Government of South Australia
Adelaide and Mount Lofty Ranges
Natural Resources Management Board

LAND MANAGEMENT PROGRAM

A Practical Guide to Rural Land Management

Course Booklet

Disclaimer

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

Acknowledgements

The contents of Property Planning Booklet were compiled as a template for landholders in the Adelaide and Mt Lofty Ranges Natural Resource Management (NRM) Board. It is a collaborative project built on the work of the Sustainable Agriculture and Training Team of the Adelaide and Mount Lofty Ranges Natural Resource Management Board and contributions from Rural Solutions South Australia and the Country Fire Service.

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An Introduction to Land Management

Background

The Land Management Program (LMP) was established in 1998 by the Northern, Central and Southern Hills Soil Conservation Boards in partnership with the Mount Lofty Ranges Catchment Program supported by the Natural Heritage Trust. In 2006, the Catchment Boards amalgamated into the Adelaide & Mount Lofty Ranges Natural Resources Management Board.

Key services of the LMP include: land management courses, field days and workshops, property visits and one to one small property advice, publication of the 'Small Talk' newsletter and the 'Events Calendar'.

The objectives of the program are to:

- increase landholders' level of awareness of natural resource management issues and problems
- ensure that property owners are aware of the causes and effects of land degradation and have an understanding of appropriate solutions to tackle these problems
- increase the confidence and ability of landholders to construct a property management plan to successfully implement 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. The quality of Adelaide's water supply is determined largely by how well the land is managed in the watershed. Agricultural production from the region benefits the State's economy. In addition the region is being promoted as 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.

Protecting our natural resources in this high rainfall region is based on the premise that integration of resources is the key to successful land management.

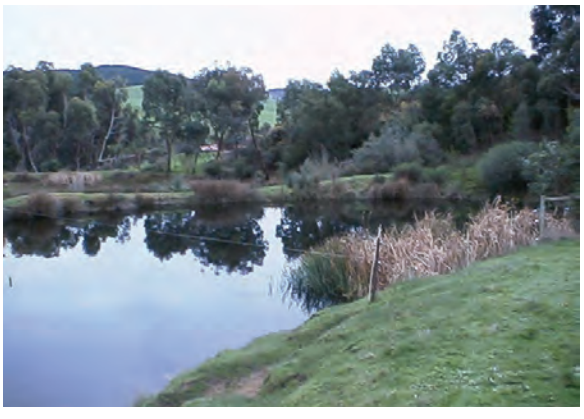


Figure 1. Typical scene in the Mount Lofty Ranges

Main issues addressed by the Land Management Program

- Soil erosion by water and wind.
- Decline in soil fertility and structure.
- Soil acidification.
- Dryland salinity.
- Surface and underground water - quality, quantity and management.
- Land management and water resources legislation.
- Revegetation.
- Management of native vegetation.
- Loss of biodiversity and wildlife habitat.
- Perennial pasture management.
- Weed control in pastures, revegetation sites and existing native vegetation.
- Pest animal control.
- Bushfire prevention.
- Use of chemicals.
- Environmentally sustainable land use.
- Property management planning.

Legal Responsibilities of Land Owners and Managers

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

(a) 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. Avoid overgrazing and check you have the correct stocking rate for your district and your pasture quality.

(b) 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 the local Authorised Officers undertaking the work and recovering the costs from the owner of the land. Your local Officer can supply a list of declared pest plants and animals for that region.

(c) The water resources section of the Act provides that any person will have the right to take water from any course (ie 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 the Adelaide and Mount Lofty Ranges Natural Resources Management Board if building a dam. This assumes that the dam wall is less than 3 m. However, if the dam wall is greater than three metres, or the dam capacity exceeds 5 ML, the landholder must submit a development application to the local council. An engineer's report may be required if the wall is greater than 6 m high. The council will then refer the application onto the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

Licenses for irrigation are required in all prescribed areas i.e. Eastern Mt 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, which will have Water Allocation Plans.

A permit for sinking a bore is required from the Department of Water, Land, and Biodiversity Conservation.

Other Acts which may impact on land managers include:

- Native Vegetation Act.
- Development Act.
- Agricultural Chemicals Act.
- Country Fires Act.
- Environmental Protection Act.
- Fruit and Plant Protection Act.
- Impounding Act.
- Stock Act.
- Apiarists Act.
- Local Government Act.

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 and affects wind and water erosion hazards.
- Water absorption – some low lying areas may become waterlogged in the wetter months and will reduce 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 outweigh 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 Land Classification).

Why Map Land Classes?

- Land classes show where you can or can not graze.
- Allows fencing to land class.
- Enables the assessment of carrying capacity by determining area available for grazing.
- Shows limitations for other enterprises eg:
  - > *Vines:* need well drained soils and avoid frosts.
  - > *Farm Forestry:* maximum slope of 20° (35%).
  - > *Cropping:* avoid land over 12° slope.
  - > *Grazing:* avoid waterlogged soils.
  - > *Strawberries:* avoid saline soils.

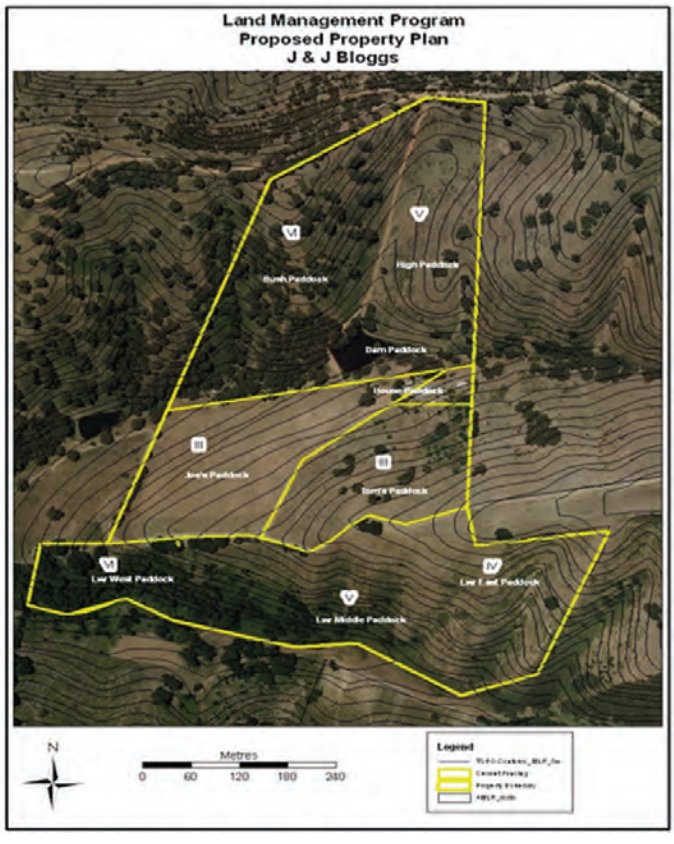


Figure 2. Example of dividing land into land classes

Table 1. Land Classification

	Land class	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 eg: 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 Class System for Grazing

A system with three classes can be used as an alternative to the more complex eight-class system.

Table 2. Land classification for grazing only

All Year Access Areas	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 >70)
Restricted Access Areas	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.
Prohibited Areas	Extreme slopes, area affected by or prone to landslips, gullying, tunnelling, salinity, areas of native vegetation or highly sensitive areas.

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

Identifying whether your 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 waterlogged land will damage your soil and pasture.

Figure 3. Waterlogged lower pasture.

Figure 4. Extreme slopes can be dangerous for stock and are best used for revegetation

Figure 5. Rockiness reduces the ability to use machinery and indicate a shallow soil depth rendering the land unsuitable for perennial horticulture.

Property Planning

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

It is important to understand that the assessment of your property cannot be done 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). Your own priorities and lifestyle will change over a period of time.

Thus property planning is a dynamic and fluid process and you can expect your plan to change over time as priorities, physical aspects of the property and your lifestyle changes. It is important to record your short term and long term goals for the property which 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.

Figure 6. An aerial photograph is the first step in property planning

To write you property plan effectively, you 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 your property is important if you are to achieve your hopes and aspirations. For most small property owners' lifestyle counts for a lot, however, particular enterprises can be a source of income if managed effectively. Whatever your priorities, appropriate management is critical to maximise your land's potential.

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

Overlay 1 includes all the physical and permanent features of the property which will impact on its management. (i.e. 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 property 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 fences.

Figure 7. Overlays on an aerial photograph are a useful aid to property planning

Stocking Rates

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

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

By mapping your land classes (as per page 4), you will be able to see which areas should be permanently excluded from grazing (watercourses, house yard etc.) and those that have restricted grazing (eg: waterlogging in winter).

Figure 8. Avoiding overstocking

What is your Regional Stocking Rate?

Table 3. Regional DSE's

Locality	DSE value/ha	Locality	DSE value/ha
Balaklava	2.9	Kersbrook	11
Birdwood	10	Lyndoch	7.5
Cherry Gardens	10	Mt Pleasant	8.1
Clarendon	9	Nuriootpa	6.4
Cockatoo Valley	7.6	One Tree Hill	6
Cudlee Creek	5	Parawa	11
Echunga	13	Port Wakefield	1.7
Gawler / Roseworthy	5	Woodside	8
Gumeracha	10.9	Yankalilla	10

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

Regional DSE values are calculated predominantly according to rainfall, but should also consider soil type and its influence on pasture growth. Generally speaking, the higher the rainfall, the higher the regional DSE value will be. However, steep slopes will significantly reduce your stocking rate.

Calculating your stocking rate

Work out the area of each of your paddocks:

Length (m) x width (m) / 10 000 = ha
Eg: 150 m x 200 m / 10 000 = 3 ha

Note: 1 ha = 2.47 acres

Work out the total number of hectares where you can carry stock for 12 months of the year. Do the same for nine months and six months.

Use the formula to work out the maximum carrying capacity:

Number ha/s x Number months grazing x Regional Stocking Rate (RSR) = DSE

12 months

Table 4. Example of stocking rate calculations

Example: A six hectare property located in Woodside where 3 ha are being locked up for hay production for six months of the year.

3 ha x 12 months x 8 RSR = 24 DSE
12months

3 ha x 6 months x 8 RSR = 12 DSE
12 months

Add them together, and 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 calculate the stocking rate for other livestock, a value is given to the species which is equivalent to the sheep.

Table 5. DSE 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

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.

Eg: 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, you must reduce your DSE by at least one third. You should also take into account any paddocks you wish to renovate. Renovating paddocks will reduce the amount of grazing available in the first instance, but be well worth the effort once established.

Figure 9. An overgrazed horse paddock and yard.

Figure 10.A well managed horse paddock.
Photos courtesy A Cole

References

Maschmedt, D. Assessing Agricultural Land. PIRSA
Grose, G.J. Land Capability Handbook. DPI Tasmania
Parry, K. Property Planning, 1998
Property Management Planning – Extension Resource Manual, PIRSA

Soil Management

Role of Soil

Soils are dynamic ecosystems containing vast numbers of living organisms. Soils anchor plants and provide the plants needs for 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 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**'.

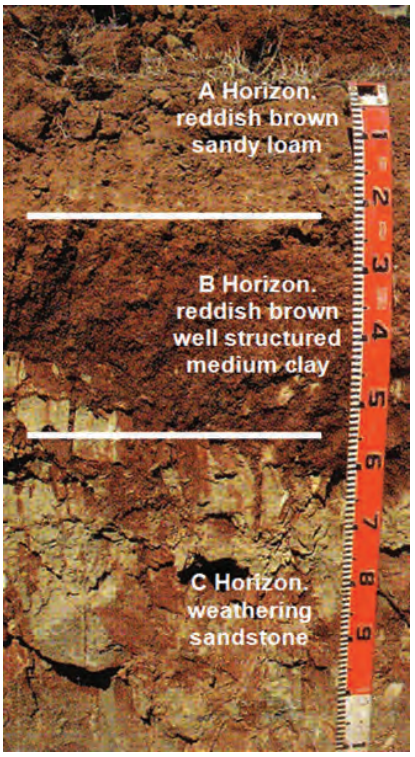
Appropriate management of soils is critical to avoid degrading them to the point where plant growth suffers. The continued removal of plant products without the addition of fertilisers will result in a loss of crucial soil nutrients. The physical condition of a soil, together with its chemical and biological 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 that 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 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.



Hard red-brown texture contrast soils with highly calcareous lower subsoils

Brown clay loam over a light clay on fine limestone

Sandy loam on a medium clay over calcareous sub-soil – often with a hard setting surface

Figure 1. Soil profiles

Texture and Structure

Texture

Soil texture is the proportion of sand, silt and clay that makes up the mineral fraction of soil. 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, ease of root growth, soil workability and resistance to erosion. Texture can be assessed by feeling the soil between the fingers and observing the behaviour of moist soil kneaded into a ball and pressed into a ribbon (see Figure 2).

Table 1. Texture and Soil Particles

Texture (feel 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

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 breakdown 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 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.

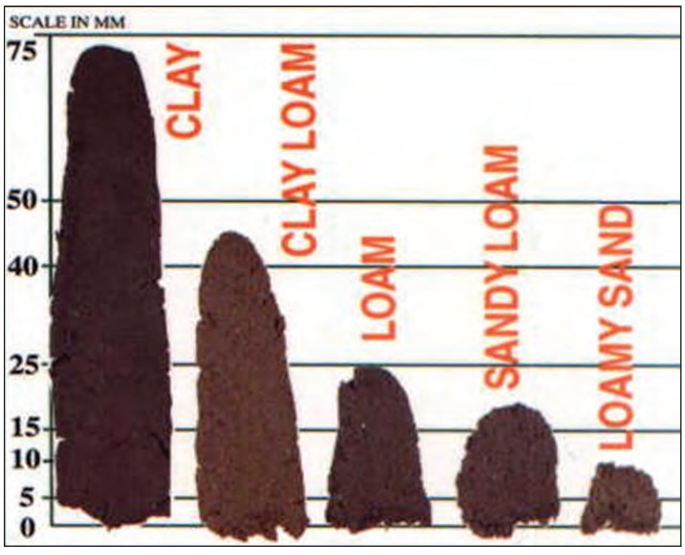


Figure 2. Field chart showing textural classes (source: ABA Better Soils Mean Better Business)

Table 3. Physical properties of soils in different textural classes (source: ABA Better Soils Mean Better Business)

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 moderate	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

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 which remain stable when wet and contain pore spaces which 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 which act as a barrier for 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 %)
- 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.

No structure.
Sandy soil.
Lacks organic matter.

Good structure.
Allows water and air into soil.

Poor structure.
Heavy clay.
Add organic matter.

Figure 3. Variations in soil structure
Photo courtesy A Cole

Gypsum (calcium sulphate) is effective on **'sodic**' soils. These are soils which have 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 they are usually around 2.5 t/ha.

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 to check 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 based on the results of a soil test. However, it is also possible to estimate nutrient levels removed from paddocks to determine how much fertilizer 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. Aim 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 they can only test a teaspoon of soil 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.

Soil test results include recommendations where deficiencies are identified, but if further assistance is required when calculating the level of fertiliser to apply, always seek professional advice. The results in Table 5 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_2}	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	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	

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, whilst clover can add approximately 100 kg/ha.

Phosphorus (P)

Most Australian soils, in their natural state, suffer from phosphorus deficiency. Available phosphorus in soil encourages good root growth and is often incorporated at sowing time (e.g. 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 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, calcrete, 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 need to be spread. 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:

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

Soil Colour

Soil colour can vary immensely and is valuable for classifying soils. The profile of a soil can exhibit a number of layers which differ markedly in colour and often give 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 subsoils 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

Soils form from parent rock with its own distinctive colour which determines the main colour group. 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 whilst 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 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 mater 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.

What does soil colour tell us?

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 zero 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.

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 which will enable the correct amount of lime to be added, to neutralise the acidity. Soil sampling kits are available from most natural resource centres.

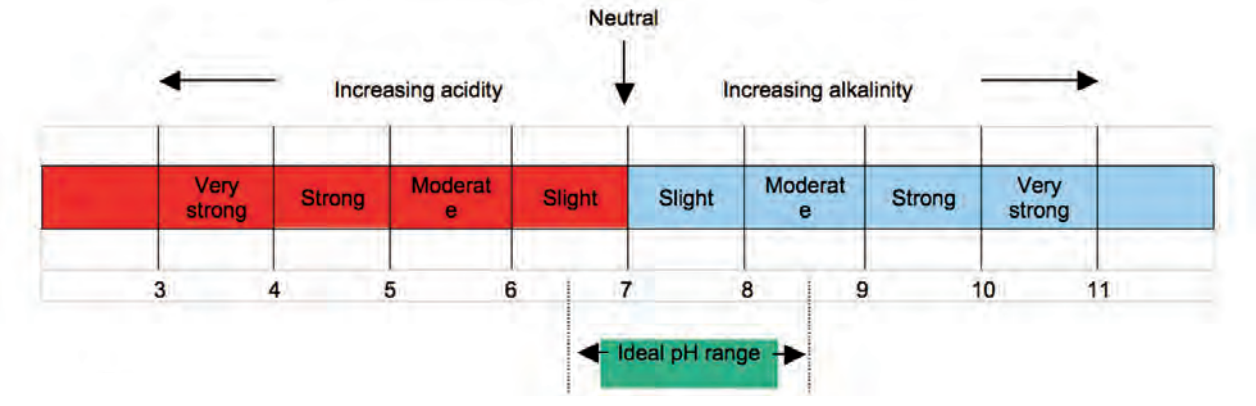


Figure 4. Soil pH scale

Most laboratories measure pH by two methods (pHwater and pHCaCl2). Typically pHCaCl2, (i.e. pH calcium chloride) is about 0.8 units lower than pHwater.

Causes

Acidification is caused by:

- Organic matter decomposing and producing organic acids.
- Nitrogen compounds being added to soils by fertilisers and legumes (e.g. 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 (e.g. 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 Mt 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' soils 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, whilst 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.

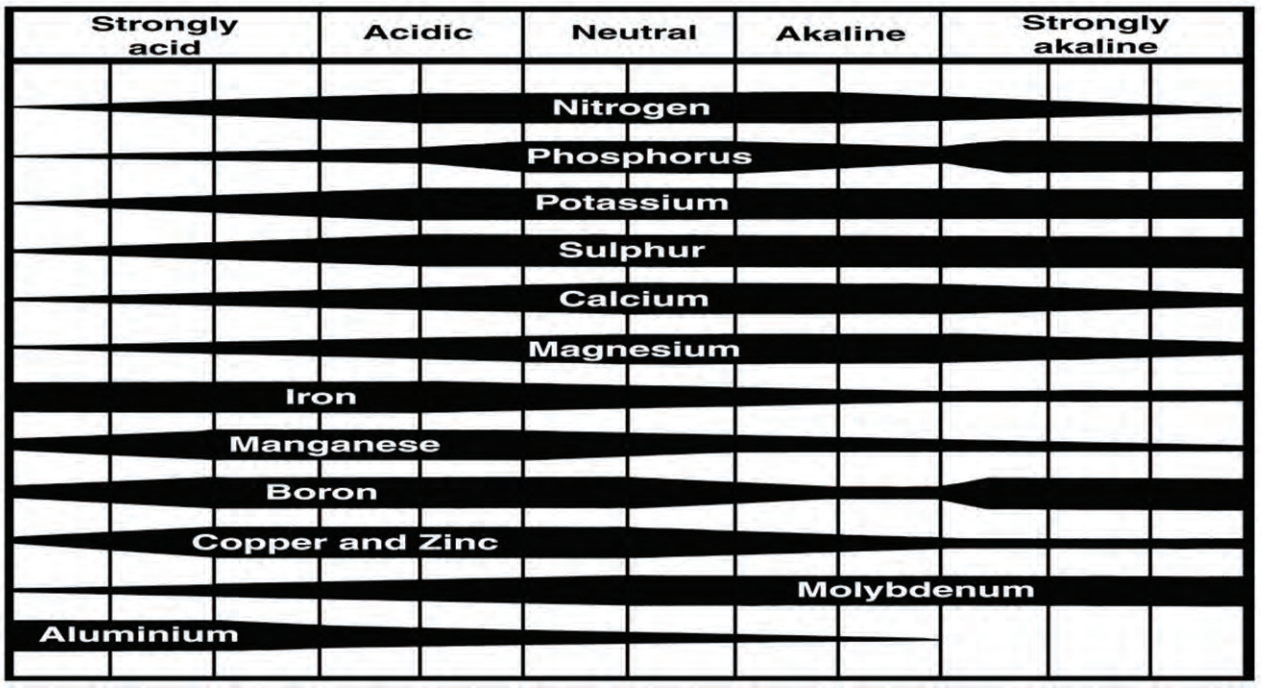


Figure 5. Nutrient availability

Correcting acid soils

Acid soils can be corrected by the addition of lime. The lime neutralises the acid and raises the pH. Lime is calcium carbonate and when it is added to soil the carbonate fraction combines with the acid (H+ ions) to form water and carbon dioxide.

$CaCO_3$ (calcium carbonate) + 2H+ (acid) $\longrightarrow$ Ca++ (calcium) + CO_3· ·(carbonate)

CO_3· ·(carbonate) + 2H+ (acid) $\longrightarrow$ H_2O (water) + CO_2 (carbon dioxide)

The best way to determine when lime needs to be applied is to conduct a soil test once every four to five years unless soils are very sandy, in which case every two years is more appropriate.

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

Table 5. Relative neutralizing values of liming materials. (Source: Australian Soil Fertility Manual)

Liming Material	Relative Neutralizing 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

Lime requirements

The amount of lime required to raise the pH of a soil (i.e. reduce acidity) will depend upon 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 (see Table 7).

Table 6. 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

For grazing properties, if pH ($CaCl_2$) 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 ($CaCl_2$).

Table 7. Target pH for different land uses

Land Use	Target pH ($CaCl_2$)	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	5.5–6.5 6.0–7.0

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 (CaCl2) = 4.6

Lime Required = (target pH – current pH) x Soil Texture Factor (see Table 7)

= (5.5 – 4.6) x 3.25 = 2.9 t/ha

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 three to five 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 land remuneration and or crop/orchard establishment.

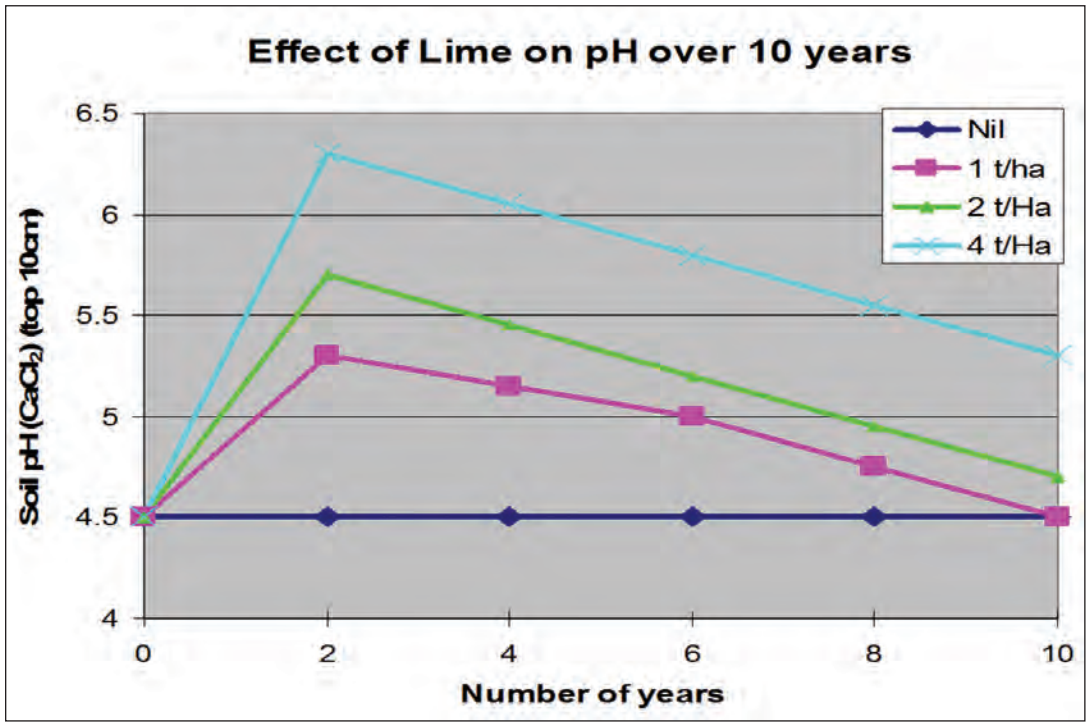


Figure 6. Effect of lime over time. (Source: Acid soil management in low rainfall farming systems of Central Western NSW, Grains Research Development Corporation, Acid Soils Action, and NSW Agriculture)

Salinity

Saline soils are those which have levels of soluble salts which are 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, magnesium, and anions of chloride, sulphate, carbonate, 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 to measure 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 which has an adverse effect on plant growth. Clearance of trees and deep rooted perennials, which historically have kept the watertable below the root-zone of plants, has played a major part in this form of degradation.

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 (i.e. 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. Waterlogged soils can cause poor plant growth due to oxygen starvation in the root zone. They can also be detrimental for plant growth because waterlogged soils tend to lose nitrogen and can 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 contain 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 1 mm 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:

- Maintain adequate vegetation or stubble cover, especially when the soil surface is loose. Grazing animals tend to loosen and bare the soil surface.
- Minimise the time between the first cultivation and early crop emergence.
- Use low intensity tillage practices (e.g. direct drill, no-till).
- Manage sandhills and other very sandy soils separately from less erodible soils. Ultimately they should be fenced off and permanently stabilised by planting to perennial vegetation.
- Establish 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 (i.e. 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% are likely to exhibit medium to high risk of water erosion. On these slopes contour banks have been constructed to reduce run-off and erosion.

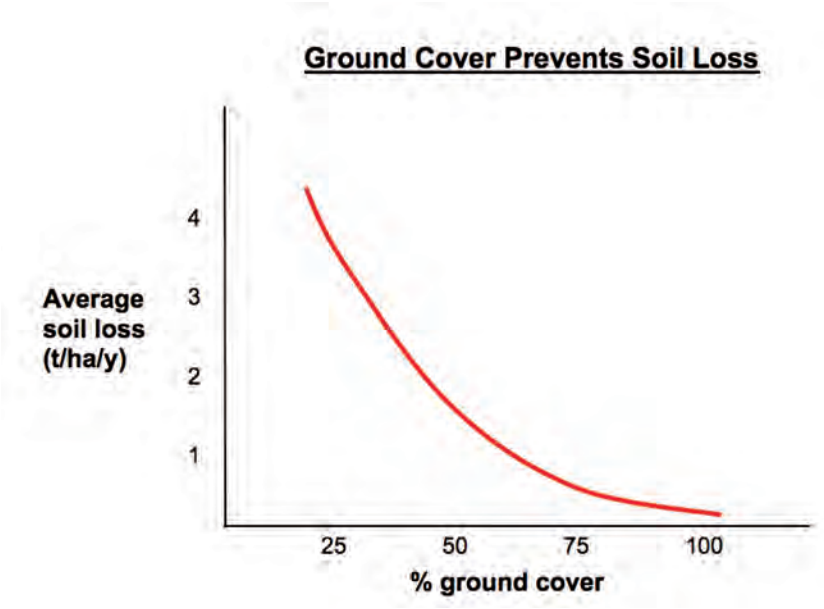


Figure 7. Ground cover and soil loss (source: Managing pastures on small properties in the Mt Lofty Ranges, PIRSA, fact sheet)

In high rainfall areas with steep slopes 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 6). 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.

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Pasture Management

The Role of Pasture

The concept of an ideal pasture will vary 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 e.g. Subterraneam clover *(Trifolium subterraneum)*. Perennial plants live for more than two 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 countries 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 which may suffer from this condition. Cultivars available differ greatly in maturity, growth habit, and resistance to disease and moisture requirements. Minimum rainfall is approximately 600 mm p.a. for dryland pasture cultivars (e.g. *Avalon, Victorian and Ellett*). Perennial ryegrass is also ideal under irrigation where it can be sown with white clover. Sowing rates range from 8–30 kg/ha depending on seed size, rainfall and irrigation.

Figure 1. Perennial Ryegrass
Photo courtesy A Cole

Phalaris *(Phalaris aquatica)*

Phalaris is a deep-rooted perennial grass native to the Mediterranean region, which requires at least 450 mm rainfall p.a. 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 it is the most sensitive of the temperate grasses 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 veterinarian 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, Sirosa and Sirolan.

Figure 2. Phalaris. Photo Courtesy A Cole

Italian/Annual ryegrass *(Lolium multiflorium)*

This pasture is suited to lower rainfall areas where perennial ryegass 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 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. Minimum rainfall requirement is 450 mm, unless irrigated cultivars are being used. 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 sightly 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. 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.

Figure 3. Cocksfoot. Photo Courtesy A Cole

White Clover (Trifolium repens)

White clover is a perennial clover native to Europe which is suited to regions which have at least 750 mm of rainfall p.a. 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 clovers is by its large leaf size, another by stolen density. Persistence in pasture is usually in those cultivars whose stolen density is 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 dryland, and 3–5 kg/ha in high rainfall areas or where irrigation is available. Cultivars include NuSiral, Demand and Haifa.

Table 1. Characteristics of some subterranean clover varieties (source: Seed Distributors SA)

Cultivar	Rainfall (mm)	Days to Flowering	Hard Seed (10 high)	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

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 p.a. to in excess of 750 mm p.a. depending on the variety. Subterranean clover is a self-regenerating annual which buries its seed in the ground. They add considerable quantities of nitrogen to the soil which benefit the growth of pasture grasses Sowing rates are generally 4–12 kg/ha when mixed with perennial grasses. If irrigated, rates may be as high as 15–25 kg/ha. Cultivars include Nugarin, Trikkala, Gosse and Leura.

Figure 4. Subterranean clover. Photo courtesy A Cole

Lucerne (Medicago sativa)

Figure 5. Lucerne

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 1–10 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.

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 rainfall is at least 450 mm p.a. Sowing rate is generally 10–20 kg/ha. Cultivars include Advance, Typhoon and Prosper.

Figure 6. Tall Fescue

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 (i.e. Snail, Barrel, Burr). The pods of most medics generally hold between four and ten 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 5–10 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 michelanium)* 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 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. Always seek professional advice before deciding on what pastures to sow.

Horse Pasture for Northern Adelaide Plains (375–450 mm p.a.)

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.

- Guard annual ryegrass @ 10 kg/ha
- Barrel medics (Mogul, Caliph, Paraggio, and Sephi) @ 5 kg/ha
- Balansa clover (Paradana) @ 1 kg/ha

Guard 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. When sowing Guard ryegrass it is important to ensure that any existing ryegrass species are completely eradicated before planting.

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

Non Irrigated Perennial Pasture (650+ mm p.a.)

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 Mt Lofty Ranges.

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

Non Irrigated Perennial Pasture (450–600 mm p.a.)

On lighter sandy loams in lower rainfall areas, cocksfoot and phalaris can be considered in place of perennial ryegrass which will struggle to persist. The following pasture mix is often sown in the Mt Lofty Ranges.

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

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, and the risk of soil degradation, such as erosion, may increase.

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

Table 2. Pasture utilization for irrigated and non irrigated perennial pastures in the Mt Lofty Ranges (source: Managing Irrigated Pastures in the Mt Lofty Ranges, PIRSA, 2002)

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 'utilized' includes all pasture eaten by stock or preserved as hay or silage, and excludes plant material which naturally decomposes during the season.

Pasture Benchmarks – for pasture sustainability and persistence (rainfall >500 mm)

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 fertilizer, 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/m2 (minimum) and 100 plants/m2 (ideal)
- phalaris, tall fescue and cocksfoot - at least 20 plants/m2
- lucerne and chicory - at least 30 plants/m2
- subterranean clover seed reserves - 50 kg/ha (minimum) and 300+ kg/ha (ideal).

After the Break (May/June)

- subterranean clover plants – 50 plants/m2 (minimum) and 150 plants/m2 (ideal)

Late Spring

- legume percent (as dry matter) – 30% (minimum) and 50% (ideal)

Summer

- remove livestock when there is less than 600kg 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 to grow can impact on livestock productivity. As a general rule, legumes are high in protein while grasses provide fibre and energy.

Feed	Dry Matter % (excludes 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

The quality and quantity of a pasture changes 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 where sugars are converted to lactic acid. This usually takes about two 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 case pastures are cut when plant dry matter is around 60–70%. The bales are wrapped tightly in plastic wrappers 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 %, is optimum at this time (see Figure 7).

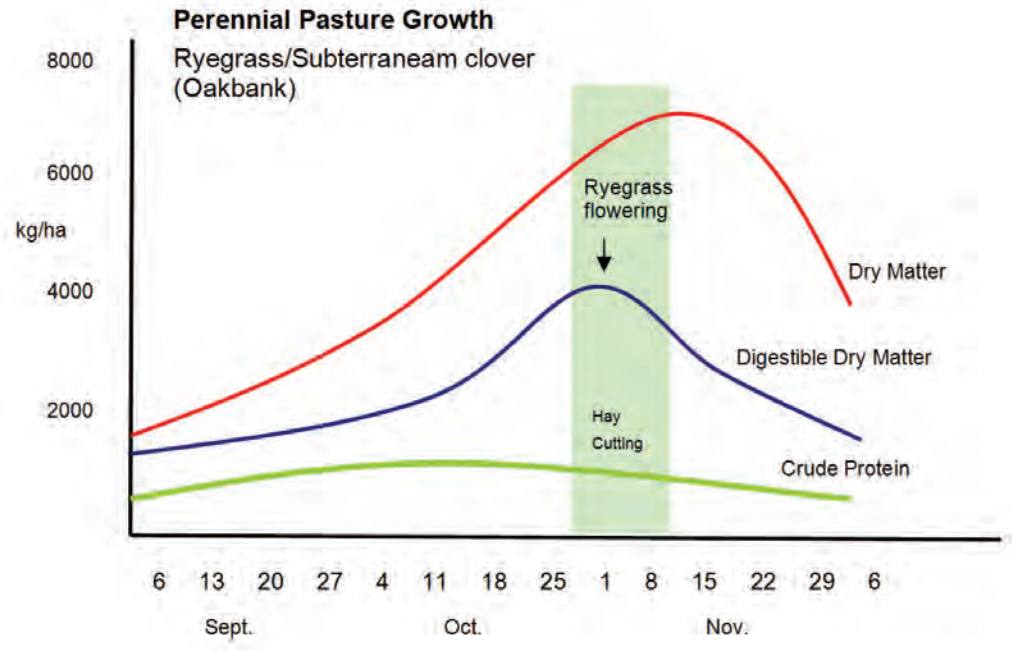


Figure 7. Growth of perennial pasture, Mt Lofty Ranges >600 mm

Oaten hay generally contains a lower % protein than grass/legume hay (see 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.

Table 4. Nutritional values of hay (source: Hoofprints – a manual for horse property management)

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

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 any nutrient imbalances and identify the pH (acidity) of the soil (refer to Chapter Three Soil Management). When growing grass dominant pastures in high rainfall areas, plants are unlikely to receive adequate levels of nitrogen normally provided by legumes such as clovers and medics. In these circumstances 15–25 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 fertilizer in August which contains nitrogen, phosphorus and potassium. Livestock should be removed from paddocks at this time to ensure maximum growth.

Grazing Management

Rotational Grazing

Pasture productivity and weed control depends 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 utilize pasture throughout the year. Strip grazing and cell grazing are both forms of rotational grazing. The aim of this strategy is to enable the plants to recover quickly from being grazed, after which they grow to a suitable height when they are ready 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, lower leaves can become shaded, brown off and rot with a loss of productivity. There is no set figure for how frequently stock should be moved on from a paddock. Times could vary between three 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 7).

10% cover

70% cover

100% cover

Figure 8. Estimations of pasture ground cover

Grazing Pressure

The higher the grazing pressure the more efficiently pasture feed is utilized with less waste. Grazing pressure can be increased within a property by increasing the number of paddocks, whilst the overall stocking rate remains constant. On small properties livestock should be rotated through at least four 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 (i.e. 40 cows divided by 48 hectares). If the property is divided into four paddocks the grazing pressure can be 3.3 cows/hectare (i.e. 40 cows divided by 12 hectares). If six paddocks are available the grazing pressure can be five 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 which contain very few good pasture species, and are dominated by weeds, may need to be re-sown. However, it is important that clear benefits will be observed, because the process can be expensive and is not without risks. The presence of weeds alone is not necessarily a good reason to start again with a new pasture. Pastures may have a minimum number of pasture species present which would benefit simply from good weed control, the addition of appropriate fertilizers and strategic grazing. Some pastures may only require additional seed to be 'oversown' to improve the density. If unsure, landholders should seek professional advice before embarking on the process of 'pasture renovation' (i.e. sowing a new pasture).

Figure 9. Disk drill for seeding perennial pastures

If new pastures need to be sown, it is important to ensure that good weed control is carried out in the year prior to seeding. 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 three months of a newly sown pasture, and only limited grazing will be available for another nine months, so the feed requirements of all livestock on the property will need to be considered for that year.

Unless paddocks need to be levelled (i.e. 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 two-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 Mt Lofty Ranges.

1. Assess, select and plan early

- Assess existing pasture, weeds and soil fertility (refer to 'pasture benchmarks' page 25).
- Seek professional advice if unsure whether to resow.
- Check on the availability of equipment and/or contractors.

2. 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).
- Spraytop, slash or graze to control annual pasture weeds.

3. Check soil fertility

- Soil test over Summer to check fertility levels.
- Apply lime (if required) anytime up to sowing.
- Seek advice on a suitable fertilizer program.

4. Graze prior to sowing

- Graze well over Summer to remove residues.

5. Control weeds and pests in Autumn

- Allow a full weed germination after the Autumn break (normally three weeks after opening rains).
- Spray appropriate herbicides /insecticides to control weeds and pests (e.g. red legged earthmite).
- Cultivate only if paddock has to be levelled. Cultivate to achieve a firm, fine weed-free seedbed.

6. 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.

7. 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.

8. Monitor weeds and pests

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

9. 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.

High Rainfall Pasture Management Calendar

The following calendar is a guide only, since 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 create a fire hazard.

Table 5. Pasture management calendar (source: High rainfall pasture management calendar, Fact Sheet, PIRSA)

Month	Activity
January to March	Graze down dry residues to 3 cm. Do not overgraze, and maintain 70% cover. Supplementary feed livestock. Soil test paddocks to determine fertilizer and lime application rates. Lime paddocks in March, if necessary.
April	Fertilize according to soil test reports. If fertilizing close to watercourses, split applications are recommended (half in Autumn and theremainder 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 fertilizer 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 earthmite) 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 three to four 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.

Identification and Management of Pasture Weeds

Good land management remains the key to controlling most weeds in pastures. If the use of chemicals 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 which will help to keep weeds from becoming a serious problem. These include:

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

- oversowing with perennial grass and clover
- hardgrazing 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 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 (source: MLR Animal and Plant Control Board)

Weeds \ Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blackberry, Broom	■	■	▒	▒	▒						■	■
Gorse	■	■	▒	▒	▒	▒	▒	▒	▒	▒	■	■
Boneseed									▒	■	■	■
Hawthorn										■	■	■
Olive (wild)	■	■	▒	▒	▒	▒	▒	▒	▒	▒	■	■
Salvation Jane and Thistles				■	■	■	■	▒	▒	▒	▒	
Broadleaf Pasture Weeds				■	■	■	■	▒				
Cape Tulip						■	■	■	■	▒		
Bridal Creeper					▒	▒	■	■	■	▒	▒	
Watsonia									■	■	■	
Water Dropwort					▒	▒	▒	▒	■	■	■	■

Legend	Optimum	■	Suitable	▒	Seek Advice	▒	Not Suitable	

Annual Broadleaf Weeds (e.g. 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)*. Whilst herbicide use is an important tool for controlling these plants, it is only one of the management options available.

Capeweed

Storksbill

Salvation Jane

Figure 10. Common annual broadleaf pasture weeds
Photo courtesy A Cole

If paddocks becomes 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 broad leaf 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 only 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 end of August within 1 km of vineyards or horticultural crops etc., or damage to these crops can occur.**

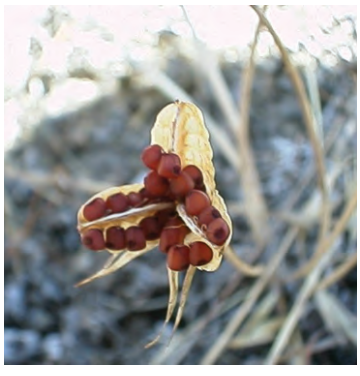
Biological control can be used as part of an integrated weed management program. In the case of Salvation Jane effective control can take up to ten years. There are four main insects that are the focus of Salvation Jane biological control. The **crown weevil** larvae attack the growing crown of the plant, whilst 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 (e.g. 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 up to 12.5 cm and thrives in low fertility soils found throughout the high rainfall areas of the Mount Lofty Ranges. Landholders may also discover Lesser Guildford grass *(Romulea minutiflora)* which has a similar distribution.

It has been known to create problems for livestock (especially horses and cattle) when it forms a tough fibrous ball, blocking the animals 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.



Seeds

Bulb

Flower (pale to bright pink)

Figure 11. Guildford grass (Romulea rosea)

Herbicide applications may be necessary where this weed has become dominant. Metsulfuron methyl applied at 15 g/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 and Cape Tulip 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 lay ground bare, encouraging the establishment of further weeds.

Figure 12. Cape Tulip (Homeria spp.)

Figure 13. Watsonia (Watsonia bulbillifera)

Perennial Broadleaf Weeds (e.g. Catsear and Dock)

Perennial broadleaf weeds can be difficult to control once they are established in a pasture. They often have well established roots 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 tap root which seeks out sub-soil moisture at depth, while the variegated thistle *(Silybum marianum)* is unlikely to be eaten by stock and 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.

Dock

Catsear

Figure 14. Common perennial broadleaf weeds

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 red legged earth mite, lucerne flea and blackheaded pasture cockchafer. Severe damage can result from large infestations.

Figure 15. Lucerne Flea damage (source: Victorian DPI, Agriculture Note 0415)

Red Legged Earth Mite (RLEM)

The red legged earth mite *(Halotydeus destructor)* is a major pest of pastures, especially subterranean clover, annual medics and lucerne. It thrives in the Adelaide and Mt Lofty Ranges region which experiences 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 in Spring which ultimately hatch in Autumn. The optimum dates can be predicted by accessing the TIMERITE website program (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 RLEM numbers. There are a number of predators of RLEM, 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 RLEM, 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 to 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. There are known to be predators of this pest, 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: Victorian DPI, Agriculture Note 0415

Figure 17. Pasture Cockchafer 20 mm (source: Victorian DPI, Agriculture Note 1364)

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 the roots of pasture plants resulting in bare patches and exposed soil. Eggs hatch in early November with larvae doing 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

There are a number of diseases of pasture plants 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.

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Environmental Weeds

What is a weed?

A weed has been defined in many ways. One of the most simple 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 a good source of honey, while in wetter areas it is not a desirable plant and can compete with perennial pastures and cereal crops. So we see that 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 us manage and prioritise 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 (WONS)

A list of 20 Weeds of National Significance has been determined by the Australian Federal Government from 3000 non-native naturalized plants in the Australian Environment. They were determined through a weed risk assessment process which assessed the weeds invasiveness and impact characteristics, potential and current area of spread and the current primary industry, environment and socio-economic impacts. Of the highest scoring weeds we have ten in South Australia; these include Bridal Creeper, Blackberry, Gorse, Salvinia, Prickly Mimosa, Chilean Needle Grass, Boneseed/Bitou Bush, Athel Pine, Mesquite and Serrated Tussock. These weeds are a high priority for control throughout South Australia.

Currently a total of 115 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 owners have a legal obligation to remove these plants from their properties and roadsides. A list of declared pest plants can be found on the Natural Resources Management web site http://www.amlrnrm.sa.gov.au/

Annuals, Biennials and Perennials

Annual weeds germinate, grow, set seed and die all in the same 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 (fig1.), Caltrop and Khaki Weed.

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

Figure 1. Capeweed. Photo courtesy A Cole

Figure 2. Thistle. Photo courtesy A Cole

Perennials live longer than two 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, in which cultivation will spread the weed. Translocated herbicides are effective at post-seedling stages of growth. Examples of perennial weeds include Blackberry, Gorse, Broom, Cape Tulip and Bridal Creeper.

Figure 4. Broom.
Photo courtesy A Cole

Integrated Weed Management

Integrated Weed Management (IWM) combines the use of complementary weed control methods so that all weeds are controlled by one or more components of the weed management system. There are three main approaches that you can use to develop your integrated weed management program:

- prevent weed problems before they start (by limiting their introduction and spread)
- restrict weed growth (by helping your crops or pastures to compete), and
- make it difficult for weeds to adapt (by keeping weeds 'off balance')

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 that you wish to control, 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.

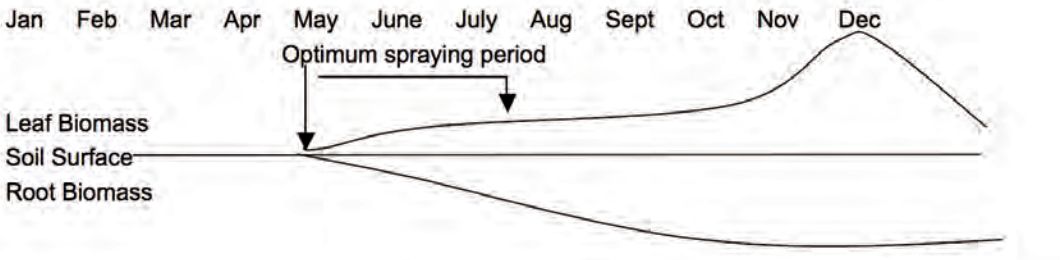
When using foliar spraying as an application method you need to be acutely aware of the risk of spray drift. When spraying you have an obligation to prevent the drift of herbicide onto desired vegetation and beyond the boundaries of the site or property that you are working on.

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 adhered to.

Timing of Spray Programs

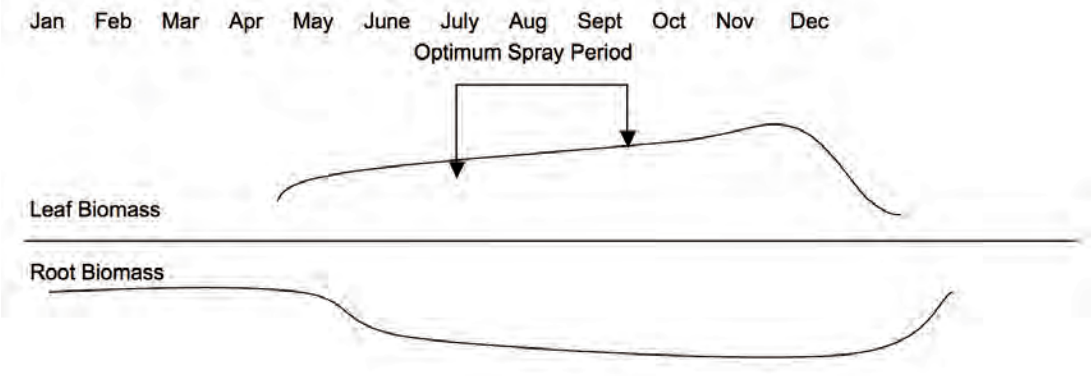
Annuals

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.



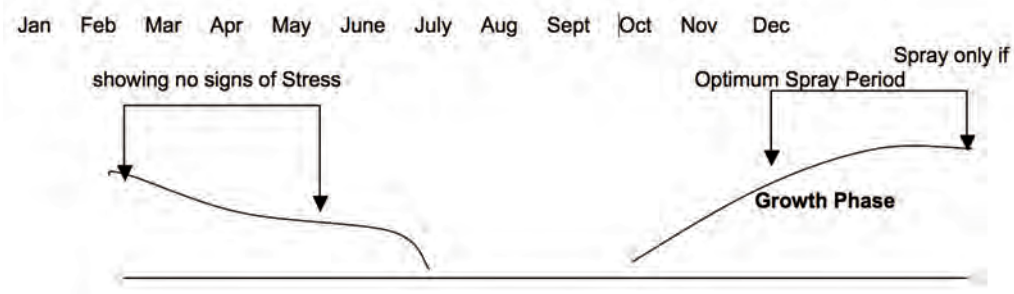
Herbaceous and Bulbous Perennials

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 so 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.



Control Techniques

Cut and Swab

The 'cut and swab' method uses less herbicide, reduces the risk of off-target damage and if disposed from the site in an appropriate manner, reduces the debris left behind after spraying. To achieve the most effective outcome using this method it is advised that you clear the immediate area around the stem of the plant, cut horizontally using secateurs, loppers, hand saw or chain saw below any nodes of growth at the base of the plant. It is important to cut as low to the ground as possible to prevent regrowth. Herbicide is then applied as soon as possible (preferably within ten seconds) to the exposed surface before the plants cells close up and inhibit the entry of herbicide. It is easiest to have two people for this process, one to cut and one ready to apply the herbicide as soon as is possible. 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° no deeper than 20mm and no more than 50mm apart right around the trunk. This angle will aid herbicide retention in the hole, increased absorption by the plant and reducing the risk of spillage. Similar to the cut and swab method, the herbicide must be applied within ten seconds of the hole being drilled. Again it will be easiest 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 plants entire system and allow trees to resprout 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. The method involves the use of a wick or rope applicator to apply the herbicide directly to the leaves and stems of the plant and 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 so that only species growing above a certain height will receive herbicide and in this way it is 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 weeds 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 are mandatory label instructions that must be complied with. 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 and 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 identify spots you have missed and where you have sprayed.

Herbicide Resistance

Within 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 the resistant plants are selected 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 Integrated Weed Management (IWM) approach is recommended. Land management with an IWM 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

Ultimately, 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.

Manual Removal is quite effective in controlling small infestations and isolated plants. Manual removal is selective, minimises risk to 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 whilst minimising soil disturbance. Manual removal of plants often requires complete removal of root systems i.e. Taproots, Bulbs and Tubers and can be done by hand or through the use of a 'tree popper'.

Mowing or Slashing 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 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, if an area is grazed too heavily, desirable plants may not recover and weed species 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, i.e. to eat palatable plants and leave behind unpalatable plants which then thrive and set seed.

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

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 plants death but often germinates weed seeds in the soil and stimulates new and fresh growth to allow for effective spraying. It is important to remember when respraying weeds in this instance 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 to reduce the biomass and allow access for other weed control methods. It is essential in this instance, that follow-up controls are implemented. You also need to ensure that all regulations have been followed including council and CFS permits (See Chapter 9 Bushfire Prevention, for further information).

Biological Control involves using biological agents from the weeds country of origin to assist in the control and on-going management of weed species. As part of an integrated control program, biological control can offer a realistic solution to some weed issues. Some examples of biological control agents include the Gorse Spider Mite and Gorse Thrip (fig 5.) to control Gorse *(Ulex europaeus)*, Rust Fungus to control Bridal Creeper *(Asparagus asparagoides)* and the Horehound Plume Moth to control Horehound *(Marrubium vulgare)*.

Figure 5. Gorse Thrip. From the Tasmanian Institute of Agricultural Research

Biological control by its nature is never 100% effective. Good to excellent control can be achieved but rarely eradication. Where biological control is not particularly effective on its own account, it can sometimes be effective when used in conjunction with other control measures. Successful bio-control agents are self generating and capable of spreading throughout the infested weed areas without assistance. Costs in 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. After the bio-control agent is proven the continued survival may require restricted use of sprays 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

Minimal disturbance bushcare techniques should be implemented in areas when 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, frilling, cut and swab, wiping and careful spot spraying. Minimum disturbance bushcare relies on several principles for success, these include:

- Always work from good to bad areas (ie work from the small, isolated infestations to the bigger 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 plant identification skills, skills in bushcare techniques, understanding of bushland ecology and the bush regeneration principles. (See 67 – 79)

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 implementing 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 to ensure weeds will not be introduced.
- 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.

Restricting the spread of existing weed infestations

- Carry out control works prior to other works.
- Slash and cultivate when weeds are outside of seeding period.
- Work 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 to reduce spread of weed seeds.

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 stop 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 costs in time and money in the future.

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 NRM Board and to report a new weed infestation or talking to your neighbour about it or changing management aspects of your property.

Develop a Weed Action Plan

Integrated weed management is an integral part of achieving successful control of any weed on any scale. Development of a weed 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 weeds – a mud map is fine.
- Prioritise the weed(s) for control.
- Determine management options for the weed(s).
- 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 on going monitoring. As mentioned earlier, monitoring assists in the detection of new weed infestations and is also important in reviewing your weed control program. Surveying your property on a regular basis and observing how your weed control program is progressing is very valuable. You might find that one control technique is not as successful as you first thought it would be, this would be an ideal to time to ask yourself some 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 your learnt knowledge to achieve successful control of a weed sooner or in a more economical way.

On-going monitoring enables you 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 on-going maintenance works will result the weeds becoming as much of a problem as they were prior to the initial control.

References

www.weeds.gov.au

CRC for Weed Management. 2004, *Introductory Weed Management Manual*

Georg. D. 1995. *Weed Control Principles*, Minister for Employment, Training and Further Education South Australia

Trees For Life 2008, *Bush For Life Minimal Disturbance Bush Regeneration Techniques*, Trees For Life

Water Resources

Watercourses

Regulations

In South Australia all persons have a general statutory duty of care under the Natural Resource Management (NRM) 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 Natural Resources Management Act 2004:

- It is the duty of the owner of land on which a watercourse is situated to take all reasonable steps to prevent damage to bed and banks and to the ecosystem that depends on the watercourse.
- The owner of land can take water from a watercourse, lake or well and collect surface water. However, the land owner will need a permit if the land is situated in a prescribed area.
- The owner of land cannot place or build any structure in a watercourse, or remove any sand, soil or rock. Stock crossings require a permit.

Natural Resources Management Boards have developed plans that aim to strike a balance to ensure that the allocation of the area's water resources is done 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. To achieve this, any water-affecting activities (WAA) require a permit which is administered through NRM Boards.

What are water affecting activities? (WAA)

Water affecting activities are defined as activities that can 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 lakes, dams and watercourses, floodplains, groundwater, springs, wetlands, waterholes and catchment landscapes, among others. Management of water affecting activities is required to protect our natural systems and water dependent ecosystems, maintain water quality and minimise impacts on other water users.

Activities requiring a permit in the Adelaide and Mt Lofty Ranges NRM Board region

The NRM Act 2004 and Volume D of the Adelaide and Mount Lofty Ranges Natural Resource Management Plan outlines WAA's which, when undertaken, may require a permit. These include, but are not limited to:

- The construction or enlargement of dams or structures to collect or divert water.
- Building of structures, obstructing or depositing solid materials in a watercourse, lake or floodplain, e.g. erosion control, construction of water crossings or dumping material.
- Excavating material from a watercourse, lake or floodplain, e.g. excavating or cleaning soaks, waterholes and on-stream dams.
- Destroying vegetation in a watercourse, lake or floodplain, e.g. removal of reeds.
- Draining or discharging water or brine into a watercourse or lake, e.g. desalination waste, stormwater including urban discharge, drainage and salinity control.
- The use of effluent or water imported to an area for commercial activities, e.g. irrigation.

Permits must be lodged with the Adelaide and Mount Lofty Natural Resources Management Board and can be downloaded from the Board's website www.amlrnrm.sa.gov.au It is best to apply for your permit at least two months before you intend to undertake the activity. If planning to drill, deepen or backfill wells, bores or groundwater access trenches, landholders should contact The Department of Water Land and Biodiversity Conservation for a permit www.amlrnrm.sa.gov.au. Landholders should also note that a license is required to irrigate.

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).

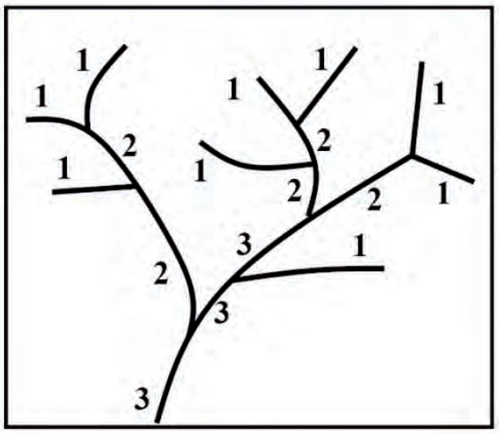


Figure 1. Strahler stream order

Benefits of riparian zones

The area beside watercourses that form the interface 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 biodiversity of the region. To achieve a well managed riparian zone the first step is to fence off the creek line to prevent livestock entering the watercourse. The larger the riparian zone the more effective it will be; a minimum distance of five meters is recommended, or twenty metres either side for a major watercourse. Once the riparian zone is fenced off re-planting the area with native vegetation will enhance the ability of the riparian zone to protect water quality.

The benefit of having a well-managed riparian zone is to protect water quality by:

- Filtering surface runoff.
- Energy dissipation.
- Controlling soil erosion and salinity.
- Shading of the watercourse – reduces the water temperature and prevents algae blooms.
- Preventing direct stock access to watercourses.

A well-managed riparian zone also provides shade and shelter for stock, 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 poorly managed eroding watercourse

Figure 3. A well-managed fenced and revegetated watercourse
Photos courtesy A Cole

Watercourse processes and dynamics

Channel flow

Channel flow refers to the discharge of water that occurs in a waterway, where discharge is the volume of water that passes through a given section of the waterway within a specified time. Channel flow can be altered by rainfall amounts, water retention (i.e. dams and weirs), entry of groundwater and evaporation.

Water velocity is a measure of how fast water flows.

How does groundwater and run-off affect the riparian zone?

Run-off and groundwater can influence the riparian zone in two main ways:

- They contribute to erosion of the riparian zone.
- They can supply excess nutrients to the riparian zone.

The riparian zone is an important buffering (filtering) zone between land use activities and the watercourse. The amount of run-off from a catchment and the quality of the run-off water and the groundwater, will impact on the efficiency of the riparian zone. The larger the water supply running into the riparian zone the harder it is for the riparian zone to filter out excess nutrients before the water enters the watercourse. This excess water can also lead to more streambank erosion. Refer to the Erosion – Flood Control section below for management strategies for reducing the amount of run-off.

Erosion

Streambank and streambed stabilization

Vegetation is highly valuable in controlling streambank and streambed erosion. Revegetation must be a major component of any erosion control program and without revegetation almost all erosion control works are likely to fail in the long term.

Vegetation contributes to erosion control in the following ways:

- Roots provide reinforcement and stability to watercourse bed and banks.
- Ground hugging vegetation shields bed and bank materials, providing 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 reducing the risk of bank failure due to heavy saturated soils.
- Vegetation can considerably reduce water velocity by contributing to the roughness of a stream.

Please consult your local Natural Resource Management Board office for options on structures that can be implemented to control severe streambank erosion.

Stock crossing points

Uncontrolled stock access to watercourses and poorly constructed creek crossings contribute to reduced water quality and watercourse erosion, leading to increased turbidity and decreased water quality. In addition, poorly constructed crossings impede water flows, adversely affecting water biota and can further contribute to watercourse erosion.

The type of stock crossing you install will depend on your watercourse line, the use of the crossing and the likely water flow. Stock crossing options can include; culverts, bridges and low-level crossings (fords). Stock crossing points should be located on a straight stretch of the watercourse that is not eroding and preferably where the channel has a hard bottom and the banks are not too steep. Fencing should be located along the crossing to prevent animals from moving along the watercourse.

Figure 4. Correctly designed stock crossing point

Figure5. Correctly designed and installed culvert creek crossing- Photos Courtesy A Cole

Flood control

A well-vegetated or forested catchment will produce much less runoff than a bare, overgrazed catchment. Rainfall is trapped by vegetation, surface runoff is slower and the rate of infiltration 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.

Common Weeds of Watercourses

Identification

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

Table 1. Common watercourse weeds (Auld & Meld, 1999)

Common name	Botanical name	Identification
Blackberry	*Rubus fruticosus 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)	*Ulex europaeus*	Shrub, to two m high, densely branched in younger parts, eventually bare at base. Leaves very prickly, yellow flowers.
Periwinkle	*Vinca major*	A low-growing perennial, shrubby herb. Shiny green oval-shaped leaves in opposite pairs. Flowers tubular and flat-lobed at mouth to fifty mm diameter, bluish purple.
Three corner garlic (Figure 7)	*Allium triquetrum*	A garlic-like herb with small white underground bulbs and three-sided leaves. Snowdrop-like white flowers
Watsonia (Figure8)	*Watsonia bulbillifera*	An erect perennial herb up to 2 m high. Leaves basal and linear and flowers curved trumpet-shaped, salmon pink to red.
Willows	*Salix spp.*	Willows are deciduous trees or shrubs. They have small seeds with long, silky hairs attached to one end like a parachute, which help them spread. The seeds are usually short-lived, from days to a few weeks

Figure 6. Gorse

Photos courtesy A Cole

Figure 7. Three-corner garlic

Figure 8. Wastonia

Control of weeds and the use of herbicides in water courses

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 i.e. 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 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 adhered to.

Willows along watercourses

In parts of Europe, Asia and America, where willows are native, they are widely used for controlling watercourse erosion. Willows were introduced to Australia were used extensively for watercourse erosion control. Unfortunately, willows have spread extensively in the Australian climate since they have few insect pests or diseases, have ability to spread by water and have little competition.

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 indigenous understory, which means there is little protection provided for native fauna. Willows shed few large branches, which are necessary habitat for fish. Willows are also deciduous, with the majority of leaves falling in autumn. This impacts on food for fish and water insects, depletes the water of oxygen throughout the year and reduces water quality.

- **Displacements of indigenous plants**

  Willows are able 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.

Staged or gradual removal of willows, in conjunction with revegetation using indigenous plants is the best option to maintain stream stability and improve environmental outcomes. Widespread, rapid removal of willows is not recommended since this can create more problems such as exposing watercourse banks leading to erosion. 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 regraded 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 – parrots 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 9. Myriophyllum aquaticum (parrots feather)
Photo courtesy A Cole

Figure 10. Eichhornia crassipes (water hyacinth) weed present in a farm dam

The control of weeds in farm dams can be difficult because often dams have multiple uses i.e. 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 the control options available. 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. 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 that matches 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 you observe the withholding period for the particular chemical and the regulations regarding chemical use in or near waterways.
- Biological control – uses the natural enemies of the problem weed. It is a non-polluting and usually self-sustaining form of control; however a large amount of research is required to ensure that the biological control agent does not attack crops or native plants.

Dams and Bores

Regulations

The Natural Resource Management Act 2004 provides for the control of various activities that affect water, including farm dams (please refer to the Watercourse regulation section of this chapter).

The construction of a dam, enlargement or modification of an existing dam requires the landholder to apply for one of two authorisations depending on the size of your dam. Below are the requirements which determine the authorisation you require:

- Dam construction, enlargement or modifications to a volume of 5000 kilolitres (<5 megalitres) or less, and/or with walls of three metres or less above the natural ground surface can only be undertaken with a Water Affecting Activity (WAA) permit. For permit applications forms landholders should contact their local NRM Board or The Department of Water Land and Biodiversity Conservation (DWLBC).
- Across the State, dam construction, enlargement or modifications of a volume greater than 5000 kilolitres (>5 megalitres) and/or with walls greater than three metres above the natural ground surface can only be undertaken with development approval. To seek development approval, landholders must contact their Local Council.
- If the property is located within the Hills Face Zone (from Sellicks Beach in the south to Gawler in the north), a development application will need to be lodged with the Local Council.

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

Construction

A good farm dam is a valuable asset 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 to provide enough water for your farming operations at an economical cost.

Size

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

Evaporation losses must be taken into consideration. A shallow storage (i.e. less than four meters deep), will suffer larger evaporation losses than a deeper one with a similar volume. Please refer to the last section of this chapter “How much water is needed?” for guidelines on livestock and horticulture needs.

Location

Once you have determined the storage capacity required for your dam, the next step is to find a site that can successfully collect and hold that required volume of water. The location of your dam will greatly depend on your 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.

There are a number of factors that you should consider when determining your dam location, including:

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

The catchment of your dam is defined as the area that collects rainfall run-off and directs it to the dam. This catchment area can be natural, like paddocks or artificial, like roads and roofs. The amount of run-off that a dam receives from the catchment is dependant on several factors, including:

- Rainfall intensity.
- Slope of the catchment.
- Groundcover – pasture vs. vegetative areas.
- Soil type.

To estimate the annual yield of your catchment is somewhat imprecise, but a useful rule of thumb is that approximately 10 to 15% of the rain that falls is natural runoff which can be captured in dams. The total water stored on a property cannot exceed 50% of the total runoff for that property.

Below is an example of how to calculate your dam volume entitlement in the Adelaide & Mount Lofty Ranges Natural Resources Management Board region for stock and domestic purposes:

Average annual rainfall	= 800 mm
Depth of runoff	= 80 mm (assuming runoff is 10% of rainfall)
Area of property	= 20 ha
Volume of runoff (cubic metres)	= Catchment area (square metres) × Runoff from catchment (metres)
	= 20 ha x 80 mm
	= 200 000 m2 x 0.08 metres
	= 16 000 m3
Converting to megalitres	= 16 000 m3 / 1000 litres
	= 16 megalitres

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

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

Average annual rainfall	= 500 mm
Depth of runoff	= 50 mm (assuming runoff is 10% of rainfall)
Runoff per hectare (m3)	= 1 hectare (10 000 m2) x 50 mm / 1000
	= 500 m3

So total runoff is 500 000 litres (i.e. 500 m3 x 1000) = 0.5 megalitres
If a four megalitre dam is required a catchment of eight hectares would be needed.

Note

1 cubic metre = 1000 litres 1 000 000 litres = 1 megalitre 1 ha = 10 000 m2

Figure 11. Calculating dam volume entitlement

If small flows consistently travel down the spillway (tickle flows) in the winter or spring months the vegetative cover on the spillway will be modified. Vegetative loss and soil erosion may well 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.

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. In the Mount Lofty Ranges the hydrology of the area has been drastically altered due to the high level of dam construction. One of the primary impacts of dam construction is the change in flow regimes resulting in watercourses not flowing until each and 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.

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 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 overtop and the overflow will flow 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. To assist with the construction of a low flow by pass contact your local Natural Resources Management Centre.

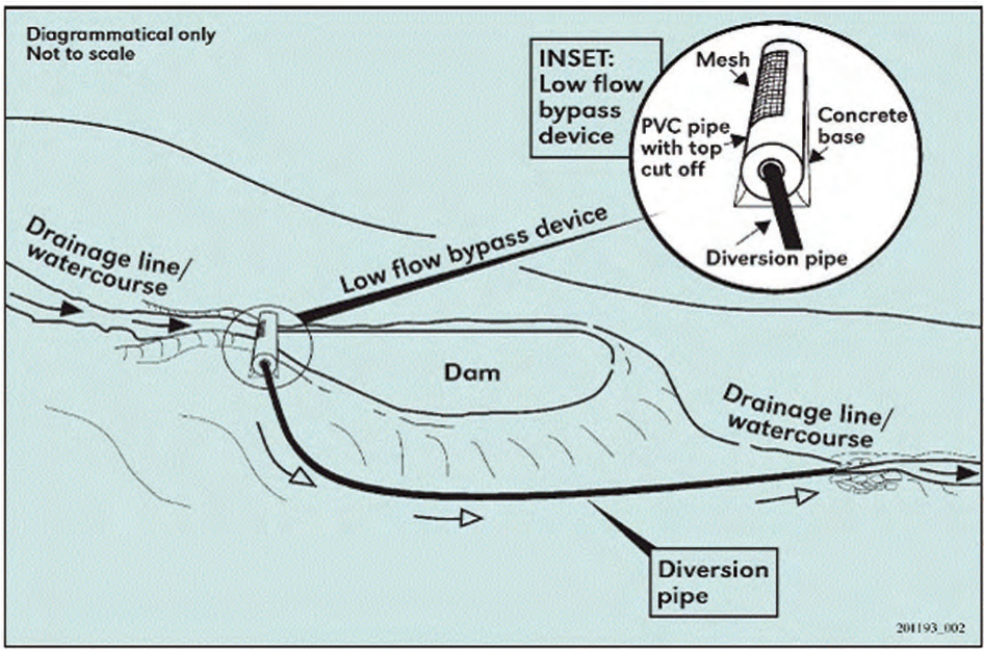


Figure 12. Low flow bypass (Courtesy of the Department of Water Land and Biodiversity Conservation)

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 excellent wildlife habitat. When fencing off a farm dam it is important not to prevent 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 it will also ensure that your dam capacity is maintained. It is recommended that your silt trap would 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, you can establish vegetation around the dam. This will have numerous benefits aside 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. Mat-forming grasses (i.e. kikuyu) 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 can cause cracks, leaks and ultimately will cause the dam wall to collapse.**

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 right 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 and is consequently a major cause for dam wall leakage. However, if you already have a large tree (or trees) on the wall, you will do more damage by removing them than leaving them alone. You are also subject to laws regarding the removal of significant trees.

Figure 13. Seepage through the dam wall creates erosion
Photo courtesy A Cole

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.

Figure 14. A correctly constructed spillway
Photo courtesy A Cole

Salinity

The quality of water can restrict its use for farm enterprises. Whilst livestock are fairly tolerant of moderately saline water, production from horticultural crops and pastures can be severely affected. See Table 2 for the upper salinity levels tolerated by a variety of usages.

Table 2. Recommended upper salinity levels for a range of different farm activities.
(Reproduced from "So You Thought Owning a Small Farm or Property Was Easy" Fontana and Williamson).

Usage	Upper Salinity (ppm or mg/L)
Crops & Pastures	
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
Flowers and Shrubs	
Violets	300
Aster, azalea, begonia, camellia, dahlia	700
Fuchsia, gladiolus, poinsettia, rose, zinnia	1 000
Chrysanthemum, oleander, stock	1 350
Fruit	
Avocado, strawberry, walnut	700
Apple, almond, apricot, grapefruit, lemon, orange	1 000
Peach, pear, plum, olive, raspberry, fig, grape	1 350
Lawn Grasses	
Fescue, ryegrass	1 200
Santa Anna couch	5 000
Kikuyu	25 000
Vegetables	
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
Livestock	
Poultry	3 500
Pigs	4 000
Horses	7 000
Dairy cattle	6 000
Beef cattle	10 000
Sheep	13 000
Human consumption	1 500
Sea water	30 000

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 15). Excess algae growth often results from a combination of excess nutrients and sunlight. Algae in the water may block pump filters, create odours and bad tasting water, and 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 16).
- 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 water primrose, giant waterlily, swamp lily and tall spike rush, and phragmites and bulrush.

Figure 15. A severe blue-green algae bloom

Figure 16. Native vegetation planted around a dam's edge

How much water is needed?

Domestic requirements

Table 3. Average daily domestic water requirements

Type of Use	Average Daily Requirement (litres)
Household with septic system	180 per person
Household without septic system	135 per person
Home Garden	3000 per 0.1 ha (for summer months only)

Livestock needs

Drinking water requirements for stock will vary according to the type of stock (Table 4), weather, quality and nature of food, water quality, 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 4. Annual Livestock Water Requirements
(Reproduced from "So You Thought Owning a Small Farm or Property Was Easy?" Fontana and Williamson)

Type of Stock	Annual Requirements (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

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:

- Installation of the most efficient irrigation system for the type of enterprise
- The use of mulch and/or ground covers (fig 17.)
- 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

Figure 17. Use of mulch in orchards

Further details can be obtained from PIRSA Water Budgeting Guideline fact sheets available at www.pir.sa.gov.au/factsheets.

Case Study: Water Resources and Requirements on a Small Property (Mt Barker)

Average Annual Rainfall: 772 mm. Property Size: 11 acres (4.4 ha)

Livestock Needs

Maximum livestock carrying capacity for the property = 14 wethers

Water requirements on dry feed/sheep = 3600 L per annum
Water requirements on green feed/sheep = 2700 L per annum

14 Animals on dry feed for six months = 1800 L × 14 = 25 200 L (4200 L per month)
14 Animals on green feed for six months = 1350 L × 14 = 18 900 L (3150 L per month)
Total **= 44 100 L per year needed from dam**

Domestic Requirements

Assume four people plus septic system
180L per person per day × 4 = 720 L per day
Total **= 720 L × 365 = 262 800 L per year from rainwater**

Garden/Orchard Requirements

Assume an area of 1500 m2 (0.15 ha) irrigating at 1.5 ML per ha (of 1 500 000 L)
0.15 × 1 500 000 L = 225 000 L
Total **= 225 000 L per year needed from dam**

Total Requirements

Domestic (rainfall) = 262 800 L
Orchard and Livestock (dam) = 225 000 + 44 100 = 306 900 L
Total **= 569 700 L**

Water Resources

Dam size is 2.5 ML (2 500 000 L)
Collection off roof areas (every mm of rain falling on each square metre produces 1 L of water):

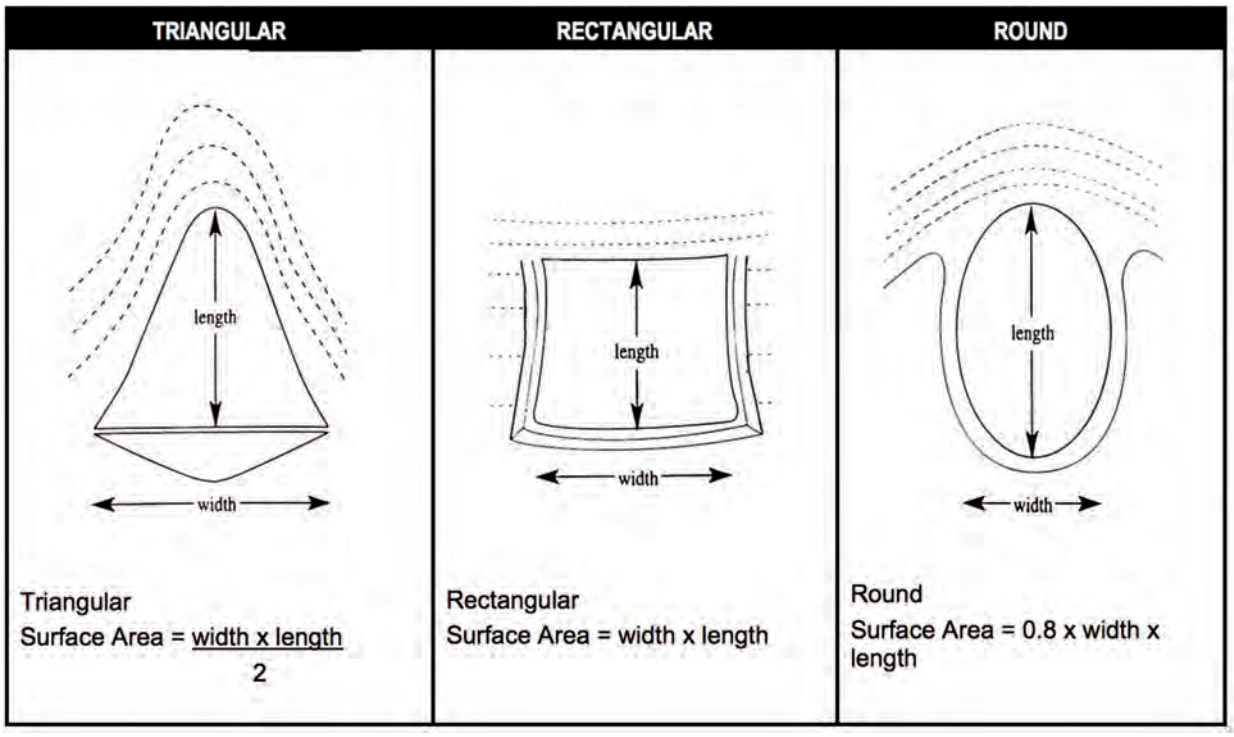
Months	Rainfall (mm)	House roof collection (L) 22mX16m	Shed roof collection (L) 15mx6m	Domestic Use (L)	Livestock Needs (14sheep)
J	28	9 504	2 430	21 900	4 200
F	26	9 152	2 340	21 900	4 200
M	32	11 264	2 880	21 900	4 200
A	61	21 472	5 490	21 900	4 200
M	90	31 680	8 100	21 900	3 150
J	100	35 200	9 000	21 900	3 150
J	106	37 312	9 540	21 900	3 150
A	103	36 256	9 270	21 900	3 150
S	85	29 920	7 650	21 900	3 150
O	68	23 936	6 120	21 900	3 150
N	40	14 080	3 600	21 900	4 200
D	34	11 968	3 060	21 900	4 200
Total	**772**	**271 744**	**69 480**	**262 800**	**44100**

Conclusion

The landholder can collect a total of 341 224 L 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, garden/orchard and domestic needs.

Calculating the volume of a farm dam

To calculate the volume of a farm dam you will need to measure the surface area **(A)** and the maximum depth **(D)** of the dam in metres. To calculate the surface area **(A)** of your dam you will need to decide the shape of the dam from the options below.



Step 1
Decide the shape of the dam from the options above.

Step 2
Measure the relevant width and length at **top water level** (TWL) and enter those on the Recording Sheet (see overleaf).

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 *Volume = 0.4 x Surface Area x 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 1000 to convert cubic metres to megalitres and enter on the Recording Sheet.

This is the Dam Capacity in megalitres (ML)

Width (m)
Length (m)
Depth (m)
Surface Area (SA)
Volume (cubic metres)
Volume (megalitres)

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Native Vegetation and Biodiversity

Purpose of Conserving Remnant Native Vegetation and Revegetating

Biodiversity and Habitats

Biodiversity is the term used to encompass the diversity of genes, species (plants, animals and micro-organisms) and ecosystems. At the property scale, landholders can conserve biodiversity through the management of native vegetation.

Native vegetation has been extensively cleared in the Adelaide and Mt Lofty Ranges region, with most of the remaining vegetation on hilltops, steep slopes, roadsides and watercourses. Consequentially, these plant communities generally grow on non-arable land, with few good examples from productive soils. 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. Consequentially, many of the region's fauna are now extinct or rare. Protecting and restoring native vegetation is essential for the long term survival of remaining species.

If conserving biodiversity is one of your goals, use the following priorities to help you to decide where to start:

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 boundary fences will effectively exclude stock from neighbouring properties.
- Control feral animals such as rabbits, foxes, cats and deer.
- Consider if and how you will need to protect it from over-abundant native grazing animals (kangaroos).
- Control weeds using the following principles:
  - > Accurate plant identification 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. High threat bushland weeds in the Adelaide & Mount Lofty Ranges Region (Croft et al. 2005)

Bridal Creeper and Bridal Veil	Bulbil Watsonia
Blackberry	Boneseed
English Ivy and Cape Ivy	Cape/Montpellier and English Broom
Periwinkle	Erica
Monadenia (African Weed Orchid)	Gorse
Olive	

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 the areas which are most likely to regenerate is further explained on page 70.

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 to represent the original vegetation association.

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 (eg dragonflies) and yabbies that rely on watercourses.

The width of the watercourse protected and vegetated (the 'buffer) determines the effectiveness of the work. Some guidelines are provided on page 68. However, site constraints and funding requirements will also need to be considered.

For more information see: Staton, J. & O'Sullivan, J. (2006) Stock and Waterways: a Manager's Guide, Land & Water Australia, Canberra.

Tackling Land Degradation

Mass Erosion

Revegetation can fulfil an important role in reducing mass erosion, but it is important to understand that it has limitations as well. Seeking expert advice and fencing the area off to exclude stock are the first steps to reduce 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 using excess soil moisture that would otherwise cause saline groundwater to rise.

Waterlogging

Widely spaced trees can be used to dry out mildly waterlogged soils as well as providing shade. Moderately to very waterlogging prone soils were likely to have been swamps in the past. Swamps are important habitat for many species and are protected on the Fleurieu Peninsula, therefore they are best managed as conservation areas.

Figure 1. Mass erosion at Upper Hermatage.
Photo courtesy Adelaide & Mount Lofty Natural Resources Mangement Board

Wind Erosion

Windbreaks can be planted in areas where soil types 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.

Figure 2. Wind erosion in Strathalbyn.
Photo courtesy Adelaide & Mount Lofty Ranges Natural Resources Management Board

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 adequate to provide shade for all stock.

Figure 3. Shade will be appreciated by your stock

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 SA, remnant native vegetation is protected from being cut down, however 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 not cut down 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 off-set carbon emissions and there are 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, so if you are considering such a scheme, it is worth investigating 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.

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, who would be happy to provide advice on the most suitable species for your area.

Figure 4. An arid land native garden.
Photo courtesy Adelaide & Mount Lofty Ranges Natural Resources Management Board

Recognise Remnant Areas

What is Remnant Vegetation?

While most people would tend to think of remnant native vegetation as relatively intact blocks of native vegetation 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 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	Similar looking introduced species
Kangaroo Thorn *(Acacia paradoxa)*	Gorse *(Ulex europaeus)*
Large-leaf Bush Pea *(Pultenaea daphnoides)*	Montpellier Broom *(Genista monspessulana)*
Old Man's Beard *(Clematis microphylla)*	Bridal Creeper *(Myrsiphyllum asparagoides)*
Wallaby Grasses *(Austrodanthonia spp.)*	Pussy Tail *(Pentaschistis pallida)*
Sea Rush *(Juncus kraussii)*	Spiny Rush (Juncus acutus)
Native Cherry *(Exocarpus cupressiformis)* and Southern Cypress Pine *(Callitris gracilis)*	Conifers

Many plants from other regions and States have also naturalised in the Adelaide & Mount Lofty Natural Resources Management region and are considered bushland weeds, such as:

- Several wattles including Cootamundra Wattle *(Acacia baileyana),* Western Coast Wattle *(A. cyclops)* and Early Black Wattle *(A. decurrens).*
- 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 any management techniques to adopt. Features of good quality remnant vegetation include:

- High number of different native plant species
- Low cover and threat from weeds
- Minimal bare ground
- A range of different plant life forms
- Natural regeneration
- Healthy trees, with large, hollow-bearing trees and fallen logs present in the site
- Few feral animals
- Low grazing pressure
- High numbers of different native fauna species
- Large size, square or round shape, with other remnants near-by

For more information see: Croft, SJ, Pedlar, JA & Milne, TI (2005) *Bushland Condition Monitoring Manual – Southern Mount Lofty Ranges*, Nature Conservation Society of South Australia.

Regulations

The following two Acts are the main Acts relating to native vegetation and biodiversity. However, other Acts may also apply, in particular the Development Act.

Native Vegetation Act 1999

Remnant native vegetation is protected from clearance under this South Australian Act. Strict exemptions exist for certain situations such as for maintaining roadsides, fencelines, firebreaks and developments. For more information see
www.dwlbc.sa.gov.au/native/nvsa/index

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. Three ecological communities that occur in the Adelaide and Mount Lofty Ranges region are protected under this act:

- Fleurieu Peninsula Swamps.
- Peppermint Box *(Eucalyptus odorata)* grassy woodland.
- Iron-grass Natural Temperate Grassland.

For more information see: www.environment.gov.au/epbc/index

Where to Undertake Revegetation

Where revegetation works should be established, and how they are designed, depends on the purpose for which it is 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 select a layout that minimises the amount of fencing and results in multiple benefits. For example, a biodiversity corridor can also act as a shelterbelt. It may seem extreme, but turning an entire paddock into native vegetation may be more beneficial and less costly than having little bits 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	Adjacent to existing remnants in order to buffer them, increase their size and encourage natural regeneration. Connecting corridors between remnants, (wider and shorter corridors are better than long thin ones). Large blocks (bigger is better), try coordinating with neighbouring properties. Incorporate existing habitats such as standing and dead trees, rocky outcrops and watercourses.	High diversity of species (30 plus). Species replicate the original vegetation association for the site. More ground-layer than middle layer than over-storey. Create dense and open areas.
Improving Water Quality	At least 5m either side of a minor watercourse and 20 m or more each side of a major watercourse. The wider the buffer, the less likely the fence may be damaged during floods, and the better habitat will be provided.	Plant different species on the toe, middle and upper banks and floodplain based on their water requirements.
Landslip Control	Revegetate above, on and below the landslip.	Deep-rooted trees and shrubs.
Gully, Tunnel and Watercourse Erosion Control	Fencing the areas off and planting sedges, small shrubs, and grasses may be of assistance. Revegetation with a mix of species above the eroding area may help to reduce the flow of surface and subsoil moisture to the eroding area. Have the site assessed by an expert to determine if revegetation will be of further assistance.	Do not plant trees on the erosion site. Seek expert advice.
Salinity Mitigation	Revegetate recharge areas in the catchment. Fence off and revegetate salt affected areas.	Select salt tolerant native species for salt affected areas.
Windbreaks and Shelterbelts	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. Protection is provided for a distance 12–15 times the height of the windbreak.	Minimum three rows (10m) wide. Plant the tallest species in the centre row.
Waterlogging	Mildly waterlogging prone soils. Plant in rows to make working the paddock easier.	Plant waterlogging tolerant trees 20–30 m apart. Use sturdy, stock proof guards.
Shade	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.	If planting a single row, space trees 5–10 m apart. If scattered, minimum 30m apart.
Buffers and Screens	Dependent on what is being buffered or screened.	As for windbreaks and shelterbelts.
Timber – small scale	Most locations are suitable. Plant either blocks or in rows along fencelines.	Plant single species blocks. Close spacings (2–5 m).
Timber – commercial scale	Seek advice. Sites need to be large enough to be commercially viable, and should not be too steep for harvesting operations.	Select species dependent on the desired product. Pruning or thinning may be required

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 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, therefore use tubestock planting or hand direct seeding to establish middle and ground-layer species.
- **Weeds** – some weeds such as 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 monitoring..
- **Power lines** – ETSA has strict guidelines about what can or can not be planted underneath powerlines, and they can, (and have), removed unsuitable revegetation.
- **Other utilities** – such as Telstra and SA Water also have guidelines. Knowing where these utilities are located is essential for your site assessment.
- **Native grasses and herbs** – areas dominated by native grasses, herbs, lilies and other ground layer species should be avoided when doing weed control and should generally not be planted into. Assess the site in October-November to identify the presence of such species.
- **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 planted.

Weed Control

Existing pasture as well as grassy and herbaceous weeds will compete with revegetation for moisture and light and therefore should be controlled before planting. These weeds should be monitored for one or two years after planting. Each planted seedling should have a weed free area 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 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 the grasses have a lot of dead matter, control will be more effective if the grass is slashed or grazed first and the re-growth sprayed. Herbicides are often applied once or twice before planting, and again once or twice afterwards.

Non-herbicide methods of weed control include physical removal by hand-pulling or scalping (with the flat side of a mattock), using a flame thrower, or mulching. Commercial mat products are available but are expensive for large sites.

For more information see Chapter 5, Environmental Weeds.

Fencing

Revegetation areas should not be grazed and therefore usually require fencing. The type of fencing used will depend on the type of stock. 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, more than one gate may be required for access.

There should be a gap of at least two metres between the edge of the revegetation and the fenceline so that the revegetation area can be accessed for maintenance work such as weed control. The gap may require slashing to control weeds.

Fire Breaks

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

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 food and habitat suitable for native birds and animals.

Seed and cutting material should also be collected from as near-by to the site as is feasible to take advantage of, and protect, local plant genetics. This is commonly referred to as 'local provenance seed.' Where the amount of seed available in the local area is inadequate, a purpose-designed seed-orchard may be required.

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, soil type, paddock trees and remnant roadside vegetation. The nearest intact remnant vegetation does not always represent what would have grown on your site since it was probably left because it was on a less productive soil type. Remember that some vegetation communities consist or exist as grasslands. Ensure that these low existing vegetation communities are not altered by plant overstory species.

Visiting a good remnant example of the vegetation community natural to your site may help you plan your revegetation species list and planting design. In particular take note of:

- **The density and diversity of trees** – pace out the distance between trees to give yourself 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). The diversity of tree species is low, often only one.
- **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 are often in dense clumps with open spaces between rather than uniformly distributed.
- **The range of ground layer species.**

The diversity and abundance of species in a typical vegetation community is highest in the ground layer and decreases towards the canopy. Unfortunately, only a few ground layer species are available for revegetation in relatively small numbers, however they should still be included in revegetation and can reproduce quickly.

High numbers of fast growing, 'coloniser' species (predominantly Wattles *(Acacia spp.)*) should be used for weedy sites as they can out-compete grassy and herbaceous weeds. Some species of wattles may die-out over time, so ensure there are other, longer-lived species to take their place.

Revegetation Species

Revegetation lists are provided for different parts of the region by Trees for Life and in *What Seed is That?* (Bonney 2005, see reference list). These lists are for broad areas and any single site would only use a sub-set of the tree and shrub species. The lists contain few ground layer species however so seek out advice on what other ground layer species should be included, but be aware that not all species can be propagated.

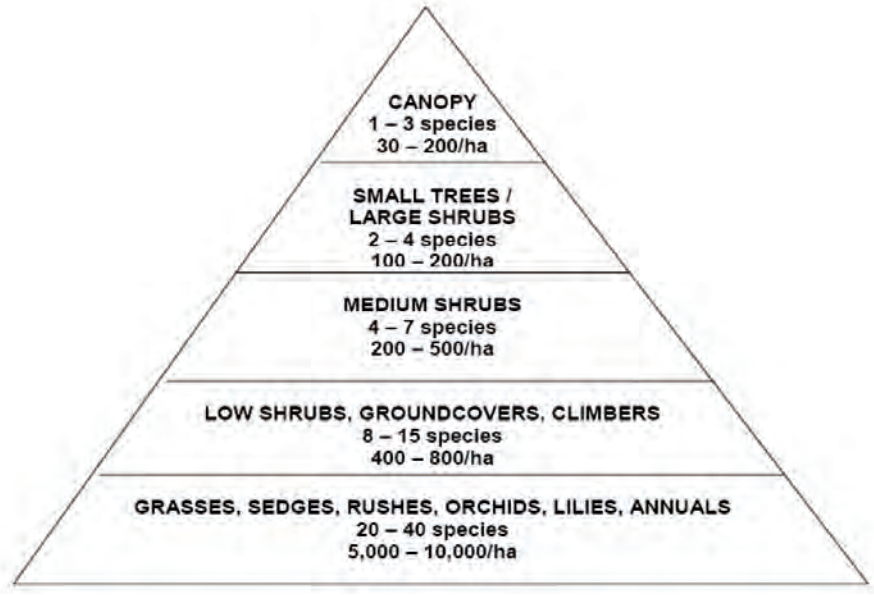


Figure 5. The number of species and abundance of plants in different canopy layers of a typical natural vegetation community

Revegetation Techniques

Natural Regeneration

For an area to regenerate, seeds or bulbs must be either existing as soil seed reserves or be available from nearby existing remnant vegetation. Therefore, the least agriculturally productive land will usually regenerate most readily because it has undergone less modification and usually contains some remnant vegetation. Areas that have been cropped or had an introduced pasture sown will regenerate more slowly and require active assistance by using one of the methods below.

Regeneration areas should be monitored for the first few years, photo-points may be of use, as will keeping notes on what is present and in what abundance. After a few years of regeneration, 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.

Machine Direct Seeding

A specialised machine is used to sow a mixture of native seed straight into the ground. Site preparation including good weed control and monitoring for insect pests can increase the effectiveness of this method. 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. It 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. Up to 1.5 kg of seed per hectare is required depending upon the area to be seeded.

Figure 6. A direct seeding machine in action

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 rake a small area with a rake or hoe, scatter seed and cover. Large seed should not be visible, and fine seed should be sprinkled on top. Mixing a quick-growing hard coat seed *(Dodonaea, Acacia)* with finer seed *(Eucalyptus, Leptospermum)* 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 this way.

Tubestock Planting

Tubestock planting is 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 six months to grow to planting size or are propagated from cuttings. Specialised planters are available for each: 'pottiputkis' for cells, and Hamilton Tree Planters for tubes. Specialised mechanical augers are also available. Mattocks are the best 'garden' equipment to use, and spades are the most laborious.

Figure 7. Hamilton tree planters with round or square ends for different shaped seedling tubes

Figure 8. A Pottiputki planter for planting seedlings grown in cells, with a "kidney tray" on the ground used for carrying seedlings

You can grow your own tubestock or order them from a nursery that grows local native species. Most species need be six months old before they can be planted out, while some may be up to 18 months. Therefore you will need to order or sow seedlings well in advance of the planting time. Buying seedlings off the shelf is the most expensive option.

Tubestock are usually established at densities of 1000 seedlings per hectare, however, for sites with a lot of perennial grassy weeds, much higher densities of Wattles *(Acacias)* can be used 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, lower densities 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 very well. 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 (left) and three years on (right), showing how irregular plant spacings can be used to replicate natural density variation

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. Other ways to increase the variation of density with machine direct seeding are:

- lift the seeder at random intervals to create gaps
- include plenty of ground cover species in the seed mix
- criss-cross the seeding lines, or for easier site maintenance have wavering lines
- plant tubestock of species not available in direct seeding between the lines.

Except for trees, where only a small number of one species is available, it is better to put them all close together, or in two or three clumps, rather than spreading them across the site. This way they are more likely to cross-pollinate and reproduce.

Timing

The best time to plant depends on the season, but the table below provides a rough guide for different areas. Generally speaking, drier sites should be planted earlier than wetter sites, and planting should be done early in low rainfall seasons and later in high rainfall seasons. The planting time should always allow for a germination and subsequent control of weeds.

Site Conditions	When to Plant
Low rainfall (Adelaide Plains)	Mid-June to end of July
High rainfall (Adelaide Hills), well drained soil type	Mid-July to end of August
High rainfall, waterlogging prone soil	Mid-August to mid-September

Protection for Seedlings

Red Legged Earth Mites

As with germinating pastures and crops, direct seeded revegetation is highly susceptible to damage from red legged earth mites. Insecticides are the most common form of control. Insecticide use may be minimized by utilizing the 'time rite' system for RLEM control in the year prior to revegetation (refer to the Pasture Management Chapter).

Rabbits, Hares and Kangaroos

Tree guards may be necessary if you have high numbers of rabbits, hares, deer or kangaroos, however, controlling the animals themselves is usually more economical than guarding individual plants. If guards are necessary, consider if 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
- Groundcovers 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 has plenty of air-flow (to prevent humidity and fungi). Milk cartons make good guards in most situations for their price 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 consider if it is really necessary.

On-going Management of Remnant Vegetation and Revegetation

Weed Control

Weeds require on-going 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 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 being grazed, such as introduced annual and perennial grasses. These are not always necessary to control unless they pose a fire hazard, in which case slashing can be used. Instead, develop and implement a weed management plan that focuses on controlling weeds in the best bits of bush first, and removing high-threat weeds. Always use minimal disturbance methods in remnant and established revegetation areas.

Animal Control

Monitor for, 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 machine direct seeding. 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.

References

The following are useful references that can be applied to the entire region. Many organisations and individuals have also prepared localised guidelines and planting lists for their area. Visit or contact your local Natural Resources Centre to find out what information is available for your area.

Bonney, N. (2003) *What seed is that?* Revised Edition, Neville Bonney, Tantanoola, SA.

Croft, SJ, Pedlar, JA & Milne, TI (2005) *Bushland Condition Monitoring Manual – Southern Mount Lofty Ranges,* Nature Conservation Society of South Australia

Dashorst, G.R.M. & Jessop, J. P. (1998) *Plants of the Adelaide Plains & Hills,* Second Edition, State Herbarium of South Australia

Gibbs, J. (2005) *Grass Identification Manual – for Everyone,* 2nd Edition, Native Grass Resources Group Inc., South Australia.

Platt, S.J. (2002) *How to Plan Wildlife Landscapes; a Guide for Community Organisations*, Department of Natural Resources and Environment, Victoria (available on-line).

Prescott, A. (1988) *It's Blue with Five Petals – Wildflowers of the Adelaide Region,* A. Prescott (out of print).

Robertson, M. (2005) *Stop Bushland Weeds: A Guide to Successful Weeding in South Australia's Bushland,* 2nd Edition, The Nature Conservation Society of South Australia Inc.

Bushfire prevention

Living in a bush setting is a lifestyle choice for many South Australians. The benefits are enormous, but the risks are 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.

More detailed information can be found on the CFS website www.cfs.org.au or by contacting your 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;
- to provide for the prevention, control and suppression of fires
- to handle certain emergency situations

Key points

1) Landowners are obliged to manage fuel levels on their properties. This does not mean bare paddocks, but grasses reduced to 10cm in height where required.

2) If an authorized 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 authorized 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. In South Eastern Australia we have experienced several such events including the Victorian Black Saturday bushfires in February 2009.

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

Figure 1. A scrub fire at Morialta 2007.
Picture courtesy of CFS

To help you assess your level of bushfire risk, it is important that you understand the Fire Danger Rating. 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.

Table 1. Fire Danger Rating

Fire Danger Rating	Recommended Action and potential Fire Behaviour and Impact
CATASTROPHIC FDI 100+	ACTION: For your survival, leaving early is the best option. • Fires will be uncontrollable, unpredictable and fast moving. Flames will be higher than roof tops. Thousands of embers will be blown around. Spot fires will move quickly and come from many directions, up to 20 km ahead of the fire. • There is a very high likelihood that people in the path of the fire will die or be injured. Thousands of homes and businesses will be destroyed. • House construction standards do not go beyond a Fire Danger Index of 100. • Well prepared, constructed and actively defended homes may not be safe during a fire, • Do not expect a fire truck
EXTREME FDI 75 – 99	ACTION: Leaving early is the safest option for your survival. • Fires will be uncontrollable, unpredictable and fast moving. Flames will be higher than roof tops. Thousands of embers will be blown around. Spot fires will move quickly and come from many directions, up to 6km ahead of the fire. • There is a likelihood that people in the path of the fire will die or be injured. Hundreds of homes will be destroyed. • Only well prepared, well constructed and actively defended houses are likely to offer safety during a fire. • Do not expect a fire truck
SEVERE FDI 50 – 74	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. • Fires will be uncontrollable and move quickly. Flames may be higher than roof tops. Expect embers to be blown around. Spot fires may occur up to 4 km ahead of the fire. • There is a chance people may die or be injured. Some homes and businesses will be destroyed. • Well prepared and actively defended houses can offer safety during a fire. • Do not expect a fire truck
VERY HIGH FDI 25 – 49	ACTION: Only stay if you and your home are well prepared and you can actively defend it. • Fires can be difficult to control. Flames may burn into the tree tops. Expect embers to be blown ahead of the fire. Spot fires may occur up to 2 km ahead of the fire. • There is a low chance people may die or be injured, some homes and businesses may be damaged or destroyed. • Well prepared and actively defended houses can offer safety during a fire.
HIGH FDI 12 – 24	ACTION: Know where to get more information and monitor the situation for any changes. • Fires can be controlled, Expect embers to be blown ahead of the fire. Spot fires can occur close to the main fire. • Loss of life Is highly unlikely and damage to property will be limited. • Well prepared and actively defended houses can offer safety during a fire.
FDI 0 – 11	ACTION: Know where to get more information and monitor the situation for any changes. • Fires can be easily controlled. • Little to no risk of life and property.

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 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 actively defend your home, or leave early' well before a fire starts, is critical and it needs to be made before a bushfire occurs and well before the fire danger season arrives.

If you plan to actively '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 for up to ten hours or more?
- Are you mentally and emotionally prepared to actively defend your property?
- Are you able to implement your plan while caring for distressed young children, 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 defendable space of at least 20m 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, the preparedness of your property, or 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.

On the website link reference below are two checklists which will help you prepare a Bushfire Survival Plan, so that you are Bushfire Ready.

Everyone's Bushfire Survival Plan will be different depending upon their individual situation.

Once you have completed your plan, practice it regularly and keep it in a safe and easily accessible place for quick reference (e.g. on the fridge.)

http://www.cfs.sa.gov.au/site/home.jsp

Seasonal checklist

Winter

- ☐ 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, eg check roof space for loose tiles and gaps and repair as necessary.

Spring

- ☐ Slash or mow long grass and remove cut material (unless it can 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.
- ☐ Review and update your Bushfire Survival Plan.

Summer

- ☐ Maintain a 20 m fuel reduction zone around your home (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.
- ☐ Prepare a relocation kit.
- ☐ Ensure you have a portable battery-powered radio to hear bushfire warnings.
- ☐ Monitor Fire Danger Ratings, Total Fire Bans and fire restrictions.

Autumn

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

Figure 2. Scrub Fire at Bridgewater 2007.
Photo Courtesy of CFS

Bushfire Watch & Act and Emergency messages

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 Watch & Act and Emergency Warning system has been developed to alert the community to bushfires and provide advice on what to do during a bushfire.

Fire can threaten suddenly and without warning so you should always be ready to act.

The CFS will provide as much information as possible to help you make an informed decision however you may not always receive an official warning directly.

Monitor the CFS website www.cfs.sa.gov.au and your local ABC Radio station or FIVEaa on a battery powered radio. It is recommended you do not rely on a single source for emergency information.

There are three levels of messages that can be issued during a bushfire on radio and the CFS website. You need to understand the different messages and what they mean for you. These messages will alert you to danger so that you can take action.

However, if you are in a bushfire prone area it is important that you remain vigilant during the summer and do not rely solely on these messages as there is no guarantee you will receive one in time. A bushfire may impact upon you more quickly than CFS is able to respond.

The three levels of messages are:

Emergency Warning - Bushfire Emergency Warning message.

- An Emergency Warning message is the highest level of message. The message tells you that you will be impacted by fire and you need to take action immediately. This message will be preceded by an emergency warning signal (a siren sound) to get your attention. The message will also contain information about the severity of the fire, time to impact and what you should do.

Watch and Act - Bushfire Watch and Act message.

- A Watch and Act message alerts you that a fire is approaching, conditions are changing, and that your life may come under threat. You need to act now to prepare for the approaching fire front and protect yourself and your family.

Advice - Bushfire Advice message.

A fire has started. There is no immediate danger. This is general information to keep you up to date with developments. A fire may pose no threat to life or property because:

- It is a small, controllable fire
- It is a fuel reduction burn being conducted by fire agencies
- It is a fire burning in a remote area away from people, homes or structures.

You should take all of these messages seriously and consider the information carefully.

Property protection

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

There are various ways in which a house can ignite during a bushfire – radiant heat ahead of the fire front, burning debris falling on the building and direct flame contact. Research has shown that the biggest cause, however, is sparks and embers that can trigger a fire before, and hours after the bushfire have 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 (ie. 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 four metres wide with vertical clearance of four metres also. 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 metre Defendable space around your house by minimising the amount of fuel close to the house. This will prevent fires from burning close to the house and minimize 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:

1) Landowners need to take precautions to ensure that every item of equipment on their farm, which 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.

2) Always carry a full knapsack or water extinguisher, and rake or shovel on the machine when it is in the field. This is mandatory when harvesting a flammable crop, spreading lime or fertilizer 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 and
- 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 courtesty AMLRNRMB

Bushfire restrictions

Fire danger seasons change from season to season. Visit the website listed below for current dates.
http://www.cfs.sa.gov.au/site/fire_restrictions/fire_danger_season_dates_200809.jsp

Permits

To apply for a permit to light a fire, contact your local Council to find your nearest Authorised Officer. The Authorised 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; and
- that adequate precautions will be taken to prevent the spread of fire.

Once satisfied the Authorised Officer will issue you a permit and inform you of 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.

Figure 4. CFS conducting a ‘burn off’ at Forest Range.
Photo Courtesy of CFS

Once satisfied the Authorised Officer will issue you a permit and inform you of 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 the Environment Protection Authority, (08) 8204 2004 or 1800 623 445 or www.epa.sa.gov.au

Contact

CFS bushfire hotline 1300 362 361 www.cfs.sa.gov.au

Further reading: Fire and Emergency Services Act 2005
http://www.legislation.sa.gov.au/lz/c/a/fire%20and%20emergency%20services%20act%202005/current/2005.40.un.pdf

References

Your Guide to Preparing for and Surviving the Bushfire Season

Bushfire Survivl Plan – Your personal guide to creating a Bushfire Survival Plan

CFS website.

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 managing animals for the first time make sure you have appropriate yards, watering points and fencing and seek sound advice from a reputable source. It is 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.

There are many publications and articles you can refer to for in-depth information on livestock management. This chapter will give you some of the key points to consider for the four main categories of livestock found in the Mount Lofty Ranges.

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

These are just a few Acts or Regulations directly referring to livestock. In South Australia alone, there are in excess of 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 three hecatares of land or where handfeeding a horse is involved. Council permission may be required in this situation.

Sheep Management for New Land Managers

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 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, 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. You should allow half a square metre per sheep and remember 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 remove 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. 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 that can get very muddy in wet seasons. Lining the soil with gravel will help keep them clean and lessen the chances of foot rot. Posts and strainers must be of sufficient strength to withstand stock leaning against the fence line.

Figure1. Ringlock electric fence.
Photo courtesy of A Cole

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 any sick animals.

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 with quality hay may be necessary. Avoid stress to the animals since this contributes significantly to the problem.

Figure 2. Photo from Vison SMgroup

Nutrition

Sheep are grazing animals that will eat a wide range of grasses and broad leaf 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 established.

Figure 3. Photo courtesy of A Cole

Table 1. Maintenance Hay Rations for Sheep with No Pasture Available (Reproduced from "Drought Feeding and Management of Sheep" PIRSA

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 wt. gaining 0.7 kg each week)	Ad lib	Feed as much as they want (usually 3 to 5 kg/week).

Health

Fly strike	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 can be treated with an insecticide after the area is cleaned.
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 worms so drenching in November/December is recommended. It is advisable to use two or three different 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.
Lice	Lice treatment is undertaken within 24 hours after 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 to name a few. Meat breeds include Border Leicester, Dorset, and Suffolk. 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, Damara's, 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 4.Merino

Figure 5.Corriedale

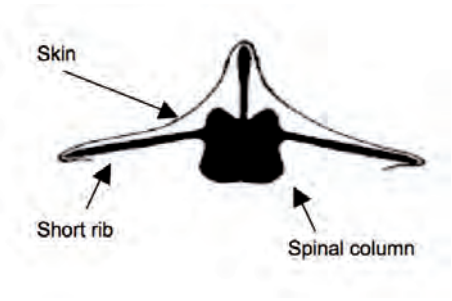
Figure 6. Wiltshire Horn.
Photos courtesy of Australian Meat & Livestock Corpration

Figure 7. Damara pers

Figure 8. Dorpa
Photos courtesy from Damara Sheep Breeders Society and Mayfield Dorpers.

Condition Scoring Sheep

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

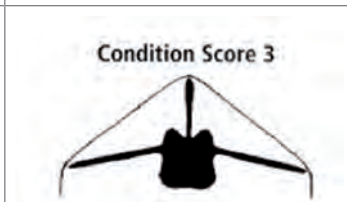
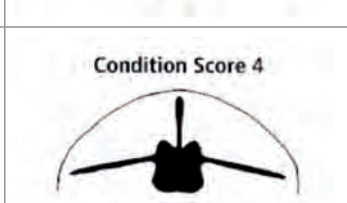
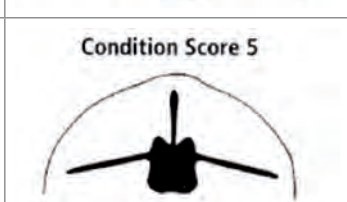


This diagram shows the spinal column of a sheep with the 'short ribs' extending from both sides and the skin stretched over. The degree of flesh between the skin and the short ribs is used to assess the health of the animal.

Figure 9. Photo courtesy of A Cole

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.

Table 2. Condition Scores (From Lifetime Wool)

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	

Cattle Management for New Land Managers

Cattle have always been one of the most popular livestock enterprises in the Mt. Lofty Ranges and if managed correctly they can be less demanding than sheep. However, they are large animals and inexperienced landholders should always handle them accordingly, so make sure that you have heavy duty yards with suitable crush and head bails.

Rotational grazing is a key strategy to manage pastures and control weeds, so establishing four to eight 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.

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 it is important that animals are not 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 you may have to supplementary feed with good quality grass/clover hay or other concentrates.

Table 3. 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 to 9 mths (175 kg liveweight)	3.5	4.0
Yearlings 10 to 12 mths (220 kg liveweight)	4.0	5.0
Stores (280 kg liveweight)	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 m 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 that can get very muddy in wet seasons. Lining the soil with gravel will help keep them clean and lessen the chances of foot rot. Posts and strainers must be off sufficient strength to withstand stock 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 10. Photo courtesy A Cole

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 nine months (282 days). Joining should occur in June – July for an autumn calving and pregnancy testing can be done after six weeks. In the last two 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 two hours of commencement or if there are any difficulties.

Health

Parasites	Worm treatments are available and are best used in February. Check on the condition of stock and watch for signs of scouring (diarrhoea) and wasting as these can be indicators of worm problems. If high worm egg counts are detected in the paddock be prepared to drench and move them on to a new area.
Bloat	Be aware that ruminant animals can suffer from bloat if they are suddenly moved to a lush clover or lucerne paddock. Veterinary support may be needed in acute cases.
Vaccinations	All adult cattle should be vaccinated annually with a five in one clostridial vaccine, whilst calves should be vaccinated at marking and again four to six weeks later.
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 it rotational grazing plus a selection of sheltered sites will help minimise any land degradation.

Figure 11. Photo courtesy Metroworld

Condition Scoring Cattle

Condition scoring of cattle is similar to sheep in that the amount of fat reserves around the short ribs is assessed. Fingers are places flat over the short ribs and the thumb 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 sheep can be used.

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

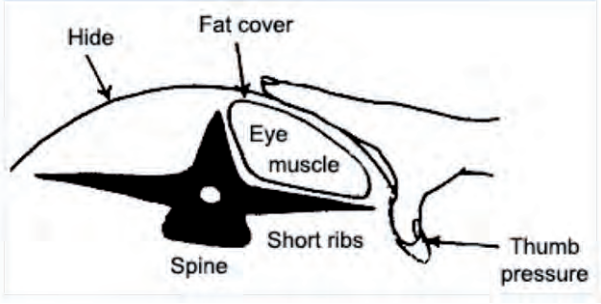


Figure 12. From 'Agriculture Notes', Victorian DPI, March 06

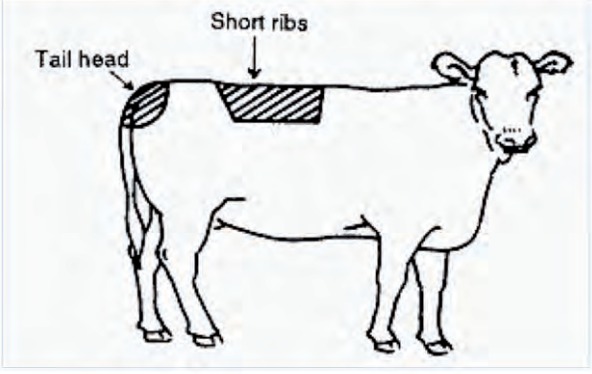


Figure 13. From 'Agriculture Notes', Victorian DPI, March 06

Heifer is score condition 2 | Heifer is score condition 3 | Cow in score condition 4.5

Figure 14. Coutesy Dairy Australia

Alpaca Management for New Land Managers

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.

Figure 15. Photo courtesy of Wintersun Alpacas

Terminology

Cria — From birth to weaning

Weaners — From weaning (approximately 4–5 months) to 12 months

Tuis — From 12 months 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 in preference to 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.

Figure 16. Photo courtesy of A Cole

When looking at pasture mixes, you should also remember that Alpacas are 'browsers' rather than 'grazers'. Consequently pasture mixes should be a variety of perennial and annual grasses high in fibre and low in protein. Protein levels should not form more than 16% for Cria's and 8–10% after weaning. Fibre should be between 25– 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 you 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 five litres per day for an adult and 10–12 litres per day in hot weather or when lactating. Hay has a much lower water content than pasture so if you are supplementary feeding, remember to ensure additional water is available.

Health

Feet and teeth	Toenails may require trimming when animals are kept on soft pastured ground. Similar foot shears to those used for sheep are suitable. Foot rot is uncommon. Any protruding teeth (not common) will need to be filed back with an appropriate rasp. Males have fighting teeth and should be removed from three years of age.
Parasites	Alpacas are naturally resistant to internal parasites and fly strike. Faecal egg counts for cria's and weaners will identify any Scourworms present. Drenching is only recommended when Scourworm egg plants exceed 350 epg (eggs per gram). Faecal egg counts for the herd should be taken twice per year to identify any animals needing drenching.
Mineral Vitamin D	Vitamin D is a deficiency that needs addressing in southern Australia during winter and early spring. Deficiency is manufactured in the body as a result of solar radiation synthesizing 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.
Vaccinations	Five-in-one vaccinations are recommended at six to eight weeks followed by a booster four to six weeks later and then annually. This should prevent the two most common clostridial diseases of enterotoxaemia and tetanus.
Eyes	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.
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.

Shearing

Like sheep, alpacas are shorn once per year. This is best done prior to 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 stop 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 any sick animals.

Horse Management for New Land Managers

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 best selection of species is also dependent upon your soil type and rainfall. Always check with a local agronomist or your 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 a ruminant animal. The same trace elements as supplementary fed to ruminant animals are not necessarily applicable. Your veterinarian is best suited to advise on any trace supplements necessary.

Figure 17. Photo courtesy A Cole

Handfeeding 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 handfeeding 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.

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. 10 cm of compacted rubble or dolomite topped with 15 cm of sand with a slope of one in thirty is an example which provides both a good surface and drainage.

Paddocks should have adequate wind breaks and shelter belts to provide protection over 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 your local Adelaide & Mount Lofty Ranges Natural Resources Management Board District Officer.

Manure Management

Horses are fastidious animals that 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 EPA 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.

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 done 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 training on an empty stomach, lack of paddock time, feed depravation and stress. Avoid stabling for long periods, or long transport events, 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 ten horses is likely to suffer every year. Early treatment by a qualified veterinarian is essential, since colic is extremely painful and can be the cause of violence and/or death.

Figure 18. Greasy Heel.

Fencing and Gateways

Fencing should always be approached after considering the properties' land class. The more paddocks, the greater the ability to rotationally graze and allow good pasture renewal. A five or six 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 possible.

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.

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

Figure 19. Electric fence with a clear white 'sighter' wire.
Photo courtesy Adelaide & Mount Lofty Ranges Natural Recourses Management Board

Buying Hay - know what is best

Livestock in late Autumn and early Winter are often stressed by feed shortages and cold weather. Feeding out hay is the most common way to supplementary feed, but when purchasing hay all too often buyers put convenience and price ahead of quality. It might be easy to buy from your neighbour but if you consider that poor quality hay can be expensive to feed out and in some cases very unpalatable it is sound advice to search around for a reliable supplier of good quality hay.

There are some principles to keep in mind when purchasing hay. Livestock generally require a minimum of 65% digestible dry matter and a minimum of 12% crude protein. If digestible dry matter falls below 65% livestock tend to eat less and lose condition, so purchasing top quality hay from a reputable grower or fodder merchant is good advice. Unimproved pastures which 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 when making hay 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 4. 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 % 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 she gets only one third of her requirements from pasture, then she 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 5. 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 handfeeding is the regular monitoring of the condition of individual animals (refer to pages 86 & 89).

If stock is insufficiently fed, or given poor quality feed, 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 cruel to the animal, difficult to reverse, expensive and can have long-term adverse effects.

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

Table 6. Livestock Feed Requirements

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

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

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HorseSA, http://www.horsesa.asn.au

Cyberhorse, www.cyberhorse.net.au

Lifetimewool, www.lifetimewool.com.au

Meat and Livestock Australia (MLA), www.mla.com.au

Adelaide and Mount Lofty Ranges Natural Resources Management Board, Fact Sheets, www.amlrnrm.sa.gov.au

Vertebrate Pest Management

Legislation

Obligations and Responsibilities for Control of Vertebrate Pests:
Natural Resources Management Act 2004
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 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, 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, twenty four 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.

Figure 1. Photo Courtesy: Invasive Animals CRC

By 1865, (within 6 years) 20,000 rabbits had been killed on 'Barwon Park'. By 1886 they had spread to Queensland and New South Wales (Williams et al. 1995). 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 1700 kilometre rabbit proof fence was built in Western Australia between 1901 – 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 can be found in many different habitats and range from coasts to deserts.

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 2004. 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 your property.
- Rabbits must NOT be wilfully or negligently released from captivity.
- Any instructions relating to the keeping of domestic rabbits, given to you by an officer authorized under the NRM Act 2004, must be complied with.
- Wild rabbits are prohibited from being kept in any situation.

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. As part of such a plan, land managers incorporate a variety of seasonally and habitat specific methods to make the most of their control efforts.

Figure 2. Photo courtesy: Peter Bird, DWLBC

An effective integrated program should include **fumigation and ripping (or harbor 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.

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 metres from these sites, with most of their feeding done within 25 to 50 metres. 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 that the rabbits move within. 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 your 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 number 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 to provide 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 (e.g. burrow is under a concrete slab) then block the entrance to the warren with material that will 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 50cm above the ground. Any materials such as wood, bricks, hard rubbish etc. should be removed or stacked at 50cm above the ground and in such a way that there are no cavities for 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 1m and a width of at least 2m outside of 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 re-opening. Rabbits invading from surrounding areas and foxes digging into a ripped warren to obtain a dead rabbit may also be responsible for re-opening warrens. Follow up work is required at these warrens to ensure that rabbit numbers are kept low. Warrens that have re-opened 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 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 Natural Resources Management Act 2004 and the Native Vegetation Act 1991.

Figure 3. Tractor with three tines ripping a rabbit warren.
Photo courtesy: 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 eg. 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 four days after ingestion so the rabbit draws on reserves stored in its body. Initially the animal will continue to behave normally until three or four 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 license in small acreage areas but **CANNOT be used on properties smaller than 1,000 square metres (Quarter Acre Block).**

*** Please Note that other herbivores such as kangaroos, possums, bandicoots and livestock may be vulnerable to Pindone. If the following techniques are adhered to, off-target poisoning will be minimised, and the benefits of your Integrated Rabbit Management Plan, will far outweigh any negatives.**

- Rabbait® containing Pindone coated oats is available commercially in various size packages through most agricultural supply retailers. It is supplied in a plastic bucket with a sealable lid and may be stored at room temperature.
- The Board produces Pindone coated diced carrots; supply varies between regional offices 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 five days apart, to be effective. The bait can be laid either as a trail through the feeding area or in bait stations placed within the feeding area. Check the product label and accompanying information for full directions of use and safety.

Trapping

There are two types of cage trap that may be used in urban areas. One type is placed in the entrance of a burrow and traps the rabbit by having one way door flaps that allows 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 Council's hire out cage traps to residents for the trapping of pest animals. These traps may be suitable to trap 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 other mentioned control measures in part of an integrated management plan since the success of this method alone is often variable and unreliable. Unless the warren is found in delicate areas, warren ripping should follow fumigation to prevent the future return of rabbits.

Fumigant and 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 the same reason that fumigation is generally more effective after rain. To ensure safety and effectiveness, fumigation should only be carried out by Contractors carrying a Pest Technicians' License.

Figure 4. Rabbit Warren. Note: recent soil disturbance and droppings. Photo courtesy S Edwards

Biological Control Agents

Biological controls are about a short-term reduction in population numbers. As with any individual control technique, biological control is not considered a long-term, stand alone rabbit control technique. A rabbit control program needs to take advantage of the windows of opportunities given by subsequent events by implementing a warren/ harbor destruction program and follow-up measures. Biological controls can have the same effect as poisoning; reduce rabbit numbers to make warren/ harbor destruction more successful.

In 1952-1953 Myxomatosis, a biological control 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 is however still considered to be one of two very important biological controls.

The Rabbit Calicivirus (or Rabbit Haemorrhagic Disease Virus [RHDV]) is another biological control agent which was 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 eight 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 60cm high, fixed securely to posts and buried into the ground to a depth of 30cm.

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

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 is occurring within the exclosure.
Photo courtesy: Sheree 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

Rabbit Control Calendar		
October to December	January to April	May to September
Time to plan • Many young rabbits have emerged. • Rabbit numbers will reach a peak. • Damage to crops and pasture is most visible. • Some myxomatosis may be evident. • Time to contact your local NRM officer. • Organise and maintain equipment	Optimum Poisoning Time • Rabbits are hungry and territories undefended. • Rabbit numbers can be cut by 95%. • Free feeding prior to poisoning is essential. • Allow three-four days between each feed. • Lay poison three-four days after free feeding. • Destroy warrens two-three weeks after poisoning.	Follow-up and Inspection • Remove debris to prevent re-colonisation. • Burn or bury rabbit harbor. • Destroy/rip any exposed warrens found. • Fumigate any warrens acceptable.

Foxes

Foxes 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. Photo Courtesy: Invasive Animals CRC

Life Cycle

The breeding season for foxes is once a year, in spring. Generally they use a hole burrowed below ground (known as an 'earth' or 'den') in which to give birth, but they have also been known to use cavities under buildings. On average a fox will produce three to six 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 eight 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. Here are some of the other 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. Never feed foxes, 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 fox predation 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.

Figure 7. Photo Courtesy: Invasive Animals CRC

Fox Nuisance

For a range of reasons foxes are not fun to have around. 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 are often stolen and hidden away. In other instances their attraction is associated with plastic, so balls, toys and plastic-wrapped newspapers also get 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 *Natural Resources Management Act 2004* 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. These measures can be of lasting benefit in reducing fox numbers in the area, especially if they are 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, for a lasting solution, the aim is to make 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.

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 two metres 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 ten cm2 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 a fox can too.

Destroying Fox Shelters

To deter foxes from establishing areas of shelter, remove or thin out any dense vegetation. Get rid of 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.

Figure 8. Photo Courtesy: Invasive Animals CRC

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 be sure to 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 damage that is acceptable. 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 underground fox dens that are accessible. This method will only control those foxes in the den at the time of fumigation. It 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.

Figure 9. Fox caught in wire cage. Photo courtesy D Peacock

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 Council's hire out cage traps to residents for the trapping of pest animals. These traps, if large enough, may be suitable to catch foxes. Large-size 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 Boards.

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. They also cause soil erosion due to their hard hooves, impact livestock through their potential to carry diseases and competition for pastures, and often damage fences and crops. Deer pose a significant risk to public safety and may result in potentially 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 may also exhibit crepuscular (dawn and dusk) and/or nocturnal (night) activity patterns. Deer diet generally consists of grass, forbs (herbaceous flowering plants other than grasses), and some browse on preferred plants i.e. Eucalypt saplings.

Throughout a majority 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 twenty animals (sometimes larger). During the Rut males gather themselves a harem of females by competing with other males. Common behaviours for a 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 Adelaide & Mount Lofty Ranges 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 buck grows up to 95cm at the shoulder, weighing approximately 90kg. Colouring can vary from black, white, common (grey-brown) and menil (light brown). Fallow deer bucks have a prominent ‘adams 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 10. Fallow Deer Buck and Doe
Photo: Courtesy Troy Bowman

Red Deer

Red deer are the larger of the two species with a mature stag growing up to 120cm at the shoulder and weighing approximately 160kg. 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 animals lower back.

Figure 11. Red Deer Hind and Calf
Photo: George Mackenzie, Australian Deer Association

Management

Active management of feral deer populations is limited to trapping and shooting. Please ensure that any feral deer are controlled in a humane manner using appropriate calibre firearms, shot placement and hunting techniques that minimises 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 hurdles to overcome 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, Number 2, Fencing and Handling Yards, RIRDC Report 98/13.

Rights and Responsibilities

(As detailed in the South Australian Natural Resources Management Act 2004 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, Number 2, Fencing and Handling Yards, RIRDC Report 98/13. (See http://www.rirdc.gov.au/reports/DEE/Deermanual2.doc)

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