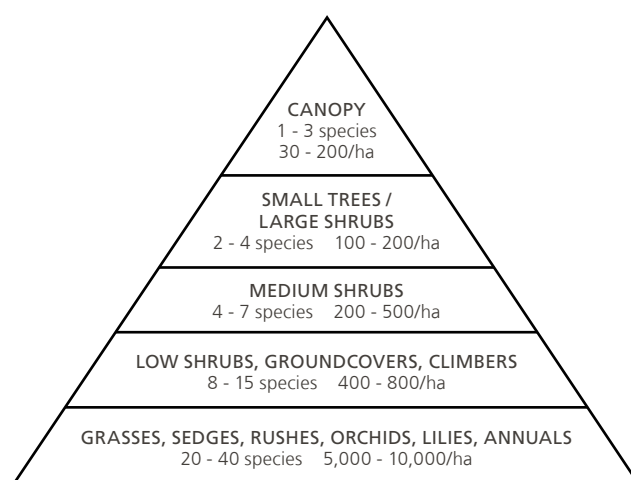


Figure 5: The number of species and abundance of plants in different canopy layers of a typical natural vegetation community

## Revegetation species

Revegetation lists are provided for different parts of the region by Trees For Life ([www.treesforlife.org.au](http://www.treesforlife.org.au)) and in publications such as *What seed is that?* (Bonney 2005). These lists are for broad areas and any single site would only use a sub-set of the tree and shrub species listed, so advice should be sought from experts. The lists contain few ground layer species. Seek advice on what other ground layer species should be included, but be aware that not all species can be propagated.

### Further information

Advice should be sought from your local Natural Resources Centre (see [www.naturalresources.sa.gov.au/adelaidemtloftyranges/land/landholder-services](http://www.naturalresources.sa.gov.au/adelaidemtloftyranges/land/landholder-services)).

## Revegetation techniques

### Natural regeneration

For an area to regenerate naturally, seeds or bulbs must be either existing as soil seed reserves or from nearby existing remnant vegetation from where they can be blown or washed in or carried in by birds. Often, the least agriculturally productive land will regenerate most readily because it has undergone less modification and usually contains some remnant vegetation. Areas that have been intensively cropped or have an introduced pasture will regenerate more slowly and require active assistance via one of the methods below.

Regeneration areas should be monitored for the first few years using methods such as bushland condition monitoring (from the NCSSA) and the bush rapid assessment technique or BushRAT (Department of Environment, Water and Natural Resources). Photopoints may also be of use, as will keeping notes on what is present and the extent of its abundance and the extent of ongoing weed and introduced animal control etc.

After a few years of regeneration, it is important to assess whether the species regenerating represent the full range of species for the vegetation association. Species which are 'absent' may be actively planted back, or could simply require more time for the right levels of shade, shelter, temperature and soil moisture.



*Figure 6: A direct seeding machine in action  
Photo: AMLR NRM Board*

### Machine direct seeding

The technique of direct seeding involves planting seeds where they are to grow, rather than planting them in a pot and transplanting the resulting plant as a seedling. With machine direct seeding an appropriate mixture of native seeds are placed by a purpose-built machine into a prepared site, or the machine prepares the site as it plants the seed.

This method is cheaper and easier than planting seedlings or hand direct seeding, but only a limited range of species can be established, so supplementary planting with tubestock is usually required. Other disadvantages are that this method uses a great deal of seed compared with tubestock transplanting; it can be slow to get results; and is difficult to maintain weed-free after seeding. The method is also not suited to all sites; for example, steep and/or rocky sites and those with existing trees or understorey species, or very boggy soils. Approximately 1.5 kg of seed per hectare is required in high rainfall areas.

## Hand direct seeding

Hand direct seeding is the cheapest method of active revegetation but has mixed results. To prepare an area for seeding, spray out spots first, then lightly scalp the surface with a mattock, spade or similar tool immediately prior to sowing, scatter seed and cover. At seeding the soil surface can be roughened with a hand tool to allow seed to be buried or to sit on the surface, depending on its size. The seed is sprinkled onto the surface and pushed in with a hand tool or boot. Seeds can be mixed with sand or sawdust and shaken over the soil surface by hand or applied using custom-made tools.

Mixing a quick-growing hard coat seed (for example *Dodonaea* spp., *Acacia* spp.) with finer seed (for example, *Eucalyptus* spp., *Leptospermum* spp.) can bring good results, although care should be taken not to create over-crowded conditions by sowing excessive amounts of seed. Hand-seeding spots can be sheltered with fallen branches to protect seedlings from browsing or to minimise the potential for seeds to be washed from the soil during rain or windy events. Native grass can be hand-broadcast over larger areas and the seed does not need to be removed from the grass heads as it will drop out naturally. Native daisies may also be established in this manner.

## Tubestock planting

Tubestock planting is often the most expensive method of revegetation but has the most reliable results and enables the placement and spacing of different species to be more accurately determined from the outset. The greatest range of species can be established from tubestock.

Seedlings are usually grown in either 'cells' (solid trays for 40 seedlings) or tubes. Cells are cheaper and also have a smaller root mass (therefore requiring less digging). Tubes are necessary for species that take longer than 6 months to grow to planting size or are propagated from cuttings. Specialised planters are available for each; for example, 'pottiputkis' for cells, and Hamilton Tree Planters for tubes. Specialised mechanical augers are also available. Mattocks are often the best 'garden' tool to use, with spades being the most laborious.

You can grow your own tubestock or order them from a nursery that grows local native species. Most species should be at least 6 months old before they can be planted out, while some may be up to 18 months. Therefore tubestock seed will need to be ordered and/or sown well in advance of the planting time. Buying pre-grown seedlings 'off the shelf' is the most expensive option.



Figure 7: Hamilton tree planters with round or square ends for different shaped seedling tubes. Photo: AMLR NRM Board.



Figure 8: A pottiputki planter for planting seedlings grown in cells, with a kidney tray on the ground used for carrying seedlings. Photo: AMLR NRM Board.

Tubestock densities will vary depending on the species and the plant community which is being re-established. In sites with large amounts of perennial grassy weeds, very high densities of species such as wattles (*Acacias*) can be used initially to shade out weeds. Alternatively, to create a more open site, or if the site contains a good cover of native grasses or sedges and rushes, low densities of appropriate tree and shrub species should be used.

## Planting layout

Revegetation has traditionally followed a forestry-type layout, with each species evenly spread across a site in parallel rows and even spacings between plants. This type of layout is easier for site maintenance but does not replicate natural vegetation structures authentically. It should therefore only be used where biodiversity is not a priority outcome. In large sites, planting in rows may be necessary for site maintenance, but irregular spacing along the rows can increase the variability, as does planting several of the same species close by. Ideally, tubestock and hand direct seeding should be planted with irregular spacings to create a patchy structure.



*Figures 9 and 10: The same site at planting (top) and 3 years on (above), showing how irregular plant spacings can be used to replicate natural density variation. Photos: AMLR NRM Board.*

Machine direct seeding invariably results in the creation of vegetative rows; however, the uneven distribution of seedlings along the rows tends to provide some variety of densities.

Suggested ways to develop a 'natural' vegetation structure and species distribution with machine direct seeding are:

- Lift the seeder at random intervals to create gaps.
- Include plenty of ground cover species in the seed mix.
- Seeding should be overlapping (crossed over), which will result in a more random, 'patchier' and less linear structure, which is more conducive to increasing habitat value.
- Plant tubestock of species not available in direct seeding between the lines.

Except for trees, it is more effective to place tubestock close together, or in 2 or 3 scattered clumps, rather than spreading them across the site. This way they are more likely to cross-pollinate and reproduce.

## Timing

The planting should be timed to take advantage of the best climatic conditions, mild weather and rainfall. The best time to plant is usually in autumn or winter, when the plants will get the maximum amount of rain, before the hot, dry weather in summer. Generally speaking, drier sites should be planted earlier than wetter sites, and planting should be undertaken early in low rainfall seasons and later in high rainfall seasons. The planting time should always allow time for a germination and subsequent control of weeds.

## Protection for seedlings

### Redlegged Earth Mites

As with germinating pastures and crops, direct seeded revegetation is highly susceptible to damage from Redlegged Earth Mites. If you think that you have an infestation of these sap-sucking insects contact your local natural resources centre for control advice.

### Grazing animals

Tree guards may be necessary for properties with high numbers of rabbits, hares, deer, goats or kangaroos; however, controlling the animals themselves may be more economical than guarding individual plants.

If guards are necessary, consider whether all the plants will require guarding as guards can add considerably to the cost and labour of a project:

- Prickly species are least palatable so don't require guarding.
- Drooping She-oaks (*Allocasuarina verticillata*) and Silver Banksias (*Banksia marginata*) are highly palatable and therefore are a priority to guard.
- Species from the pea family, such as bush peas (*Pultenaea* spp.) are also very palatable.
- Ground covers should not usually be guarded as guards interfere with their growth form.
- Grasses, wattles (*Acacia* spp.) and eucalypts (*Eucalyptus* spp.) are only moderately palatable and can withstand light grazing.

Guards against rabbits and hares are readily available from a number of sources. Select a type that is not too narrow (otherwise seedlings tend to grow tall quickly but have weak stems) and with plenty of air flow (to prevent humidity and fungi). Milk cartons are cheap and effective guards in most situations and have the advantage of degrading naturally. Guards against kangaroos need to be at least a metre high and very sturdy.

### White snails

White snails may be a problem for revegetation in low rainfall areas. Baiting is the most common solution but there may be off-target damage so its use requires careful consideration.

## Ongoing management of remnant vegetation and revegetation

### Weed control

The control of weeds requires perseverance and ongoing commitment in both revegetation and remnant areas. Revegetation usually requires a high level of weed control in the first few years to reduce competition for moisture and light. The site should be monitored for new weeds, which might be blown in or brought in by animals. The approach to, and principles for, weed control in older revegetation sites should be much the same as for remnant vegetation.

When stock is first removed from remnant vegetation areas there may be a flush of growth from weeds that were previously being grazed, such as introduced annual and perennial grasses. The control of these is not always necessary unless they pose a fire hazard, in which case slashing can be used. Instead, a weed management plan should be developed and implemented, one that focuses on controlling weeds in the best bits of bush first; removing high-threat weeds should be a priority. Always use minimal-disturbance methods in remnant and established revegetation areas.

### Animal control

Monitor and control pest animals as required using minimal disturbance methods.

### Secondary planting

Some species do not tolerate full sun or weed competition and are therefore best planted a few years after initial revegetation is undertaken. Secondary planting can add diversity to older sites, especially sites which have been machine direct-seeded. Competition for moisture is high in revegetated areas and there is usually a higher mortality rate in secondary plantings in low rainfall years. Hand direct seeding can help to overcome this problem.

# 8. Bushfire prevention

Living in a bush setting is a lifestyle choice for many South Australians. The benefits are enormous, but the risk of serious bushfires is also real.

All people living in the bush, including those in suburban fringe areas of Adelaide and regional South Australia, are vulnerable. Therefore it is vital you have a practical *Bushfire survival plan*, manage your property to minimise risk to yourself and others around you, and act responsibly on days of severe or higher fire danger.

More detailed information and a basic *Bushfire survival plan* template can be found on the CFS website ([www.cfs.org.au](http://www.cfs.org.au)) or by contacting the CFS regional office or local council.

## Legislation

### *Fire and Emergency Services Act 2005*

The purpose of the Act, which established the South Australian Fire and Emergency Services Commission, is to:

- provide for the continuation of a metropolitan fire and emergency service, a country fire and emergency service, and a state emergency service
- provide for the prevention, control and suppression of fires
- handle certain emergency situations.

### Key points:

- Landowners are obliged to manage vegetation on their properties. This does not mean bare paddocks, but grasses reduced to 10 cm in height, where required.
- If an authorised officer believes that conditions on private land in a fire district may cause an unreasonable risk of the outbreak of fire on the land, or the spread of fire through the land, the authorised officer may, by notice in writing, require the owner to take specified action to remedy the situation within such time specified in the notice.

## Fire danger rating

There has been an increased frequency of extreme bushfires in the last 10 years. South-eastern Australia has experienced several such events including the Victorian Black Saturday bushfires in February 2009.

A National Fire Danger Rating system has been introduced to categorise these events and to provide the community with a clearer picture of how to prepare and respond.

Understanding the fire danger rating will help you to assess your level of bushfire risk. The rating is forecast by the Bureau of Meteorology for the following day and is an early indicator (or 'trigger') for you of the potential danger. Your actions and *Bushfire survival plan* should reflect this.



Figure 1: A scrub fire at Morialta in 2007. Photo: CFS.

Table 1: Fire danger index ratings

Fire danger index rating	Recommended action and potential fire behaviour and impact
<p><b>CATASTROPHIC</b> FDI 100+</p> <p><b>TOTAL FIRE BAN DAY</b></p>	<p><b>ACTION: For your survival, leaving early is the best option.</b></p> <ul style="list-style-type: none"> <li>• These are the worst conditions for a bush or grass fire.</li> <li>• If a fire starts and takes hold, it will be extremely difficult to control and will take significant fire-fighting resources and cooler conditions to bring it under control.</li> <li>• Spot fires will start well ahead of the main fire and cause rapid spread of the fire. Embers will come from many directions.</li> <li>• Homes are not designed or constructed to withstand fires in these conditions.</li> <li>• The safest place to be is away from bushfire-prone areas.</li> </ul>
<p><b>EXTREME</b> FDI 75–99</p> <p><b>TOTAL FIRE BAN DAY</b></p>	<p><b>ACTION: Leaving early is the safest option for your survival.</b></p> <ul style="list-style-type: none"> <li>• These are very hot, dry and windy conditions for a bush or grass fire.</li> <li>• If a fire starts and takes hold, it will be unpredictable, move very rapidly and be very difficult for fire fighters to bring under control.</li> <li>• Spot fires will start and move quickly. Embers may come from many directions.</li> <li>• Homes that are prepared to the highest level, have been constructed to bushfire protection levels and are actively defended may provide safety.</li> <li>• You must be physically and mentally prepared to defend in these conditions.</li> <li>• The safest place to be is away from bushfire-prone areas.</li> </ul>
<p><b>SEVERE</b> FDI 50–74</p> <p><b>TOTAL FIRE BAN DAY</b></p>	<p><b>ACTION: Leaving early is the safest option for your survival. Only stay if you and your home are well prepared and you can actively defend it during a fire.</b></p> <ul style="list-style-type: none"> <li>• These are hot, dry and possibly windy conditions for a bush or grass fire.</li> <li>• If a fire starts and takes hold, it will be hard for fire fighters to bring it under control.</li> <li>• Well-prepared homes that are actively defended can provide safety.</li> <li>• You must be physically and mentally prepared to defend in these conditions.</li> </ul>
<p><b>VERY HIGH</b> FDI 25–49</p>	<p><b>ACTION: Only stay if you and your home are well prepared and you can actively defend it.</b></p> <ul style="list-style-type: none"> <li>• If a fire starts, it is likely to be controlled in these conditions and homes can provide safety.</li> <li>• Be aware of how fires can start and reduce the risk.</li> </ul>
<p><b>HIGH</b> FDI 12–24</p>	<p><b>ACTION: Know where to get more information and monitor the situation for any changes.</b></p> <ul style="list-style-type: none"> <li>• If a fire starts, it is likely to be controlled in these conditions and homes can provide safety.</li> <li>• Be aware of how fires can start and reduce the risk.</li> </ul>
<p><b>LOW–MODERATE</b> FDI 0–11</p>	<p><b>ACTION: Know where to get more information and monitor the situation for any changes.</b></p> <ul style="list-style-type: none"> <li>• If a fire starts, it is likely to be controlled in these conditions and homes can provide safety.</li> <li>• Be aware of how fires can start and reduce the risk.</li> </ul>



## Bushfire survival plan

Your *Bushfire survival plan* outlines the work required to help safeguard your property and, most importantly, what actions you and your family will take on severe or higher fire risk days and if a fire threatens.

If you live in the bush, the suburban fringe or in regional South Australia, then you are in danger of experiencing a bushfire.

**The decision whether to stay and defend your home, or leave early, is critical and it needs to be made before a bushfire occurs and well before the fire danger season arrives.**

**If you plan to stay and defend your property, you will need to consider the following:**

- Is your home constructed to meet the latest regulations for building in bushfire-prone areas?
- Is your property prepared and maintained for bushfire?
- Are you physically fit to fight spot fires in and around your home? Keep in mind that actively defending your home can take longer than 10 hours in some cases.
- Are you mentally and emotionally prepared to actively defend your property?
- Are you able to implement your plan while caring for distressed young children or elderly or disabled people in your home?
- Do you have the resources, equipment and necessary skills and knowledge to effectively fight a fire?
- Does your home have a defensible space of at least 20 m cleared of flammable materials and vegetation?
- Is your home in a location that puts it at higher than normal risk or makes it difficult to defend, such as on a steep slope or in close proximity to bushland?

If these questions make you doubt your ability or the preparedness of your property, or if you are for any reason unsure about staying and defending your property, then you should prepare a plan to leave early.

**Your *Bushfire survival plan* must be prepared with all members of the household in advance of a fire or the bushfire season.**

Everyone's *Bushfire survival plan* will be different and depend upon their individual situation.

**Once you have completed your plan, run through or practise it regularly and keep it in a safe and easily accessible place for quick reference (for example, on the fridge).**

### Further information

The CFS website contains a great deal of information on how to prepare for the bushfire season and generate a *Bushfire survival plan*.



*Figure 2: Scrub fire at Bridgewater in 2007. Photo: CFS.*

## Seasonal checklist

The following check list is adapted from the CFS fact sheet *Prepare your property* ([www.cfs.sa.gov.au](http://www.cfs.sa.gov.au)).

### Winter

- Clear all gutters and create as much defensible space as possible around your home.
- Remove dead vegetation from around the home and prune lower limbs of trees.
- Obtain council permit to burn off garden waste, or dispose of the material through mulching or at a council tip.
- Ember-proof the home, for example, check roof space for loose tiles and gaps and repair as necessary.

### Spring

- Slash or mow long grass and remove cut material (unless it is likely to rot down before summer).
- Remove weeds around sheds and fences.
- Cut back trees overhanging the roof.
- Remove fallen branches and other debris.
- Check and service all mechanical equipment, including grass cutters, water pumps, sprinkler systems and fire extinguishers.
- Remove leaves from gutters.
- Prepare/check your bushfire survival kit.
- Review and update your *Bushfire survival plan*.

### Summer

- Maintain a defensible space of at least 20 m around your home and 5 m around sheds and garages (greater if on a slope).
- Clear around trees.
- Remove leaves from gutters.
- Slash stubble near sheds/buildings.
- Check reserve water supplies.
- Rehearse your *Bushfire survival plan* with your family.
- Ensure you have a portable battery-powered radio and spare batteries in your bushfire survival kit to enable you listen to bushfire warnings.
- Monitor fire danger ratings.

### Autumn

- Remove undergrowth and dead vegetation.
- Seek council permission for a burn-off.
- Check for any fire hazards and remove.

## Bushfire information and warnings

The police and emergency services are committed to providing timely and accurate information to the community during emergencies – including bushfires. To achieve this, a *Bushfire information* and *Bushfire warning* system has been developed to alert the community to bushfires and provide advice on what to do during a bushfire.

The CFS will issue bushfire information and warning messages when there is a potential threat to public safety in the immediate area of a fire. They are distributed by multiple means of communication including ABC local radio and the CFS website, smartphone app and social media platforms and text messages.

The system is based on two forms of message:

**BUSHFIRE INFORMATION MESSAGES** will be issued when there is a potential threat to public safety in the immediate area of a bushfire.

**BUSHFIRE WARNING MESSAGES** will be issued when a bushfire, burning out of control under very high to extreme weather conditions, requires an immediate response from the public to ensure their safety and survival. Bushfire warning messages will be preceded by a distinctive siren-like sound – the standard emergency warning signal. Bushfire information and bushfire warning messages will be issued via multiple media communication channels including local radio stations.

**Note: it is important to have a battery-powered radio to monitor bushfire information messages and bushfire warning messages.**

## Property protection

The key message here is act before the fire danger season starts.

There are various ways by which a house can ignite during a bushfire. These are:

- radiant heat ahead of the fire front
- burning debris falling on the building
- direct flame contact.

Research has shown that the biggest cause, however, is sparks and embers, which can trigger a fire before, and hours after, the bushfire has passed. Sparks and embers enter a home wherever there is a gap, such as under roofing tiles, under the floor, in crevices, window sills, vents and under verandahs.

Some basic measures to improve your home safety are:

**Smooth surfaces:** no nooks or crannies where leaves and debris can gather.

**Roofing:** well-secured metal roofing is preferable. A tiled roof needs to be well fitted with fire-resistant sarking (fibreglass-based aluminium foil).

**Walls:** non-flammable wall materials such as brick, mud brick and fibre cement. Vinyl weatherboards, rough timber and other claddings can warp or catch fire.

**Windows, crevices and vents:** spark-proof the home with metal flywire screens on windows and doors, or install fire-resistant metal shutters. Cover all wall cavities in fine wire mesh.

**Skylights:** install wire-reinforced glass or a thermo-plastic cover on skylights as plastic can melt and glass break in strong heat.

**Property access:** gateways should be at least 4 m wide with a vertical clearance of 4 m. There should be clear access with a turnaround point for fire-fighting vehicles.

**Gutters:** regularly clean gutters and remove leaves and bark from any areas where they become trapped.

**Prepare a 20 m defendable zone around your house:** do this by minimising the amount of fuel close to the house. This will prevent fires from burning close to the house and minimise the effect of radiant heat and direct flame impact.

**Sprinkler system:** a home bushfire sprinkler system that directs water over the roof, windows, doors and exposed under-floor areas is one of the most effective ways of protecting against radiant heat, direct flame and ember attack. Seek professional advice for design and installation.

## Maintenance of machinery

During the fire danger season:

- Landowners need to take precautions to ensure that every item of equipment on their farm that generates heat in one form or another is in good working order and is not likely to ignite crops or other flammable substances during farming operations.

- Always carry a full knapsack or water extinguisher and a rake or shovel on the machine when it is in the field. This is mandatory when harvesting a flammable crop, spreading lime or fertiliser or moving a flammable crop on the land where it has been harvested.

## Livestock protection

Identify the 'safest' paddock on your property or neighbouring property.

It should:

- have a reliable water supply
- have clear access
- be well grazed with minimum fuel to carry fire
- be well fenced.

Consider moving your stock into the 'safe' paddock on total fire ban days.

If animals do sustain burns the best form of immediate first aid is sponging with cold water until proper veterinary care is available.

If you have stock, you should intensively graze pasture near your home during late spring and early summer to reduce fuel levels. Check the CFS website for further detail.



*Figure 3: Supplementary feeding after a bushfire  
Photo: Adelaide and Mount Lofty Ranges NRM Board*

## Bushfire restrictions

Fire danger seasons change from season to season. Visit the CFS website for current dates.

[www.cfs.sa.gov.au](http://www.cfs.sa.gov.au)

### Permits

To apply for a permit to light a fire, contact your council to find your nearest authorised officer.

The officer is required to assess the permit application to ensure that:

- they are satisfied that the lighting and maintaining of the fire is, in all circumstances of the case, justified
- adequate precautions will be taken to prevent the spread of fire.

Once satisfied, the authorised officer will issue you with a permit and a permit number and will subsequently send you a copy of the permit. The conditions that must be complied with are included in the permit.

For a permit to undertake burning off, contact your local council.

### Hot works during summer

Bushfires can be started when hot works, such as grinding, welding, mowing/slashing and earthworks, are undertaken.

If you do need to undertake these types of works during summer when grasses are dried, ensure you have suitable fire cover, such as a farm fire unit, a water-fire extinguisher or a water-filled knapsack nearby.

### Crop harvesting

The use of harvesting machinery during summer should be carefully planned and considered.

- All harvesters are prone to fire but crop and machine losses can be minimised with hygiene, inspection and maintenance. Bearings, hydraulic lines and belts need to be closely monitored and the harvester should be kept free of dust and chaff accumulation.
- According to Kondinin Group research, on average, annually, around 7% of harvesters will start a fire. Of these, one in 10 will cause significant damage to the machine or surrounding crop.
- If you detect a fire, face the harvester into the wind and evacuate promptly.



Figure 4: CFS conducting a burn off at Forest Range  
Photo: CFS

## Further information

CFS bushfire hotline 1300 362 361.

- CFS website: [www.cfs.sa.gov.au](http://www.cfs.sa.gov.au)

### CFS Facebook

- SA Country Fire Service Talk:  
[www.facebook.com/countryfireservice](http://www.facebook.com/countryfireservice)
- SA Country Fire Service Updates:  
[www.facebook.com/cfsupdates](http://www.facebook.com/cfsupdates)

### CFS Twitter

- CFS Talk: <http://twitter.com/#!/cfsstalk>
- CFS Alerts: <http://twitter.com/#!/cfsalerts>

### CFS Smartphone App

[www.cfs.sa.gov.au/site/news\\_and\\_media/cfs\\_smartphone\\_application.jsp](http://www.cfs.sa.gov.au/site/news_and_media/cfs_smartphone_application.jsp)

### Further reading:

- *Fire and Emergency Services Act 2005*  
[www.legislation.sa.gov.au](http://www.legislation.sa.gov.au)

# 9. Livestock management

Managing livestock remains a popular enterprise on many small farms, but for new landholders it can sometimes be quite daunting. Sheep, cattle, horses and alpacas are all seen on properties throughout the Mount Lofty Ranges. If you are managing animals for the first time it is important to have appropriate yards, watering points and fencing and to seek sound advice from a reputable source. It is also important to maintain the soil on your property and have maximum cover of good pasture. Refer to chapters 3 and 4 for soil and pasture management.

Many publications and articles are available that contain in-depth information on livestock management. This chapter will give you some of the key points to consider in relation to the four main categories of livestock found in the Mount Lofty Ranges: sheep, cattle, alpacas and horses.

## Legislation

*Natural Resources Management Act 2004*

*Livestock Act 1997*

*Animal Welfare Act 1985*

*Environment Protection Act 1993*

*Native Vegetation Act 1991*

*The Development Act 1993*

The Acts given above are just a few of the many Acts or regulations directly referring to livestock. In South Australia alone, there are over 50 pieces of legislation that refer to animal management in one form or another. Horse owners in particular need to be aware of *The Development Act 1993*, which defines 'horsekeeping' as a property where there is more than one horse for every 3 ha of land or where hand feeding a horse is involved. Council permission may be required in this situation.

## Sheep management for new farmers

For many landholders, grazing sheep provides one of the best ways to manage land in the Mount Lofty Ranges. These animals play an important part in good pasture management as well as in weed control. They are lighter than both cattle and horses and consequently do less soil damage during the wetter winter months. In addition they tend to be less selective feeders and will clean up a range of weeds very effectively.

Inexperienced landholders will find sheep relatively easy to handle and health checks are straightforward, provided the property has suitable yards. Sheep require a safe environment, good pasture, regular inspections and a sound disease prevention program and prompt treatment for sickness or injury.

## Sheep yards

Small holding paddocks are adequate for mustering sheep that require veterinary treatment, quarantine or are being readied for movement. Half a square metre per sheep should be allowed, keeping in mind that water at all times and shade in the hotter months are also a requirement. Sheep yards for loading sheep can be permanent or temporary.

## Fences

It is important that sheep are adequately fenced to reduce the possibility of damage to other people's property or to vehicles on roadways. Ringlock with two or three single strands of barbed wire at the top and fence posts 30 cm apart (Figure 1) are generally adequate. Remember to include gates and raceways for easier movement in your plan. Gates should also be wide enough to allow entry by farm vehicles. Gates are high-traffic areas and can become very muddy in wet seasons. Lining the soil with gravel will help to keep them clean and reduce damage. Posts and strainers must be of sufficient strength to withstand stock leaning against the fence line.

## Shade and shelter

Sheep do not need special requirements. A treed shelter belt will provide both shade and shelter from the harshest of weather conditions, particularly at lambing. A shed with a clean floor is ideal for shearing or for nursing sick animals.



*Figure 1: Ringlock electric fencing*  
*Photo: A. Cole*

## Lambing

The gestation period for sheep is about 150 days and pregnant ewes must be given adequate feed during late pregnancy to avoid 'pregnancy toxaemia' caused by low blood sugar. Ewes can die from this condition so supplementary feeding may be necessary. Avoid stress to the animals since this contributes significantly to the problem.

## Nutrition

Sheep are grazing animals and will eat a wide range of grasses and broadleaf annuals. Pasture can consist of perennial and annual grasses and legumes, depending on rainfall and soil type. Sheep will avoid rank pasture (pasture that has been allowed to grow too tall) but will graze a pasture down to bare ground if allowed. It is essential that overstocking is avoided and a rotational grazing pattern is established to avoid damage to pastures.



Figure 2: Early weaned lambs can feed as much as they want



Figure 3: Sheep feeding on a supply of hay  
Photo: A. Cole

Table 1: Maintenance hay rations for sheep with no pasture available

Class of sheep (kept in store condition)	Grass/ clover hay requirements (kg/sheep/week)	Comment
Adult dry sheep (or ewes in early pregnancy)	4.5	Adjust for cold weather, larger breeds and rams.
Pregnant ewes (last 4 weeks before lambing)	7.5	
Ewes with lamb at foot (first month)	12.5	
Ewes with lamb at foot (second month)	11.0	
Early weaned lambs (up to 20 kg gaining 0.7 kg each week)	Ad lib	Feed as much as they want (usually 3 to 5 kg/week).

Source: Primary Industries and Resources SA (2005)

## Health

### Flystrike

Watch for flystrike, especially during the warm humid periods of spring and autumn. Crutching and backline treatments are recommended but if individual sheep are affected they should be treated thoroughly by fully cleaning away the dead tissue and applying an insecticide.

### Feet

Foot abscess can occur so avoid grazing sheep in wet and muddy areas – the land benefits and so do the sheep. Draining abscesses and applying antibiotics is effective in tackling this problem.

### Worms

Sheep are commonly infected by intestinal worms such as roundworms, black scour worms and small stomach worm, so drenching based on faecal egg count is recommended. It is advisable to rotate drenches over time to avoid worm resistance.

## Vaccinations

Five-in-one vaccinations are recommended. This should prevent the two most common clostridial diseases of enterotoxaemia (pulpy kidney) and tetanus. Seek veterinary advice about other vaccinations that may be required in your area.

## Lice

Lice treatment should be undertaken within two weeks of shearing, when individual animals are treated with a backline chemical.

## Ovine Johne's Disease

A bacterial disease affecting the intestinal wall and preventing absorption of nutrient. Wasting, diarrhoea and bottle jaw (fluid accumulation under the jaw) are symptoms. This disease is not widespread in Australia, and to keep Australia relatively free it is mandatory to report any outbreaks. Contact your local veterinarian for advice if suspected.

## Breeds

There are many breeds of sheep available to the small landholder. Wool breeds include the Merino, Poll Merino, Corriedale, Border Leicester and Poll Dorset. Meat breeds include Border Leicester, Dorset, Suffolk and their cross-breeds. Many small landholders (and commercial farmers as well) are turning to breeds that shed their own fleece and thus avoid the work of shearing. These breeds include Dorpers, Damaras, Wiltshire Horn and Wiltipoll. Many breeds have their own association and website, which will help you select the right breed for your area and circumstances.



*Figure 5: Border Leicester  
Photo: I. Turner*



*Figure 6: Wiltipolls  
Photo: G. Toll*



*Figures 4: Merino and Poll Merino  
Photo: I. Turner*



*Figure 7: Poll Dorsets  
Photo: I. Turner*



Figure 8: Suffolks. Photo: I. Turner.

## Condition-scoring sheep

One of the problems new landholders may experience is being able to tell if their animals are in good condition.

Figure 9 shows the spinal column of a sheep with the 'short ribs' extending from both sides and the skin stretched over. The degree of flesh between the skin and the short ribs is used to assess the health of the animal.

To determine the condition score, place your thumb on the backbone just behind the last long rib and your fingers against the stubby ends of the short ribs. Feel the amount of fat on the animal and compare with the following pictures (see Figure 10).

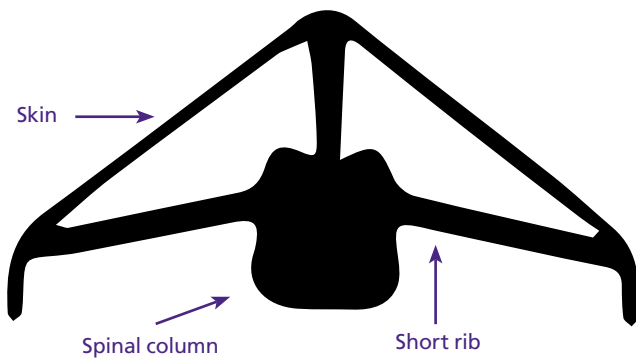


Figure 9: Condition scoring sheep



Figure 10: Condition scoring sheep by feeling the backbone  
Photo: A. Cole

Table 2: Condition scores

Condition score 1 Animal is too thin and possibly emaciated	
Condition score 2 Ideal condition for wethers and lean meat	
Condition score 3 No excess fat; ideal condition for lambs	
Condition score 4 Animal is in good condition	
Condition score 5 Animal is carrying too much fat	

Source: Lifetime Wool, 2006



## Cattle management for new farmers

Cattle have always been one of the most popular livestock enterprises in the Mount Lofty Ranges and if managed correctly they can be less demanding than sheep. However, they are large animals and should always be handled accordingly, so make sure you have heavy-duty yards with suitable crush and head bails for safe handling.

Rotational grazing is a key strategy to manage pastures and control weeds, so establishing 4–8 paddocks on a small Hills property is a good idea. Fortunately most cattle respond well to electric fencing, which provides a cheaper alternative to conventional fencing.

*Table 3: Cattle terminology*

Bull	A mature male animal used for breeding
Cow	A mature female used for breeding
Calf	A young animal less than one year old
Weaner	A calf that has left its mother
Heifer	A young female before she has had her first calf
Steer	A young castrated (de-sexed) male

## Nutrition

Cattle and sheep tend to graze pastures by tearing at plants, so the animals should not be permitted to graze newly sown pastures too early. Cattle will not graze pastures as low as sheep and tend to be more selective feeders.

When paddock feed is low during late summer and autumn, supplementary feeding with good-quality grass/clover hay or other concentrates may be necessary.

*Table 4: Daily survival ration for cattle fed only hay*

Types of stock (held at fat score 2)	Average quality pasture hay (kg)	Average quality cereal hay (kg)
Weaners 6–9 months (175 kg live weight)	3.5	4.0
Yearlings 10–12 months (220 kg live weight)	4.0	5.0
Steers (280 kg live weight)	5.0	6.0
Cows (last 3 months of pregnancy)	9.0	9.0
Cows with calf (3 months and older)	10.0	12.0

## Fences

It is important that cattle are adequately fenced to remove the possibility of damage to other people's property or to vehicles on roadways. Five plain wire electric or ringlock and barbed wire with fence posts 30 cm apart are generally adequate. In your plan, remember to include gates and raceways for easier movement. Gates should also be wide enough to allow entry by farm vehicles. Gates are high-traffic areas and get very muddy in wet seasons. Lining the soil with gravel will help to keep them clean and dry. Posts and strainers must be of sufficient strength to withstand stock leaning against the fence line. Cattle yards will be necessary for easy movement of cattle. These can be permanently located in an appropriate area for ease of truck movement or can be temporary if only a small number is irregularly handled.



*Figure 11: Cattle at a wire fence*  
*Photo: Adelaide and Mt Lofty Ranges NRM Board*

## Breeding

Raising steers has potentially less complications than managing a breeding herd, but for those interested in the latter it is worth noting that the gestation period for cows is approximately 9 months (282 days). Joining (mating) should occur in June to July for an autumn calving and pregnancy testing can be done after 6 weeks. In the last 2 months of pregnancy ensure good nutrition and supplementary-feed if necessary. Some assistance may be necessary at calving time, so it is a good idea to move these animals to a paddock near the house and be prepared to contact a veterinarian if the calf is not born within 2 hours of commencement of labour or if any difficulties become apparent.

## Health

### Parasites

Worm treatments are best used based on faecal egg count. Check on the condition of stock and if high worm egg counts are detected be prepared to drench and move them on to a new area.

### Bloat

Ruminant animals can suffer from bloat if they are suddenly moved to a lush clover or lucerne paddock. Veterinary support may be needed in these cases.

### Vaccinations

All adult cattle should be vaccinated annually with a five-in-one clostridial vaccine, while calves should be vaccinated at marking and again 4–6 weeks later. Check with your local vet for any other vaccinations that may be needed for your area.

### Grass tetany

Grass tetany is not uncommon in the high rainfall district and is caused by a lack of magnesium when grass-dominant pastures are flourishing, through May to September. Symptoms include walking stiffly, exhibiting muscle spasms and convulsions, rolling of the eyes and frothing at the mouth. Death can occur within half an hour, so avoid stress, feed clover hay and provide a magnesium supplement to herds at risk. Soil testing can determine the likelihood of this condition.

### Bovine Johne's Disease

A bacterial disease affecting the intestinal wall and preventing absorption of nutrient. Wasting, diarrhoea and bottle jaw (fluid accumulation under the jaw) are symptoms. This disease is not widespread in Australia, and to keep Australia relatively free it is mandatory to report any outbreaks. Contact your local veterinarian for advice if suspected.

## Shade and shelter

Windbreaks and shelter belts will protect cattle from the harshest of climatic conditions. On hot days cattle will congregate under trees and they will also choose shelter under trees at night. These areas are particularly prone to erosion due to high traffic and rotational grazing. A selection of sheltered sites will also help to minimise any land degradation.



Figure 12: Cattle sheltering under the shade of paddock trees  
Photo: L. Hyde

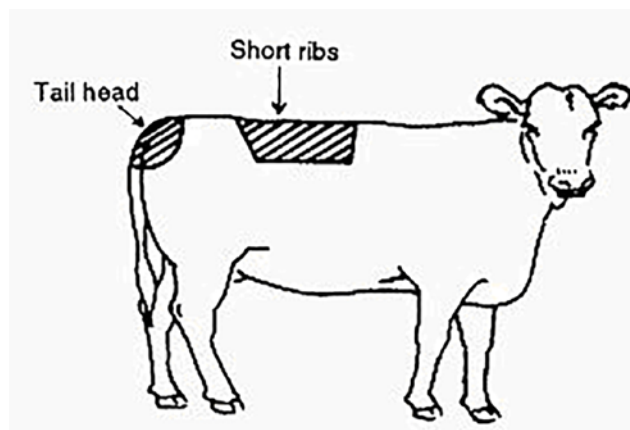


Figure 14: Two areas of cattle to conduct condition scoring  
Source: Victorian Department of Primary Industries (2006)

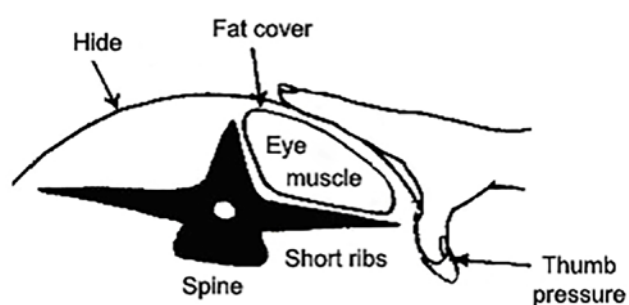


Figure 13: How to conduct condition scoring of cattle  
Source: Victorian Department of Primary Industries (2006)

### Condition-scoring cattle

Condition scoring of cattle is similar to sheep, in that the amount of fat reserves around the short ribs is assessed. The fingers are placed flat over the short ribs and the thumb is pressed into the end of the short rib.

The condition score is given according to the ease with which the short rib can be felt. The same description of condition scores for sheep can be used.

Condition scoring can also be done by an assessment of the tail head. Again the same descriptors as score conditioning for sheep can be used.

This test is obviously subjective and advice should be sought by landholders who have limited experience with livestock management.

## Alpaca management for new farmers

Alpacas are part of the camelid family, originating from South America in areas of high altitude. Their ability to withstand temperatures varying from freezing to extremely hot has enabled them to adapt well to Australian climatic conditions.

They generally have a gentle nature, which makes them an easy breed to handle, and under normal conditions will interact with their human handlers.

Highly intelligent, alpacas are a herd animal, preferring to be with their herd, although they socialise well with other livestock breeds. They are fiercely protective of their territory and families, which is why they have gained a reputation as excellent guard animals for livestock vulnerable to fox attack.

Table 5: Terminology for alpacas

Cria	From birth to weaning
Weaners	From weaning (approximately 4–5 months) to 12 months
Tuis	From 12 to 24 months
Hembras	Adult females
Machos	Adult males

## Nutrition

Alpacas are herbivorous, requiring good-quality pasture for optimum management. They have a preference for grasses and will eat these rather than clovers, broadleaf species or shrubs. For this reason, they are not the best species for cleaning paddocks of weedy broadleaf species such as Capeweed or Salvation Jane.

When looking at pasture mixes, it is important to keep in mind that Alpacas are 'browsers' rather than 'grazers'. Consequently, pasture mixes should consist of a variety of perennial and annual grasses high in fibre and low in protein. Protein levels should not form more than 16% for crias and 8–10% after weaning. Fibre should be between 25% and 50% of their diet. Species include Cocksfoot, Tall Fescue, Phalaris, and native grasses such as Wallaby Grass and Microleana. A subterranean clover should also be added to the mix for good soil health. There are many different species suitable and even more varieties. A local agronomist is best positioned to advise on a mixture suitable for your area.

Alpacas have padded feet and exert much less pressure on the ground than horses, cattle or even sheep. In fact, their impact on our soil in terms of kilopascals per unit of ground is less than half the average human. This makes them one of the most environmentally friendly livestock animals available to the small landholder.

Fresh clean water should be made available at all times. Alpacas will require approximately 5 L per day for an adult and 10–12 L per day in hot weather or when lactating. Hay has a much lower water content than pasture so if supplementary feeding is being done, remember to ensure that additional water is available.



*Figure 15: Alpacas generally prefer to be with their herd  
Photo: Adelaide and Mt Lofty Ranges NRM Board*

## Health

Feet and teeth	<p>Toenails may require trimming when animals are kept on soft-pastured ground. Similar foot shears to those used on sheep are suitable.</p> <p>Any protruding teeth (not common) will need to be filed back with an appropriate rasp.</p> <p>Males have fighting teeth and these should be removed from 3 years of age.</p>
Parasites	<p>Alpacas are naturally resistant to internal parasites and fly strike.</p> <p>Faecal egg counts for crias and weaners will identify any Scourworms present. Drenching is only recommended when Scourworm egg plants exceed 350 epg (eggs per gram).</p> <p>Faecal egg counts for the herd should be taken twice per year to identify any animals needing drenching.</p>
Mineral deficiency	<p>Vitamin D is a deficiency that needs addressing in southern Australia during winter and early spring. Vitamin D is manufactured in the body as a result of solar radiation synthesising in the skin. This is likely to be reduced in winter particularly through thick fleeces. Because alpacas are disinclined to partake in mineral supplement licks, Vitamin D should be injected in late autumn and midwinter or fed with pelleted grain or feed.</p>
Vaccinations	<p>Five-in-one vaccinations are recommended at 6–8 weeks of age followed by a booster 4–6 weeks later and then annually. This should prevent the two most common clostridial diseases of enterotoxaemia and tetanus.</p>
Eyes	<p>Alpacas are susceptible to eye problems caused by sharp seed awns. They should be prevented from foraging in paddocks where the grasses have been left to seed.</p>
Bovine Johne's Disease	<p>A bacterial disease affecting the intestinal wall and preventing absorption of nutrient. Wasting, diarrhoea and bottle jaw (fluid accumulation under the jaw) are symptoms. This disease is not widespread in Australia, and to keep Australia relatively free it is mandatory to report any outbreaks. Contact your local veterinarian for advice if suspected.</p>

## Shearing

Like sheep, alpacas are shorn once per year. This is best done prior to the pasture reaching seed formation, to prevent contamination of the fleece.

Shearing can be done using conventional sheep- or goat-shearing equipment or a pair of hand shears. Alpaca fibre is non-greasy and shears must be well oiled to prevent overheating.

## Shade and shelter

Alpacas are very hardy animals and do not need special requirements. A treed shelter belt will provide both shade and shelter from the harshest of weather conditions. A shed with a clean floor is ideal for shearing or for nursing sick animals.

## Horse management for new farmers

### Nutrition

If rainfall is adequate, a good mix of perennial grasses and a sub-clover is ideal, not only for good nutrition but to maintain adequate soil cover. Suitable pasture grasses include Phalaris, Cocksfoot, Kikuyu and Perennial Ryegrass, but the selection of species is also dependent upon soil type and rainfall. Always check with a local agronomist or the local land management advisor before deciding on a pasture re-seed or renovation. You can expect the average 500 kg horse to eat up to 60 kg of fresh green pasture per day. Horses, unlike sheep and cattle, are not ruminant animals. The same trace elements as are supplementary-fed to ruminant animals are not necessarily applicable. Your veterinarian is best suited to advise on any trace supplements necessary.

Hand feeding may be necessary at certain times of the year to extend paddock feed, and/or correct any mineral deficiencies. However, this should not be done without due consideration since hand feeding interferes with normal grazing behaviour. It is important that hand-feeding does not result in an under-utilisation of paddock feed, which will as a consequence become rank and unpalatable.

Weeds can compete with good pasture species and in some cases are toxic to horses. Dock, Sorrel, Wireweed and Capeweed are all indicators of poorly managed pastures. Salvation Jane (containing pyrrolizidine alkaloids), Capeweed (containing nitrate) and Cape Tulip are common species toxic to horses.



*Figure 16: The species of pasture grass used depends on soil type and rainfall. Photo: A. Cole.*

A horse will generally require 25 litres of water per day; and up to 90 litres if working in very hot weather. Stock-watering points must be readily accessible and preferably on a hard surface to prevent erosion from constant hoof activity.

### Shade and shelter

Appropriate stables and yards, in addition to meeting any legal requirements, can also assist in handling of stock, hand feeding and spelling paddocks to allow recovery time or weed control. Stables and yards must be large enough to allow the horse to roll, lie down and move around. The stable should be built to form a windbreak for prevailing weather and have adequate cross-ventilation. Yards should have a stable base with a slight slope to allow for drainage. By way of example, 10 cm of compacted rubble or dolomite topped with 15 cm of sand with a slope of 1 in 30 provides both a good surface and drainage.

Paddocks should have enough wind breaks and shelter belts to provide protection from prevailing winds, harsh winters and hot summers. Man-made shelters and stables are useful, as noted above, but will not replace the need for natural vegetation. For advice on tree species, planting and maintenance, contact the local Natural Resources Adelaide and Mount Lofty Ranges District Officer.

## Manure management

Horses are fastidious animals and will not graze near manure clumps. Manure should be collected from paddocks at least every second day in large grazing systems and once a day in smaller systems. This will prevent under-utilisation of pastures and a build-up of worm eggs. Worms will lay eggs in the warm, moist manure and migrate to adjacent pasture on hatching, increasing infestation risk through browsing.

Many horse owners sell the manure. However, once thoroughly composted, manure is one of the best soil conditioners available. Composting must be done with consideration to Environment Protection Authority requirements in regards to run-off, smell and proximity to water-catchment areas. Once composted, manure can be spread evenly over paddocks, particularly during the main growing season of spring. Harrowing in wetter seasons or after a spring rain is also an option.

## Fencing and gateways

Fencing requirements should always be determined according to the property's land class. The more paddocks there are, the greater the ability to rotationally graze and allow good pasture renewal. A 5- or 6-wire, well-strained electric fence with a 'sighter' wire at the top will contain horses. 'Sighter' wires are usually white and are easily visible. Ringlock fencing with a stand-off electric wire at the top is also a possibility.

Gateways should be large enough for ease of movement and be appropriately placed. Be aware that gates are heavy-traffic areas and the ground may need to be lined with a surface of crushed rubble. Good management will assist in preventing erosion through these areas. Try to avoid any supplementary-feeding in gate areas to minimise traffic.



Figure 17: Electric fence with a white 'sighter' wire  
Photo: Adelaide and Mount Lofty Ranges NRM Board

To minimise traffic and congestion along fence lines, a double fence could be used with a shelter belt planting in between.

## Health

Laminitis	Laminitis, also called founder, is a serious condition primarily affecting the front feet and occasionally all feet. This is commonly seen in overweight horses grazing on lush, green pasture during spring flush. Laminitis is very painful and will affect the horse's ability to move around. Serious deformities can result if the condition is not treated. Horses at risk should be spelled in yards during the day and only allowed to graze briefly after sundown during the spring flush.
Parasites	The main gastrointestinal parasites are worm species. Faecal egg counts should be conducted at least once per year. A sample of fresh manure is tested and the number of worm eggs found will indicate the number of worms in the intestine. This will indicate whether a worming drench is required.  External parasites include greasy heel (or mud fever), caused by standing in muddy yards during warm, wet weather. Heels develop greasy, cracked or inflamed skin, which is in turn infected by parasites. Avoiding the development of muddy patches is the best form of prevention, or at least isolating those areas from daily use.
Gastric ulcers	Equine gastric ulcer syndrome (EGUS) are lesions found in the stomach. They can be developed from a variety of causes such as stress, training on an empty stomach, lack of paddock time and feed deprivation. Avoid stabling for long periods or long periods of transport and ensure your horse has a small amount of food in its stomach prior to a training event.
Colic	Colic is a dangerous condition caused by blockage, twisting, inflammation or gas in the intestinal tract. Symptoms include rolling, pawing, getting up and down, flank watching, kicking at the belly and lip curling. Good management will help prevent colic. However one in 10 horses is likely to suffer every year. Early treatment by a qualified veterinarian is essential, since colic is extremely painful and can cause death.

## Buying hay – know what is best

In late autumn and early winter livestock are often stressed by feed shortages and cold weather. Feeding out hay is the most common way to supplementary-feed, but when purchasing hay, buyers all too often put convenience and price ahead of quality. It might be easy to buy from a neighbour but poor-quality hay can be expensive to feed out and in some cases very unpalatable. It is advisable therefore to search around for a reliable supplier of good-quality hay.

A number of principles should be kept in mind when purchasing hay. Livestock generally require a minimum of 65% digestible dry matter and a minimum of 12% crude protein. If the digestible dry matter falls below 65%, the livestock tend to eat less and lose condition, so purchasing top-quality hay from a reputable grower or fodder merchant is recommended. Unimproved pastures that have been cut for hay will be very low in energy, especially low in crude protein, and if late-cut can even be so unpalatable that particular livestock will not eat it.

Quite often the most expensive hay per tonne can turn out to be the cheapest to feed out during the lean times, simply because of its higher protein and energy levels. Wet and humid weather conditions during hay-making can lead to mould when clover blackens off and loses its value. Local fodder stores will generally be aware of the season and only purchase a quality product, even if it means transporting from other districts, so expect to pay a little more in poor seasons.

**Table 6: Nutritional value of hays**

Hay type	Dry matter	Energy MJ/kg	Protein %	Fibre %
Oaten – early-cut	90	9.8	6	29
Oaten – late-cut	90	9	6	33
Grass/clover (medium quality)	90	8	12	28
Grass/clover (good quality)	90	9	14	24
Lucerne (half-flowering)	90	7	20	29
Lucerne (full-flowering)	90	7	15	32

When purchasing hay look at a sample bale to assess quality.

It should be:

- green in colour (not yellow), indicating the correct time of cutting
- free of foreign materials such as weeds and weed seed heads
- sweet-smelling; have a good percentage of leafy legume
- low in coarse legume stems
- free of mould.

If purchasing lucerne hay, ensure that there is plenty of leaf compared with stalk. Leaves carry a much higher percentage of crude protein than stalk and remember the first hay cut from irrigated lucerne is generally the poorest quality.

How much to purchase will often depend on storage facilities as well as livestock numbers. A 500 kg cow eats about 15 kg of dry matter a day. If the cow gets only one-third of its requirements from pasture, then it needs approximately 11 kg of good hay at 90% dry matter to supplement grazing. An average dry cow requires about 8 kg of dry matter per day, which is about half of a small bale.

**Table 7: Daily requirements of beef cattle**

Class of stock	Kg of hay/head/day
Cow 450 kg (with calf up to 3 months)	12
Dry cow 450 kg (late pregnancy)	9
Weaners 250 kg (gaining weight)	5.5
Yearlings 350 kg (maintenance)	5.5
Steer 500 kg (maintenance)	8

Round bales are becoming more common and for some small landholders may be quite economical, but for those who do not have the equipment to handle them it might be more convenient to stay with small bales, which are easier to handle.

## Supplementary feeding – cattle and sheep

Supplementary feeding of livestock should be aimed at maintaining condition (weight) or increasing the condition of stock prior to breeding. Determining the class of animal is critical in deciding on the type and amount of feed required. A vital part of effective hand feeding is the regular monitoring of the condition of individual animals.

If stock is insufficiently fed, or given poor-quality feed, its body reserves are used up and hence weight is lost. This is acceptable to a certain extent; however, there are trigger points at which stock must be prevented from losing any further condition. Do not delay supplementary feeding until stock reach a critically thin state – this is an animal welfare issue, difficult to reverse, expensive and can have long-term adverse effects. It is more cost-efficient to feed to maintain weight than to let animals lose weight and then have to increase their body condition again.

Exact feeding rates will depend on the class of animal, the type of supplementary feed (for example, hay, pellets, lupins or barley), the availability and quality of pasture and their condition score.

The final key to hand feeding is to monitor changes in condition, so that you know whether to increase, decrease or change the composition of rations.

Table 8: Livestock feed requirements

Class of animal	Energy MJ/kg	Protein %	% of live weight can eat/day
Adult dry sheep (60 kg)	5.0	8	2.0 kg
Pregnant ewes (last 6 weeks)	8.5	13	2.8 kg
Lactating ewes (first 2 months)	14.5	14	4.2 kg
Weaner sheep (< 35 kg)	5.5	15	3.8 kg
Dry cows	41	8	1.8 kg
Lactating cows (first 3 months)	97	14	3.5 kg
Lactating and pregnant cows (4–7 months)	105	14	3.5 kg
Weaned calves	50	15	2.5 kg



# 10. Vertebrate pest management

## Legislation

Obligations and responsibilities for control of vertebrate pests:  
*Natural Resources Management Act 2004 (NRM Act)*  
*Livestock Act 1997*

Rabbit and fox warren ripping:  
*Native Vegetation Act 1991*  
*Environment Protection and Biodiversity Conservation Act 1999*  
*Development Act 1993*

Pesticides use:  
*Agricultural and Veterinary Products (Control of Use) Act 2002*  
*Controlled Substances Act 1984*  
*Environmental Protection Act 1993*

Animal welfare:  
*Animal Welfare Act 1985*

## Rabbits

Domesticated rabbits (*Oryctolagus cuniculus*) were first introduced into Australia in 1788, with the arrival of the First Fleet. Although little is known about the spread of rabbits in Australia, by 1827, thousands of feral rabbits were observed on some estates in Tasmania.

In 1837 the Everard family of Glenelg in South Australia listed 14 rabbits amongst their livestock. Five years later in 1842, John Daw listed a warren amongst his capital assets in his property in what is now suburban Adelaide. In 1859, 24 wild rabbits travelled to Australia on the clipper *Lightning*. These were introduced by Thomas Austin of 'Barwon Park', Geelong, Victoria, for hunting. It is thought that these rabbits are the ancestors of the many thousands that were soon observed throughout the state.

By 1865 (within 6 years) 20,000 rabbits had been killed on 'Barwon Park'. By 1886 they had spread as far as the Queensland and New South Wales border (NSW Department of Environment and Conservation 2005). Almost certainly, the spread of rabbits was assisted by people who established them locally for meat and sporting purposes, unaware of the potential damage that would result. By 1900, rabbits had spread to Western Australia and the Northern Territory. A 1,700 km rabbit-proof fence was built in Western Australia between 1901 and 1907 to stop the spread of rabbits. However, rabbits can dig under such fences and they can now be found in every Australian state. They are now found in many different habitats and range from coasts to deserts.



*Figure 1: Rabbits are an issue across the region*  
*Photo: Adelaide and Mt Lofty Ranges NRM Board*

## Rabbits as pets

Rabbits make good pets provided they are housed and cared for appropriately. There are many domestic breeds of rabbits available in South Australia, varying in size, colour and temperament. However, all breeds share one thing in common: they are related to wild rabbits.

To protect the environment from the effects of escaped domestic rabbits, the Government of South Australia has given domestic rabbits declaration status under the NRM Act.

This means that domestic rabbits and the owners or occupiers of land where domestic rabbits are kept have certain legal obligations including:

- Domestic breeds of rabbits must be housed in a well-constructed cage or pen that is escape-proof.
- Rabbits must *not* be allowed to roam at large on the property.
- Rabbits must *not* be wilfully or negligently released from captivity.
- Any instructions relating to the keeping of domestic rabbits given by an officer authorised under the NRM Act must be complied with.
- Wild rabbits are prohibited from being kept under any circumstances.

## Integrated management of rabbits

In order to achieve the best results and minimise rabbit numbers, it is recommended that an integrated rabbit control management plan be developed and implemented. The plan should incorporate a variety of seasonally and habitat-specific methods to make the most of their control efforts.

An effective integrated program should include *fumigation and ripping (or harbour control) of warrens* and *poisoning*. It is unlikely that such tools will effectively control rabbit populations when used independently. However, the integrated use of these control methods will significantly reduce rabbit numbers, and may even lead to complete eradication. This is particularly true for flat or gently undulating country with low vegetation density.



*Figure 2: An effective integrated control program will minimise rabbit numbers. Photo: Peter Bird, Biosecurity SA.*

### Identifying the problem

The first step is to locate any warrens or above-ground cover such as plant beds, woodheaps etc. that provide rabbits some refuge for rabbits. Rabbits are territorial and generally don't travel more than 200 m from these sites, with most of their feeding done within 25 m to 50 m. Look for signs of where rabbits have been active, such as burrows, fresh scratches in the soil, scattered or piled dung and damage to vegetation. Locate the refuge being used and make an estimate of the total area in which the rabbits move. This area is where your control program will need to concentrate. Rabbits do not respect property boundaries so it may be necessary to take joint action with neighbours.

### Choosing your control methods

There are a number of methods that can be used to control rabbits. To achieve good results it is best to use a variety of approaches. Note: rabbits can be pests in the wild but they must still be controlled in a humane manner. If in doubt seek further advice from the RSPCA.

### Removal of their refuge

Rabbits look for a sheltered place for protection from predators and as a safe environment to breed. They will either build warrens or shelter in thick vegetation or other materials such as wood piles etc. To destroy a warren or burrow, collapse it in on itself with earth-moving machinery or hand tools and then fill and level the area. If this is not possible (for example, the burrow is under a concrete slab), then block the entrance to the warren with material to prevent the rabbit from reopening it. Any vegetation or materials that provide a refuge area for rabbits to hide in should be removed. Thick ground-hugging vegetation and shrubs should be trimmed to around 50 cm above the ground. Any materials such as wood, bricks, hard rubbish etc. should be removed or stacked at 50 cm above the ground and in such a way that there are no cavities enabling rabbits to enter.

### Ripping of warrens

Mechanical ripping or destroying of the rabbit warren takes away their main means of survival – shelter. As part of an integrated rabbit management plan, ripping should follow an effective bait-laying program. This helps to reduce the re-establishment of rabbit populations, and the lack of rabbits at that time makes warren destruction a lot easier to achieve. Rip to a depth of at least one metre and a width of at least 2 m outside the most visible warren entrance. *The deeper and wider the ripping, the greater the destruction of the warren system.*

Poor ripping techniques or inadequate equipment may result in warrens being reopened. Rabbits invading from surrounding areas and foxes digging into a ripped warren to obtain a dead rabbit may also be responsible for reopened warrens. Follow-up work is required at these warrens to ensure that rabbit numbers are kept low. Warrens that have reopened must be re-ripped or fumigated, usually within 2 months of the initial control and then ongoing, as required.

Ripped warrens can also be track-rolled to reduce the risk of rabbits burrowing in on the rip line caused by the dozer. Track rolling will also help to compact the soil surface and reduce the risk of erosion. The site should be revegetated with appropriate vegetation as soon as possible.

It is important to note that when destroying rabbit warrens all due care *must* be taken to protect native vegetation as stated under the NRM Act and the *Native Vegetation Act*.



**Figure 3: Tractor with 3 tines ripping a rabbit warren**  
Photo: S. Edwards

## Baiting

**Late summer or autumn** is the best time to poison. Rabbit numbers are at their lowest as food is scarce. With plant seeds and tubers being a major part of their diet, oats or carrots are the ideal lure, and with little food available they are far more likely to feed on the provided baits. In addition, rabbits generally do not breed during this period. Hence, they are less territorial and there are no juvenile rabbits that can be left behind after poisoning. This means that all rabbits are able to emerge from burrows and take the bait.

**Pindone is an anticoagulant** used to poison rabbits where 1080 cannot be used because of off-target risks to cats and dogs via secondary poisoning, for example, in urban and semi-rural areas, market gardens, golf courses and around farm buildings. Pindone is less likely to cause secondary poisoning and an antidote (vitamin K) is available. However, it is more expensive than 1080 and more toxic to some native animals, especially kangaroos and wallabies. *Pindone is not meant to work as a single dose*. It prevents the formation of vitamin K1 in the body for about 4 days after ingestion so the rabbit draws on reserves stored in its body. Initially, the animal will continue to behave normally until 3 or 4 repeat feeds have been provided and the rabbit runs out of its vitamin K1 reserves. It is therefore vital that the product label and directions of use are adhered to.

*Pindone can be used without a licence in small acreage areas but CANNOT be used on properties smaller than 1,000 square metres (quarter-acre block).*

**Note: other herbivores such as kangaroos, possums, bandicoots and livestock may be vulnerable to Pindone. If the techniques described below are strictly followed, off-target poisoning will be minimised, and the benefits of an integrated rabbit management plan will far outweigh any negatives.**

- Pre-packaged Pindone oat bait is available commercially in various package sizes through most agricultural supply retailers. It is supplied in a plastic bucket with a sealable lid and may be stored at room temperature.
- Pindone-coated diced carrots can be sourced from the local natural resources centre; supply varies between centres and needs to be kept frozen until ready for use. Urban landowners may be able to obtain this bait in certain circumstances.

Whichever type of Pindone bait is used, it needs to be laid on three separate occasions, about 5 days apart, to be effective. The bait can be laid either as a trail through the feeding area or in bait stations placed in the feeding area. If there is a risk to off-target animals the bait can be placed in bait stations that prevent larger animals from feeding on the bait. Further information on bait station use is available from local natural resources staff. Check the product label and accompanying information for full directions of use and safety.

## Trapping

Two types of cage trap can be used in urban areas. One type is placed in the entrance to a burrow and traps the rabbit with one-way door flaps that allow the rabbit to enter but not leave. The other type is usually placed where the rabbits are eating and relies on a food attractant such as carrots to entice the rabbit into the cage, where it sets off a trigger mechanism, closing the cage door. While trapping may be an alternative where baiting and fumigation cannot be used, it is not an effective way to reduce high numbers of rabbits quickly as it requires a significant amount of time and effort. Traps must be checked regularly and trapped animals must be destroyed humanely.

Some local councils hire out cage traps to residents for the trapping of pest animals. These traps may be suitable for trapping rabbits if they have a base plate or pedal type trigger. Traps can also be purchased through hardware or agricultural product retailers or from the manufacturers. Note that the use of steel-jawed traps is prohibited.

## Fumigation of warrens

Fumigation of rabbit warrens should only be used in conjunction with the control measures previously mentioned as part of an integrated management plan. If used alone, this method is often variable and unreliable. Unless the warren is located in delicate areas, warren ripping should follow fumigation to prevent the future return of rabbits.

The fumigant and the rabbits will escape unless all entrances are plugged. Failed fumigation attempts are often the result of porous plugs or overlooked entrances. The soil used for plugs needs to be moist to lower porosity, and remain moist throughout the process. It is for this reason that fumigation is generally more effective after rain. To ensure safety and effectiveness, fumigation should only be carried out by contractors holding a pest technicians' licence.



*Figure 4: Rabbit warren; note recent soil disturbance and droppings. Photo: C. Jackson.*

## Biological control agents

Biological controls (biocontrols) are concerned with a short-term reduction in population numbers. As with any other control technique, biocontrol is not considered a long-term, stand-alone rabbit control technique. A rabbit control program needs to take advantage of the windows of opportunities offered by subsequent events through the implementation of a warren/harbour destruction program and follow-up measures. Biocontrols can have the same effect as poisoning: reducing rabbit numbers to make warren/harbour destruction more successful.

In 1952–53, myxomatosis, a biocontrol agent was introduced into rabbit populations. Myxomatosis is caused by a virus which is transmitted from one rabbit to another by biting insect vectors such as mosquitoes and fleas. Myxomatosis is considered to be a generalised acute disease which affects the skin and mucous membranes. It has resulted in the deaths of many thousands of rabbits and significantly reduced rabbit populations throughout Australia. The reduction in rabbit numbers caused the average weight of the wool cut, per head of sheep, in Australia to increase. In addition, the reduced competition for pasture allowed an extra two million sheep to be carried in the existing sheep area. Major agricultural benefits were also gained by the grain and cattle industries. Now, many decades later, the effectiveness of myxomatosis has diminished. Rabbits have developed some genetic resistance to the disease and less virulent strains of the virus have evolved. It however is still considered to be one of two very important biocontrols.

The rabbit calicivirus (or rabbit haemorrhagic disease virus [RHDV]) is another biocontrol agent, having been introduced into Australia in 1995. This virus is also spread by vectors, through rabbit-to-rabbit contact or when a rabbit contacts excreta. Calicivirus can cause a disease which damages the liver and blocks the circulatory system, eventually killing the rabbit. Rabbits under 8 weeks of age are more likely than adult rabbits to survive infection by calicivirus.

## Exclusion fencing

Wire exclusion fences can be used to keep rabbits out and prevent damage in certain areas, but they do not reduce rabbit numbers. The fence should be 60 cm high, fixed securely to posts and buried into the ground to a depth of 30 cm.

To be rabbit-proof, the wire mesh needs to be 35 mm or less to ensure that young rabbits are excluded. It can be attached to existing fencing with a 30-cm apron at the bottom, placed at right angles facing the area to be protected.

Exclusion fencing can be quite expensive but can be an effective measure in protecting areas of native vegetation, vegetable gardens and farm infrastructure (sheds and buildings).



Figure 5: Rabbit exclusion fencing; note significant natural regeneration occurring within the enclosure. Photo: S. Edwards.

## Repellents

Substances that repel or discourage rabbits may be useful in reducing damage, but they do not offer long-term control. There are commercially available products as well as various home-based preparations containing substances such as pepper, chilli, lime and sulphur.

Table 1: Rabbit control calendar

October to December	January to April	May to September
<p><b>Time to plan:</b></p> <p>Many young rabbits have emerged.</p> <p>Rabbit numbers will reach a peak.</p> <p>Damage to crops and pasture is most visible.</p> <p>Some myxomatosis may be evident.</p> <p>Contact your local natural resources officer</p> <p>Organise and maintain equipment.</p>	<p><b>Optimum poisoning time:</b></p> <p>Rabbits are hungry and territories undefended.</p> <p>Rabbit numbers can be cut by 95%.</p> <p>Free feeding prior to poisoning is essential.</p> <p>Allow 3 to 4 days between each feed.</p> <p>Lay poison 3 to 4 days after free feeding.</p> <p>Destroy warrens 2 to 3 weeks after poisoning.</p>	<p><b>Follow-up and inspection:</b></p> <p>Remove debris to prevent re-colonisation.</p> <p>Burn or bury rabbit harbour.</p> <p>Destroy/rip any exposed warrens found.</p> <p>Fumigate any warrens.</p>

## Foxes

Foxes (*Vulpes vulpes*) were first introduced into Australia in the 1870s for recreational hunting purposes. They have since spread to become one of our major vertebrate pests and are a major problem for landholders in agricultural and pastoral areas. However, foxes are highly adaptable animals, and they have also established themselves in the urban and urban fringe areas of nearly all of Australia's major cities.



Figure 6: The Red Fox is one of our major vertebrate pests  
Photo: Gary Tate and Invasive Animals CRC

### Life cycle

Foxes breed annually, in spring. Generally they use a hole burrowed below ground (known as an earth or den) to give birth, but they have also been known to use cavities under buildings. On average a fox will produce 3–6 cubs at a time, but only a few reach maturity. Cubs generally appear in late spring and, once independent, disperse to find their own territory the following autumn. The life span of a fox in the wild can be up to 8 years. In urban and urban fringe areas the average is around 18 to 24 months, with road kills being a major cause of death. When a fox dies, another may move into its territory.

### Fox problems

Being opportunistic feeders, foxes in country areas will feed mainly on small mammals, birds, reptiles, insects and fruit. However, in our urban environment they have become scavengers, taking food left outdoors for pets and scraps from domestic rubbish, as well as preying on small pets such as birds, rabbits and guinea pigs. Foxes are very territorial and will travel widely within their area in search of food. They often disappear from one part of their territory for a number of days or weeks, only to reappear when food in that area is more readily available. They generally forage for food at night and hide during the day under houses, in sheds and drain

pipes, under piles of timber, in hollow logs or within dense vegetation. In a surprising twist, this access to an abundance of food and places to shelter has resulted in fox numbers being higher in some urban areas than in the country. The following are a number of problems you may encounter if foxes are present within your local area.

### Human interaction

There have been no substantiated cases of foxes attacking people; however, foxes have been known to bite in self-defence if cornered or caught. Foxes should never be fed, as this will encourage them to associate humans with food.

### Diseases

Foxes can carry hydatids (tapeworm), which can infect humans. Precautions similar to those used to guard against infection from domestic dogs should be used. Foxes also carry mange and other canine diseases that can be transmitted to dogs if they come into contact with an infected fox.

### Preying on domestic livestock and pets

Given the opportunity, foxes will attack and kill pet rabbits, guinea pigs, poultry and aviary birds. In urban fringe areas they will also attack lambs, chickens and kid goats. These attacks can be devastating, as foxes will often kill more animals than they require for their immediate food needs. Foxes rarely bother cats or dogs and generally only fight if they are cornered and cannot escape.

### Preying on native animals

A wide range of small native mammals, birds and reptiles are highly susceptible to fox attack, in some cases resulting in the extinction of several species. Hand-feeding native animals, such as possums and birds, puts these animals at risk as they become conditioned to be less wary and are therefore more susceptible to fox attack.

### Fox nuisance

For a range of reasons foxes are not desirable neighbours. They can excavate gardens in search of insects, dig up compost heaps (particularly where blood and bone fertiliser has been used), knock over rubbish bins, mark their territory with urine and upset local dogs with their 'screaming' sound, which is heard during the mating season. In addition, the extensive digging of dens can cause damage, particularly to under-floor areas of buildings. For unknown reasons, foxes are attracted to unusual objects. It is believed they may be attracted to human sweat, because both shoes and gardening gloves left outside have been stolen and hidden away. In other instances they have been found to be attracted to plastic, with balls, toys and plastic-wrapped newspapers also stolen. They have even been known to take washing hanging on the line.

## Fox management and control options

The fox is a declared animal under the NRM Act and therefore it is the responsibility of property owners to control them. It is also illegal to keep foxes as pets.

The best approach to managing urban and urban fringe fox problems is to eliminate or prevent access to things that attract foxes to the area, such as easy sources of food and secure daytime shelter. Such an approach can be of lasting benefit in reducing fox numbers in the area, especially if undertaken in conjunction with neighbouring properties. Conventional control methods, such as shooting and poisoning, are not recommended due to the associated risk to humans and pets. Furthermore, even when a fox is destroyed, another will move into its territory within a relatively short period of time. Consequently, the most permanent solution involves making their territory undesirable – from a fox's perspective. When considering control options, it is advisable to integrate techniques by using as many of the following different methods as possible to maximise the individual benefits of each.



*Figure 7: The entrances to fox dens can be filled in*  
*Photo: Invasive Animals CRC*

## Fencing and barriers

Fox-proof fences and barriers, such as weld-mesh wire, can be used to prevent foxes gaining access to food sources or shelter. Foxes are accomplished climbers and diggers, so fences need to be dug at least 30 cm into the ground with an outward angle. They also need to be at least 2 m high and constructed with an outward floppy overhang at the top to make scaling difficult. The addition of electric wires to fencing, using an energiser and 12-volt system, can also be of benefit, but any electrified wires need to be clearly identified. All gaps and openings under or near buildings and sheds which are greater than 10 cm<sup>2</sup> should be blocked to prevent access.

Pets and domestic animals that are susceptible to fox attack, such as poultry, rabbits and guinea pigs, should be housed in a sturdy, roofed enclosure at night or when left unattended during the day. Foxes can be very determined. Cages need to be fully enclosed and made from material that they cannot chew through or dig under. As a general principle, if a cat is able to gain access to an enclosure, then so can a fox.

## Destroying fox shelters

To deter foxes from establishing areas of shelter, remove or thin out any dense vegetation. Remove piles of materials such as timber, bricks and hard rubbish so that they cannot use them to hide in. Low-hanging plants should be trimmed to around 50 cm above ground level. If you find a fox hole or den, fill in the entrance using rocks or wire to make it difficult to reopen.

## Removing food sources and attractants

Eliminate easy sources of food by ensuring that all domestic rubbish is securely sealed if left outdoors. Avoid plastic rubbish bags as foxes can easily rip these open. Do not leave any pet food or food scraps lying outside and clean up fruit from underneath fruit trees. Fruiting pest plants such as Blackberries should also be removed. Non-native mice and rats can attract foxes to your property, so if necessary undertake a rodent control program.

If possible, use an alternative to blood and bone fertilisers. Cover compost heaps or use sealed compost bins.

## Fox deterrents

If garden beds and lawns are being dug up by foxes in their search for insects, an appropriate insecticide could be used to remove the insects. However, before using this option, careful consideration should be given to the likely duration of the insect infestation and the level of acceptable fox damage. Animal repellents are also available through gardening and hardware outlets for application to lawns and garden beds to discourage foxes, but there is little evidence of their effectiveness. Domestic stock may be protected by the use of a guard or 'companion' animal such as maremma sheepdogs or alpacas. These animals have been bred to live with stock and it is claimed that they will help prevent fox attacks. Pet dogs, if left outside, may also help deter foxes from entering residential yards.

## Fumigation

In urban and urban fringe areas, carbon monoxide gas cartridges may be used to fumigate accessible underground fox dens. This method will only control those foxes in the den at the time of fumigation and is best used during the spring breeding season when there is a likelihood of cubs being in the den. Fumigation should only be used in situations away from enclosed areas, such as domestic buildings and sheds, and should only be carried out by a suitably qualified or experienced person.

## Trapping

Cage traps using a food lure such as meat can be used to trap foxes. Since foxes are wary creatures, the success of this can vary. Some local councils hire out cage traps to residents for the trapping of pest animals. These traps, if large enough, may be suitable for catching foxes. Large cage traps may be purchased through agricultural product retailers or direct from wire-product manufacturers.

*Note that the use of steel-jawed traps and snares is prohibited.*

## Poisoning

Sodium fluoroacetate, commonly called 1080, is the only poison registered for fox control in South Australia. Foxes are extremely susceptible to this poison. However, due to the risk of poisoning other animals such as dogs, its use is highly regulated. The poison cannot be used on properties less than 5 ha in size, or in high-risk situations such as the metropolitan area and other urban or urban fringe areas. Landholders can only access 1080 through their local natural resources management board.



*Figure 8: Fox caught in wire cage. Photo: D. Peacock.*

## Deer

### Impact

Deer pose a wide range of potential threats to agriculture, the environment and members of the public, and as a result, are considered a pest animal when found outside registered deer enclosures.

Deer trample and reduce native seed reserves (through browsing) and therefore reduce biodiversity and habitat for native fauna and their hard hooves cause soil erosion. Deer also impact on livestock through their potential to carry diseases and their competition for pastures, and often damage fences and crops. Deer pose a significant risk to public safety, with their potential to cause fatal car accidents. Also, during the rut (between April and June), when males are competing for mates, they can become extremely aggressive, presenting a further threat to public safety.

### Ecology

Deer are often diurnal (active throughout the day); however, if disturbed or placed under hunting pressure, they may also exhibit crepuscular (dawn and dusk) and/or nocturnal (night) activity patterns. Deer diet generally consists of grass and forbs (herbaceous flowering plants other than grasses), and some browse on preferred plants, for example, eucalypt saplings.

During most of the year (outside the rut) deer organise themselves in single-sex herds (either females and young or males), generally in groups of between three and 20 animals (sometimes larger). During the rut males gather themselves a harem of females by competing with other males. Common behaviours for males during the rut include thrashing and rubbing vegetation with their antlers to establish/mark territory, scent marking, groaning/roaring/calling to attract females and fighting other males for dominance.

### Identification

There are two species of feral deer found within the AMLR region including Fallow (by far the most abundant species) and Red Deer. When distinguishing between Fallow and Red Deer there are a few key identifying features to look for.

#### Fallow Deer

A mature Fallow Deer (*Dama dama*) buck grows up to 95 cm at the shoulder and weighs approximately 90 kg. Its colouring can vary from black, white, common (grey-brown) and melil (light brown). Fallow Deer bucks have a prominent 'adam's apple', a brush-like penile sheath and palmate antlers. Both Fallow bucks and does have a white heart-shaped marking on their rump, surrounded by a black or brown border.





Figure 9: Fallow Deer buck and doe. Photo: T. Bowman.

## Red Deer

Red Deer (*Cervus elaphus*) are the larger of the two species, with a mature stag growing up to 120 cm at the shoulder and weighing approximately 160 kg. As their name suggests, Red Deer have a red-brown coat and sometimes a cream underbelly. Red Deer have u-shaped multi-pointed antlers and a cream rump patch, which often extends onto the animal's lower back.



Figure 10: Red Deer hind and calf  
Photo: G. Mackenzie, Australian Deer Association

## Management

Active management of feral deer populations is limited to trapping and shooting. Feral deer should be controlled in a humane manner using appropriate calibre firearms, shot placement and hunting techniques that minimise the risk of stressing or wounding animals. Most rifle/hunting associations will be able to connect you with a willing and licensed hunter/shooter to assist in control.

In instances where properties are in close proximity to residential areas it is vital to ensure that the appropriate approvals are obtained from SA Police.

One of the biggest problems in relation to the prevention of feral deer populations is the avoidance of escapees from deer farms. It is vital that deer farmers build and maintain their enclosure fences to the minimum standard as set out in the *Australian deer industry manual* (RIRDC report 98/13).

## Rights and responsibilities

(As detailed in the NRM Act and [General] Regulations 2005):

- If a landholder has deer on his/her property without their consent, they are required to capture and remove or destroy the deer in a humane manner.
- Landholders who have been notified by a deer farmer that deer have escaped cannot take action to capture or destroy escaped farmed deer (carrying a visible ear tag) on their properties for a period of 48 hours after notification.
- A deer farmer has 48 hours (after notification) to recover escaped farmed deer by negotiation with the landholder on whose property they are roaming.
- A landholder can take immediate action to destroy escaped farmed deer on their property if the deer are not tagged and/or if the deer farmer has failed to notify the landholder of the escape.
- Although it is strongly encouraged that all deer are ear-tagged and carry a property identification code (PIC) to assist with the recovery of escapees, it is not a mandatory requirement.
- Deer are only required to be tagged if a person has failed to implement an action plan or comply with an order to address problems with a deer enclosure. Deer must also be tagged (with PIC) under the *Livestock Act 1997* if the deer are being transported/leaving a property.
- Landholders with deer on their property with their consent are required to maintain a minimum standard of fencing as described in the *Australian deer industry manual* (RIRDC Report 98/13) (see [www.rirdc.gov.au](http://www.rirdc.gov.au)).

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