

Industry Insights - pasture production

Supporting document



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Author: Meg Dunford (Project Officer School programs, NSW DPIRD Orange).

Editors and Advisors: Michelle Fifield (Education Officer Schools, NSW DPIRD Orange), Jo Hathway (Project Officer School programs, NSW DPIRD Tocal College) David Brouwer (NSW DPIRD, Tocal).

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Overview

This resource was developed as a part of the [Industry Insights – poster and workbook series](#). It has been designed to be used with the [Agricultural pastures of NSW poster](#) and matching [Agricultural Pastures of NSW answer guide](#).

The resource was developed to cover NSW Agricultural Technology Stage 5 Syllabus Core B Plant Production 2 content along with some cross over from Core A introduction to Agriculture and Plant Production 2 and Some HSC agriculture content.

The workbook is designed to assist deep learning into pasture production in NSW. This document has been developed as a digital resource. To access the large number of hyperlinks which it contains it must be used in this format. Suggested practical activities and extension activities have been provided to be used at the teacher's discretion.

A matching Answer Guide is also available at [Agricultural pastures of NSW poster](#).



HSC Verbs and Key Words

It is integral students address the following key terms and verbs when answering questions. The following glossary developed by the NSW Education Standards Authority is provided to assist with the answering of activities throughout this booklet.

Key Word	Definition
Account	Account for: state reasons for, report on Give an account of; narrate a series of events or transactions
Analyse	Identify components and the relationship between them; draw out and relate implications
Apply	Use, utilise, employ in a particular situation
Appreciate	Make a judgement about the value of
Assess	Make a judgement of value, quality, outcomes, results or size
Calculate	Ascertain/determine from given facts, figures or information
Clarify	Make clear or plain
Classify	Arrange or include in classes/categories
Compare	Show how things are similar or different
Construct	Make; build; put together items or arguments
Contrast	Show how things are different or opposite
Critically (analyse/ evaluate)	Add a degree or level of accuracy depth, knowledge and understanding, logic, questioning, reflection and quality to (analyse/evaluate)
Deduce	Draw conclusions
Define	State meaning and identify essential qualities
Demonstrate	Show by example
Describe	Provide characteristics and features
Discuss	Identify issues and provide points for and/or against
Distinguish	Recognise or note/indicate as being distinct or different from; to note differences between
Evaluate	Make a judgement based on criteria; determine the value of
Examine	Inquire into
Explain	Relate cause and effect; make the relationships between things evident; provide why and/or how
Extract	Choose relevant and/or appropriate details
Extrapolate	Infer from what is known
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Plan, inquire into and draw conclusions about
Justify	Support an argument or conclusion
Outline	Sketch in general terms; indicate the main features of
Predict	Suggest what may happen based on available information
Propose	Put forward (for example a point of view, idea, argument, suggestion) for consideration or action
Recall	Present remembered ideas, facts or experiences
Recommend	Provide reasons in favour
Recount	Retell a series of events
Summarise	Express, concisely, the relevant details

Source: [NSW Education Standards Authority, 2023](https://www.nsw.gov.au/education/standards-authority)

Agricultural crops and pastures of NSW

Hundreds of species of plants are cultivated by humans under managed agricultural conditions.

Australian plant-based production systems include:

- native forests, vegetation and horticulture
- plantation and environmental forestry,
- pastures (legumes and grasses),
- cropping (cereals, fodder, oilseeds, sugar, cotton, pulses),
- perennial horticulture (tree fruits, olives, nuts, vine fruits, berries, vegetables and herbs, citrus);
- seasonal horticulture (fruits, flowers and bulbs, vegetables and herbs).

These plant production systems can be carried out as:

- Extensive production- including, broadacre, dryland, rangeland systems, or as
- Intensive production systems - which involve irrigation, production nurseries, and highly intensive glasshouse, shade house or hydroponic production systems.

What is Agronomy?

Agronomy can be defined as the science that deals with the principles and practices of field management for major field crops and pastures with its central theme being the soil-plant-environment relationship.

Agronomy is a multi-disciplined science that deals with the improvement and management of specific food and fibre crops and plants grown for human and livestock consumption.

Agronomy involves understanding the sciences biology, chemistry, genetics, soil science, water science, ecology, pest and disease management as well as economics and sustainability. It also includes a commercial and social focus, to meet the quality standards and criteria set by the industry, market and consumer.

Classification of agronomic crops and pastures

Agronomic crops and pastures are classified into the following groups:

- Cereal crops such as rice, wheat, barley, oats, rye, triticale, maize etc.
- Fibre crops such as cotton, hemp, jute, flax, agave, pineapple etc.
- Oilseed crops such as canola, cotton, sunflower, safflower, soybean, mustard, sesame etc.
- Pulse crops such as chickpea, broad beans, peas, lupins, soybean, cowpea, lentil etc.
- Sugar crops such as sugarcane, beets etc.
- Fodder shrubs such as Tagasaste, saltbush, Leucaena

- Forage grasses (C4 plants) such as millet, sorghum etc.
- Summer forage legumes (C4 plants) such as Lablab, Cowpea,
- Forage brassicas such as forage rape, turnip, kale etc
- Pasture legumes such as clover, medics, Lucerne, vetch, peas, serradella etc
- Pasture grasses such as Phalaris, cocksfoot, ryegrass, kikuyu, couch, panics, bromes, fescues, kangaroo grass, Mitchell grass, wallaby grass etc.
- Narcotic crops such as tobacco, cannabis etc.
- Beverage crops such as coffee, tea, cocoa, etc.
- Medicinal crops such as echinacea, garlic, ginseng, chamomile, Saint John's wort, valerian etc.

Crops and plants are also grown to harvest products for the horticulture, floriculture, forestry and human health industries.

Plant based systems underpin all agricultural production. Crops and pastures are commonly used to:

- Produce grain, oil, fibre or fodder to be harvested, or forage to be grazed
- Fill a feed gap for grazing livestock, for example, winter crops can provide valuable feed when pasture growth is limited
- Provide continuous groundcover
- Improve soil structure
- Increase biodiversity and soil microbial activity
- Improve soil nutrient levels
- Provide a pest/disease/weed break in a cropping rotation
- Reduce soil degradation. For example deep rooted perennial plant species can decrease salinity recharge, stabilise eroded creek beds, and increase soil organic matter content which improves soil structure and nutrient status.

This publication will focus on pasture production in New South Wales.

1. Define agronomy.

2. Complete the table by giving examples of species for the following crop and pasture categories. Use the NSW DPIRD Schools Program [‘Agricultural crops and pastures of NSW’](#) poster for help.

Crop / pasture category	Examples
Cereal crops	
Fibre crops	
Oilseed crops	
Pulse crops	
Fodder shrubs	
Forage grasses (C4 plants)	
Summer forage legumes (C4 plants)	
Forage brassicas	
Pasture legumes	
Pasture grasses	
Narcotic crops	
Beverage crops	
Medicinal crops	

Group research task and presentation

Students break into groups of three or four to complete the following research task. Groups will compile their findings into a shared document which they will present to the class. Teachers to assign student groups different agronomic plants to further investigate or allow students to select their own category. Do not research more than one species from each crop and pasture category.

Instructions: For your identified species, research and complete the following:

- Common name
- Scientific name
- Description of the plant (include a description of the mature plant, flowers, seeds etc. Images can be used to assist your description.)
- Identify if the species as perennial or annual and describe its growth cycle.
- Identify the purpose and markets for the plant or plant products.
- Identify when the plant is sown and harvested.

Compile your findings into a digital report which will be shared with members of your group and presented to your class on completion.

Useful DPIRD pages to help you with your research include:

- Cereals (grains)
 - [Winter crops](#)
 - [Summer crops](#)
- Fibre
 - [Summer crops](#)
- Oilseeds
 - [Summer crops](#)
- Pulses (grain legumes)
 - [Winter crops](#)
- Fodder shrubs
 - [Forage and fodder crops](#)
- Summer forage grass (C4 plants)
 - [Forage and fodder crops](#)
- Summer forage legumes (C4 plants)
 - [Forage and fodder crops](#)
 - [Summer legume forage crops: cowpeas, lablab, soybeans](#)
- Forage brassicas
 - [Forage and fodder crops](#)
- Pasture legumes-
 - [NSW DPI Pasture species and varieties](#)
- Pasture grasses
 - [NSW DPI Pasture species and varieties](#)

Agro-Ecological zones

Although Australia's land area is significant, only 6% is arable land suitable for soil-based agriculture such as cropping and growing pasture. Most of this arable land is located on the coastal fringes of the continent, coinciding with major urban centres.

Within this arable land, distribution of agricultural crops and pastures throughout NSW is influenced by:

- climate,
- soils,
- topography,
- insect pests,
- plant diseases,
- weeds and
- economic conditions.

The following activities will allow you to investigate the Agro-ecological regions of Australia.

Go to the CSIRO publication [Agro-ecological regions of Australia, Methodologies for the derivation and key issues in resource management, 2002](#), (available on the CSIRO webpage) page 12, to complete the following questions.

1. Use Figure 1 to identify the agro-ecological zone where you live.

2. Go to [CSIRO, The eleven agro-ecological regions](#). Describe the agro-ecological zone where you live.

3. List climatic and physical factors which influence the distribution of agro-ecological zones around Australia.

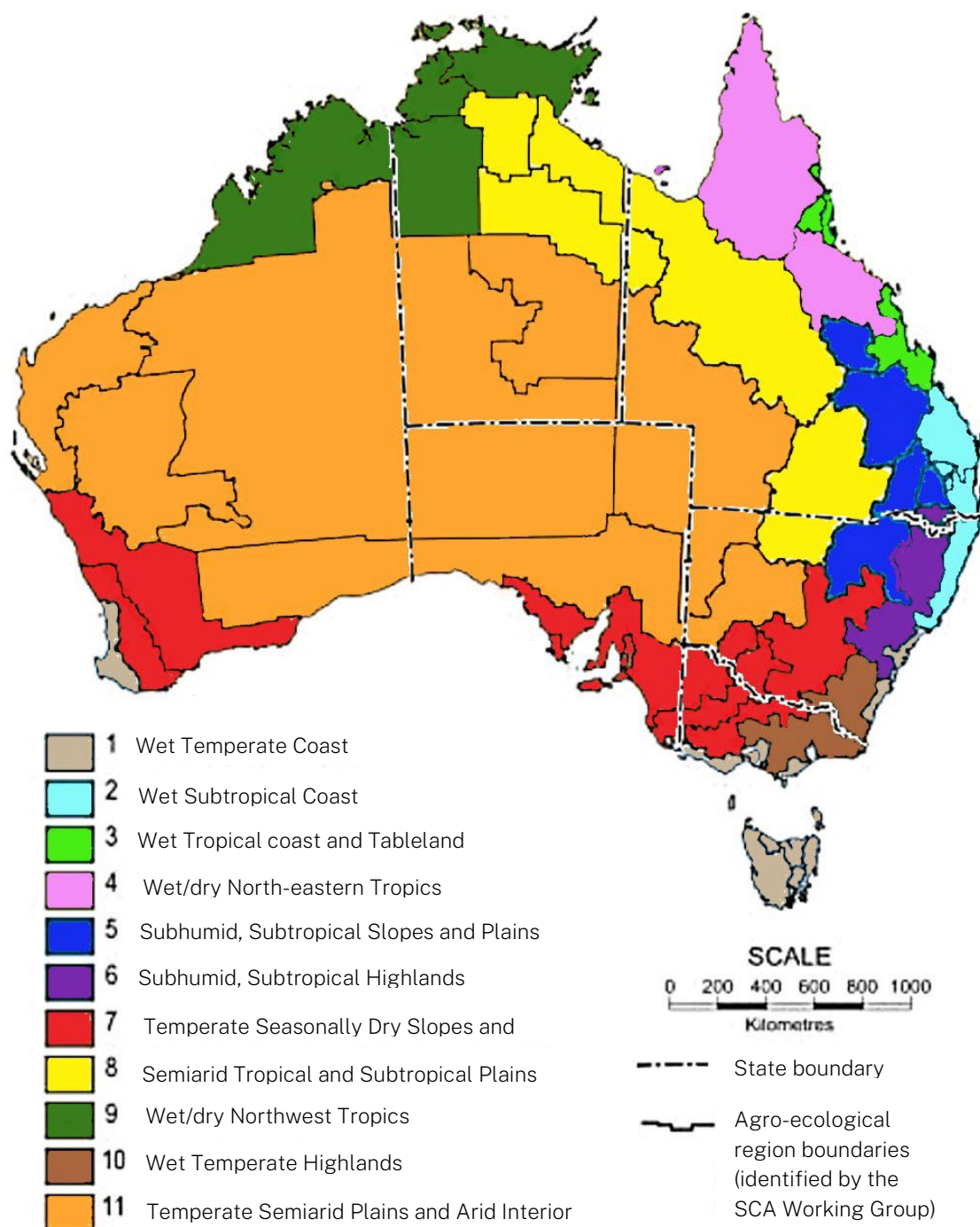


Figure 1 Source: [CSIRO, The eleven agro-ecological regions adopted for the National Strategy on Ecologically Sustainable Development in agriculture. Williams, Hook and Hamblin, 2002](#)

- [illegible]

Go to the NSW DPIRD [Categories of pasture plants](#) webpage. Apply your understanding of agro-ecological zones to complete the following question.

- [illegible]

Pasture production systems

Glossary:

Native: species native to the Australian continent that grew prior to European settlement. For example, weeping grass (*Microlaena stipoides*)

Naturalised: species introduced from overseas which have spread without human assistance and have become endemic to the landscape. For example, Kikuyu (*Cenchrus clandestinus*).

Introduced/Improved/Exotic: Species selected and introduced from overseas. Usually reliant on high soil fertility levels to give high production. For example, Lucerne (*Medicago sativa*)

Annual: species complete their whole lifecycle from germination- vegetative growth, flowering seed set and death, within a year. For example, annual ryegrass (*Lolium rigidum*)

Perennial: Grow for 2+ years. Have larger root systems, large bases and many leafy or dormant stems or tillers. For example, Lucerne and Cocksfoot (*Dactylis glomerata*).

Legume: broadleaf plants able to utilise nitrogen gas from the atmosphere for growth through the nitrogen fixing bacteria in their roots. For example, Lucerne, medics, peas, pulses and clover.

Herbs: Plants without woody stems (although they might be woody at their base). Dock, chicory, plantain and fleabane are herbs. Many herbs are weeds. Other groups of pasture plants are ferns, sedges, rushes, daisies and orchids.

Weeds: any plant growing where it is not wanted. Most are introduced species e.g. annual ryegrass in a wheat crop

Farms are complex systems, made up of interlinked components which all interact together. Pasture subsystems within a farm don't exist alone. They are linked to animal production either directly for livestock grazing, or indirectly for fodder conservation (hay or silage) which are then fed to animals.

Pastures also interact with resource subsystems such as soil and water on farm and have a range of environmental benefits including:

- Increase biodiversity
- Sequestration sink for carbon
- Soil improvement- root systems build soil organic matter content and bind soil particles together (humus), which improves soil structure
- Protect soils from degradation: - salinity and erosion
- Increase water utilisation from rain by reducing run-off
- Nutrient recycling and in the case of legumes, produce high levels of nutrients essential to animal growth and development
- Most financially viable method for maximising grazing livestock production.

In NSW, pastures can be broken down into:

- native grasslands
- modified native pastures including part of woodlands
- naturalised pastures
- improved pastures.

The major pasture plants (native and introduced) can be grouped into grasses (monocotyledons) or legumes (dicotyledons), then described as perennial or annual. Perennial species regrow each year from root reserves while annuals grow from a seed each year.

Another grouping is temperate or tropical. Temperate species tend to be winter/ spring growing, so can grow at lower temperatures. Tropical species are late spring/summer growing, can tolerate higher temperature and are more water use efficient. These differences are due to the way they carryout photosynthesis and the carbon compounds produced.

Temperate species and tropical legumes are classified as C3 and tropical grasses as C4 species. C3 plants produce 3 carbon atoms and C4 plants four carbon atoms from photosynthesis. To brush up on photosynthesis go to [NSW DPI's - Industry Insights Plant structure and function](#) publication.

C3 and C4 species both play an important role in every pasture production system in NSW. The proportion of each will depend on the location. There is a mixture of C3 and C4 species in all areas of NSW, but C4 are more common in the north and towards the coast and C3 are more common in the south. The important issue is to match the different strengths of C3 and C4 species to the production target. Production targets are specific to each farm. Examples include fodder production and harvest, growing and finishing young livestock, dairy cows lactation, merino wethers growing wool.

Knowing what species, including weeds, are present in a pasture is important for management decisions.

Most pastures contain some weeds or less desirable species. It is important to note that some weeds are more serious in a pasture, (e.g. serrated tussock) and need to be controlled. Other species, e.g. barley grass is positive for winter feed but negative to stock when seeding. The density of the weeds determines what control measures need to be used.

Weeds are most successfully controlled using competition. Knowing what pasture species and weeds are present and when they grow allows you to plan grazing or other control methods to place competition pressure on the weed.

Most pastures are made up of many species, so competition is occurring every day between species for light, water and nutrients. This competition is influenced by the growth habit of the different species i.e. short or tall growing. Longer rest periods favour the taller growing plants by shading the shorter ones. This is positive if the shorter species are weeds but negative if the shorter species are desirable and the shading causes their loss. Legumes provide nitrogen for the grasses, need sunlight for seed set and are often shorter, and sensitive to shading by grasses.

The key to obtaining high animal performance from pastures is by having productive pasture species. Production is determined by:

- Plant species
- The number of plants.
- How quickly they grow.

Pasture plants grow by increasing weight, and producing more and larger leaves and stems. The rate of these changes depend on the environment and genetics.

Go to [Categories of pasture plants](#) on the NSW DPIRD webpage to complete questions 1-3.

1. Contrast perennial and annual species and provide an advantage for each.

2. Describe the interaction between legumes and *Rhizobium* bacteria.

3. Contrast native introduced and naturalised species.

Go to the '[What are C3 and C4 Native Grass?](#)' webpage to complete question 4-7.

4. Complete the table to contrast the feature of C3 and C4 plants. The first has been given.

Feature	C3	C4
Initial molecule formed during photosynthesis	3 carbon	4 carbon

5. List three advantages of C3 plants

6. List three advantages of C4 plants

7. Assess the benefits of having a mixed species pasture for a grazing livestock enterprise. Use the following scaffold for your answer if required.

[illegible]

Assess: make a judgement of value, quality, outcome, results or size	
Pros (advantages) list and explain them all •	Cons (disadvantages) List and explain them all •
Judgement: from your findings, make a judgement if having a mixed species pasture is beneficial to a grazing enterprise	

Types of pastures- grasses and legumes

Grasses

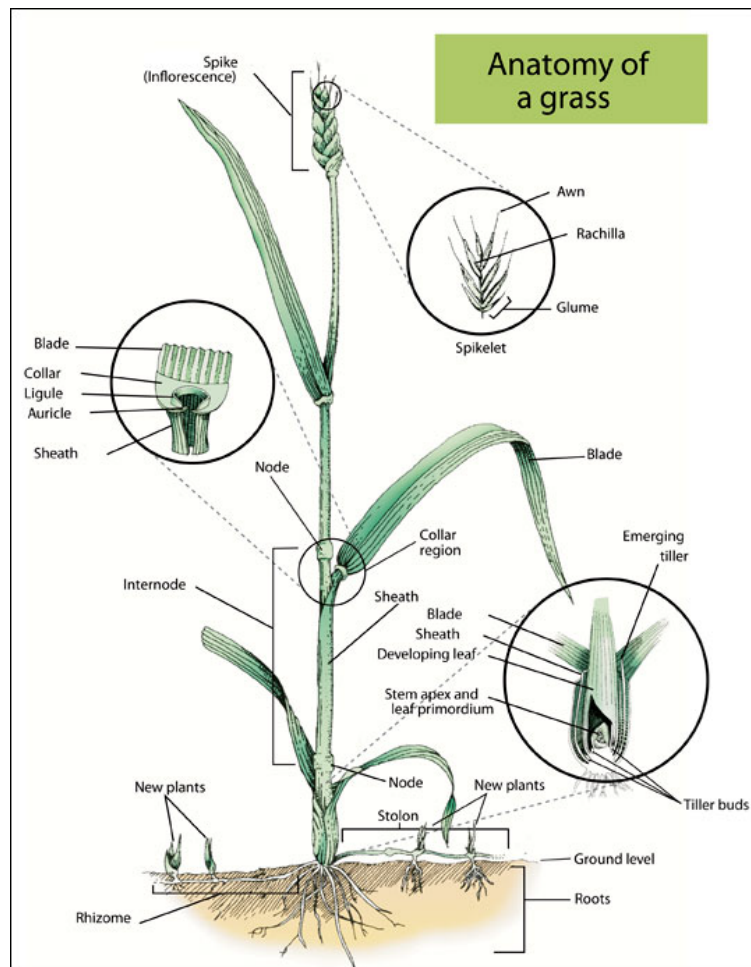


Figure 2 Parts of a pasture grass (barley) [\(Source: Dairy grazing, Extension, University of Missouri\)](#)

Glossary:

Auricle: Located at junction between sheath and blade. Pair of 'claw-like' projections. Presence, size, hairiness and shape of auricles are important for grass identification.

Collar: found on the outside of the leaf at the junction of the sheath and blade.

Culm: Alternative name for stem

Leaf blade: Elongated leaf. Grass veins run in parallel (monocotyledon). Upper part is leaf blade, lower part is the sheath.

Ligule: Thin colourless membrane around the base of the collar. Clasps stem firmly on the inside of the leaf at the junction of the sheath and blade. Prevents water and soil entering.

Leaf sheath: Begins at node, surrounds the stem and newly emerging leaf blade like a tube. Split down one side. The shape and form of the sheath e.g. flat, round, open, overlapping; are important for grass identification. Lower part of leaf, upper part is the blade.

Inflorescence (flower head/ seedhead): Pasture grasses have six main flower types: raceme (A), spike (B), panicle (C), spike-like panicle (D), whorled branches (E), digitate inflorescence (F), cluster of spikelets in a spathe (G). See below.

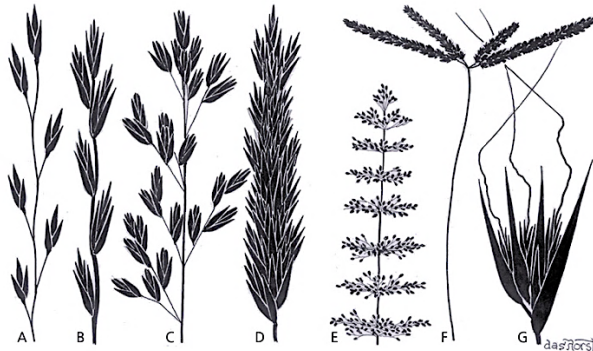


Figure 3 Types of grass flower heads (Source: [Grasses of South Australia, Jessop, Dashorst and James, 2006](#))

Panicle (seedhead/ inflorescence): A type of flower. The flower clusters are attached to the stem via branches connected to branches off the stem (Figure 3- C)

Raceme (seedhead/ inflorescence): A type of flower. Clusters are attached to the stem via branches. (Figure 3- A)

Spike (seedhead/ inflorescence): A type of flower. Clusters of flowers are attached directly to the stem. (Figure 3- B)

Grasses are monocotyledonous plants belonging to the *Poaceae* (*Gramineae*) family. Other *Poaceae* plants include bamboos, cereal grasses, native grasses, cultivated species in lawns, and pasture/forage production.

Grasses have stems that are hollow (except at the nodes), and a narrow leaf (blade). The blade is made up of two parts, the lower leaf sheath and upper leaf blade. Growth occurs from the base of the sheath, an adaptation which allows the plant to survive frequent grazing.

Grasses become larger by producing tillers from the base of the plant causing the 'clumpy' appearance. Sunlight to the base of the plant stimulates tiller production. Tillers are new shoots emerging from the plant's crown. This is called 'tillering'.

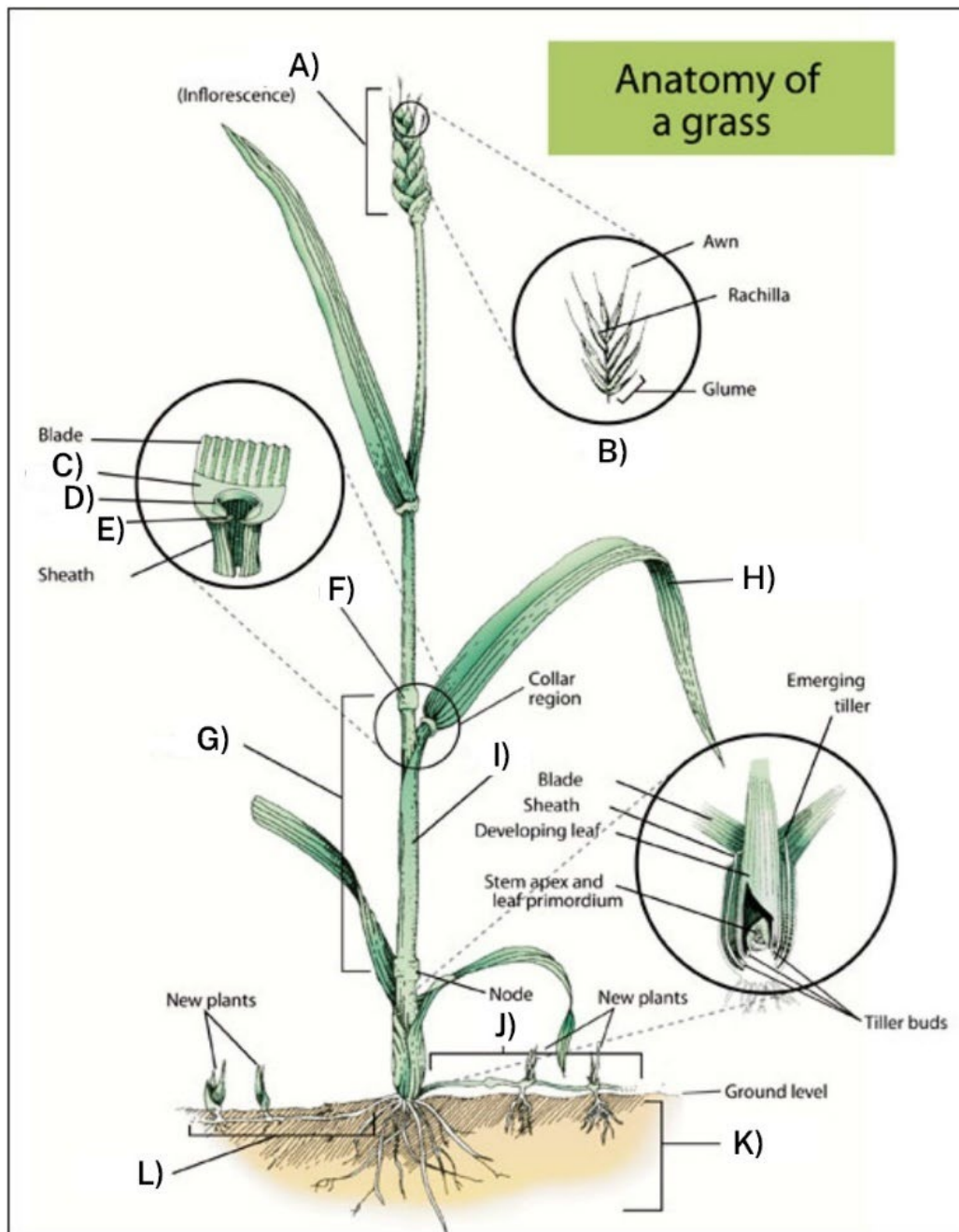
Tillers are produced over periods of growth, but die when moisture becomes limiting, or are shaded from sunlight by excess growth of older ungrazed tillers, or shading by competing species. Most species have a limit of 3 to 5 leaves per tiller.

Grazing management is used to increase tillering and help thicken pastures. By keeping pastures in the range 3–15 cm, sunlight reaches most of the plant material and allows maximum production of new tillers by photosynthesis.

Grass plants mostly reproduce through seed production. However, some grasses also propagate vegetatively (e.g., kikuyu, Rhodes grass stolon and rhizome production). Seeding is essential for annual species regeneration. Seeding is not as important for the survival of perennial pastures.

Many well managed perennial grass-based pastures have deep fibrous root systems (compared to annual grasses), which help to reduce deep drainage into the water table. The deepest roots on perennial species access water in dry times or during dormancy to keep the plant alive. The roots that drive active plant growth are the primary roots in the top 40 cm of the soil profile.

1. Label the missing parts of the following grass plant.



	Plant part		Plant part
A)		G)	
B)		H)	
C)		I)	
D)		J)	
E)		K)	
F)		L)	

2. Describe auricles

3. Describe ligules

4. Describe tillers

5. Explain how grazing management is used to influence grass plant growth.

6. Describe the impact a well-managed perennial pasture has on the water table.

Practical activity: Identify common, improved-pasture grasses

Background:

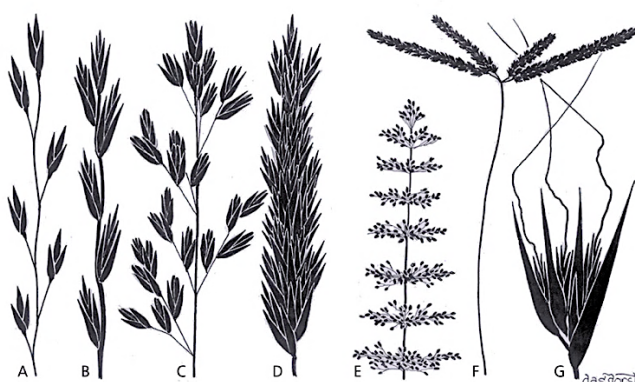
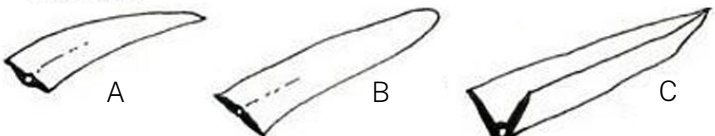
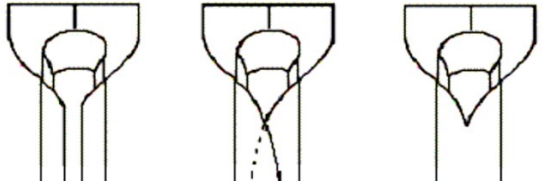
Successful grazing livestock management begins with understanding the forage (pasture) resource, including identifying the plant species present.

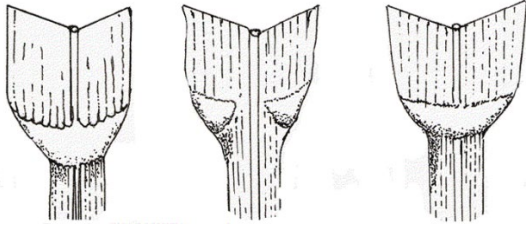
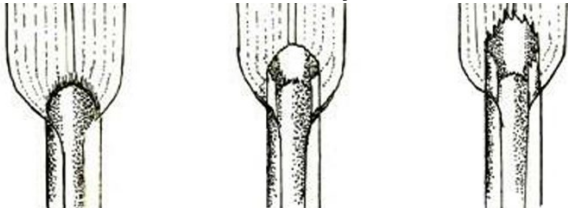
Learning to identify pasture plants and their names requires effort and time but can be a very useful tool for decision making for successful pasture management. The skill is developed through practice.

The following practical activity aims to develop skills in identifying some common, temperate, improved-pasture grasses of NSW.

Students use their understanding of grass anatomy and the following Tables to identify temperate grass species.

Refer to the following tables while undertaking the practical activity.

	Image and description
Inflorescence	 (A), spike (B), panicle (C), spike-like panicle (D), whorled branches (E), digitate inflorescence (F), cluster of spikelets in a spathe (G)
Leaf blade	 (A) Flat, pointed at tip, (B) Flat, rounded at tip, (C) V-shaped, folded, or boat-shaped tip
Sheath	Lower part of leaf. Wraps around stem 

	Split or open	Overlapping	Closed or united
Collar	Region of junction between blade and leaf sheath of grasses  Broad Divided Narrow		
Auricle	Located at junction between sheath and blade. Pair of 'claw-like' projections. Presence, size, presence of hair and shape of auricles are important for grass identification.  Overlapping Short None		
Ligule	Thin colourless membrane around the base of the collar. Clasps stem firmly on the inside of the leaf at the junction of the sheath and blade.  Fringe of hairs Membrane, rounded top Membrane, toothed		

top

Table 1: Identification Key for Common Grasses and Grass-like Weeds ([Source: HerbiGuide, 2023](#))

	Leaf blade				Ligule Type	Auricles Type	Sheath		New leaf	Seed			Other features
	Length x width mm	Surface	Hairiness	Cross section			Type	Hairiness		Length x width mm	colour	features	
Barley (<i>Hordeum vulgare</i>)	40-400 x 5-20	Dull	Hairless to slightly hairy. No hairs near collar.	Flat to twisted	Short membrane	Very large, clasping	Rolled & overlapping	Hairless or scattered hairs	Rolled	4-8 x 2-5	Yellow	Straight awn	Leaves twist clockwise
Cereal Rye (<i>Secale cereale</i>)	75-300 x 10-20	Dull, rough to touch	Hairless	Flat to twisted	Short rim < 1 mm	Small	Rolled & overlapping	Hairless	Rolled	5-7 x 2-3	Yellow	No awns.	Prominent veins on sheath
Oat (<i>Avena sativa</i>)	150-700 x 5-12	Dull, rough to touch	Hairless to slightly hairy	Flat to twisted	Short, jagged membrane	None	Rolled & overlapping	Hairless to slightly hairy	Rolled	10-15 x 2-5	Yellow	No awns or straight awns	Leave twist anticlockwise
Triticale (<i>Triticum X secale</i>)	30-300 x 10-20	Dull	Hairless to slightly hairy	Flat to twisted	Short.	Medium, maybe with hairs	Rolled	Hairless to slightly hairy	Rolled	8-12 x 2.5-4	Yellow	No awns	Sheath often bluish green at base
Wheat (<i>Triticum aestivum</i>)	30-300 x 10-20	Dull	Hairless or a few hairs near collar.	Flat to twisted	Fringed membrane	Large	Rolled & overlapping	Hairless or a few hairs near collar	Rolled	6-7 x 2-5	Yellow	No awns	Leaves twist clockwise
Annual Poa (<i>Winter Grass Poa annua</i>)	5-140 x 1-5	Light green	Hairless	Canoe like	Membrane	None	Split	Hairless	Folded	< 1 mm	Pale.	No awns	Striped sheath
Barley Grass (<i>Hordeum leporinum</i>)	40-200 x 1.5-12	Light green	Hairy on lower leaves.	Twisted	Short membrane	Large, encircle stem.	Rolled & overlapping	Hairless or a few fine hairs.	Rolled	5-10 x 2-4	Pale.	Awned	Strong clockwise twist
Great Brome (<i>Bromus diandrus</i>)	80-400 x 5-20	Dull	Hairy	Twisted	Membrane >2mm	None	Tubular, often with red/purple stripes near base.	Hairy	Rolled	20-30 x 1-2	Brown	Awned	Seedlings have purple tinge. Light green collar.
Soft Brome (<i>Bromus hordaceus</i>)	100-300 x 2-10	Dull. Light green	Hairy	Twisted	Membrane >2mm, ragged	None	Tubular	Hairy	Rolled	3 x 1	Yellow/ brown	Awned	

Table 1: Identification Key for Common Grasses and Grass-like Weeds ([Source: HerbiGuide, 2023](#))

	Leaf blade				Ligule Type	Auricles Type	Sheath		New leaf	Seed			Other features
	Length x width mm	Surface	Hairiness	Cross section			Type	Hairiness		Length x width mm	colour	features	
Couch (<i>Cynodon dactylon</i>)	10-160 x 1-5	Dull. Grey green.	Hairless or sparsely hairy	Flat or folded	Rim of hairs	None	Split but tubular at base	May have hairs on lower portion	Folded	< 1 mm		No awns.	Perennial with runners.
Fescue (<i>Festuca</i> species)	100-750 x 3-12	Dull. Dark green.	Hairless or a few hairs near the collar	Flat	Short and membranous	Large and encircle the stem		Hairless	Rolled	Small.		No awns	Perennial tussock.
Kikuyu (<i>Pennisetum clandestinum</i>)	10-300 x 2.5-7	Bright green.	Hairless or wart-based hairs	Flat or folded	Hairy ring.	None	Overlapping	Usually hairy.	Folded	Very small		No awns	Perennial with runners.
Lesser Canary Grass (<i>Phalaris minor</i>)	20-300 x 3-13	Dull	Hairless	Flat	Large, 8- 10 mm long.	None but base of blade is winged	Tubular	Hairless.	Rolled	1 mm	Brown	No awns	
Lovegrass (<i>Eragrostis curvula</i>)	250-350 x 1-5	Dull dark green to blue green	Hairless or hairy	Flat	Hairy ring	None		Hairless or hairy	Rolled	Small <1 mm	Cream to dark orange brown	Translucent	Perennial tussock.
Paspalum (<i>Paspalum dilatatum</i>)	60-600 x 3 15	Wavy edges, prominent midrib.	Hairless apart from a few near the collar	Flat to slightly folded	Large membrane, 2-4 mm long	None	Tubular	Hairless apart from a few near the collar	Rolled	Small 2-3 mm		Shiny and flattened	Often has a purplish tinge
Onion Grass (Guildford Grass <i>Romulea rosea</i>)	50-400 x 1-2	Shiny	Hairless	Cylindrical solid		None	None	Hairless	Solid	Small.	Red-brown	Shiny, dimpled and angular	Has bulbs.

Table 1: Identification Key for Common Grasses and Grass-like Weeds ([Source: HerbiGuide, 2023](#))

	Leaf blade				Ligule Type	Auricles Type	Sheath		New leaf	Seed			Other features
	Length x width mm	Surface	Hairiness	Cross section			Type	Hairiness		Length x width mm	colour	features	
Rat tailed Fescue (<i>Vulpia myuros</i>)	20-150 x 0.5-3mm wide	Shiny both sides,	Tiny hairs on top or hairless	Flat or rolled	Membrane, >1 mm	Tiny	Rolled & overlapping	Hairless	Rolled	Small, 1-2 mm long.	Pale.	Awns.	Top leaf sheath cover part of the seed head.
Sand Fescue (<i>Vulpia fasciculata</i>)	10-140 x 0.5-3	Shiny both sides,	Tiny hairs on ribs. May appear hairless	Flat or rolled	Membrane, >1 mm	None	Rolled & overlapping	Hairless	Rolled	Medium, 4-12 mm long	Pale	Awned. Awn twice as long as the seed.	
Squirrel-tailed Fescue (<i>Vulpia bromoides</i>)	10-150 x	Shiny both sides,	Tiny hairs on top or hairless	Flat or rolled	Membrane	None	Rolled & overlapping	Hairless	Rolled	Small, 2-4 mm	Pale	Awned	Seed head clear of top leaf sheath. Base reddish.
Toad Rush (<i>Juncus bufonius</i>)	45-140 x 0.2-1.5	Shiny both sides.	Hairless.	Channeled. Arise from base of stem.	None.	None	None.		From base	Tiny.		No awns	Angular solid stems
Yorkshire Fog (<i>Holcus lanatus</i>)	40-200 x 3-10	Dull	Hairy	Flat	Jagged membrane	None	Rolled & overlapping	Hairy	Rolled	Small	Yellow brown dark tip.	Shiny and hairy.	Sheath often has stripes
Darnel (<i>Lolium temulentum</i>)	50-400 x 2-15	Shiny on one side,	Hairless	Flat	Small membrane	Narrow	Rolled & overlapping	Hairless	Folded	Small, 3-6 mm long.	Pale. Brown to yellow grey	No awns	Glumes as long or longer than the spikelet.
Wild Oats / Bearded Oat (<i>Avena barbata</i>)	100-300 x 3-6	Dull	Usually hairless but young leaves may have hairs.	Flat or twisted.	Large membrane.	None	Rolled & overlapping	Hairless or hairy.	Rolled	Large, 12-20 mm long	Black or dark brown.	Twisted awns	Leave twist anticlockwise
Wild Oats (<i>Avena fatua</i>)	100-300 x 3-15	Dull	Hairless or hairy	Flat or twisted.	Large membrane.	None	Rolled & overlapping	Hairless or hairy.	Rolled	Large, 12-20 mm long	Black or dark brown.	Twisted awns	Leave twist anticlockwise
Ludo Wild Oat (<i>Avena sterilis</i> ssp. <i>ludoviciana</i>)	100-300 x 3-18	Dull	Hairless or hairy	Flat or twisted.	Membrane.	None	Split		Rolled	Large.	Black or dark brown.	Twisted awns	Leave twist anticlockwise

Table 1: Identification Key for Common Grasses and Grass-like Weeds ([Source: HerbiGuide, 2023](#))

	Leaf blade				Ligule Type	Auricles Type	Sheath		New leaf	Seed			Other features
	Length x width mm	Surface	Hairiness	Cross section			Type	Hairiness		Length x width mm	colour	features	
Tall Wheat Grass (<i>Thinopyrum elongatum</i>)	30-250 x 5-70	Dull	Hairless or a few hairs	Flat or rolled	Membrane with rim of short hairs.	Small	Tubular		Rolled	Medium, 10-12 mm long.	Pale yellow brown	Awn-less	
Cocksfoot (<i>Dactylis glomerata</i> L.)	20-500 x 2-6	Dull	Hairless, slightly rough	Flat	Long membranous	None	Flattened and rolled	Hairless or short hairs	Folded	<1mm	Pale yellow brown	Short awn	Pale collar. Flattened tillers. Panicle inflorescence
Phalaris (<i>Phalaris aquatica</i>)	20-500 x 2-14	Dull bluish green, often striped	Hairless	Flat	Large membrane, 3-12 mm	None Base of blade is winged	Split	Hairless	Rolled	Small	Light brown	No awns. Smooth and shiny.	Perennial with runners. Collar often lighter colour
Annual Ryegrass (<i>Lolium rigidum</i>)	30-150 x 1-5	Shiny on one side,	Almost hairless	Flat	Small membrane 1.5 mm.	Variable from none to long. Often shriveled.	Rolled & overlapping	Hairless	Folded	Small, 2-3 mm long.	Pale. Brown to yellow grey	No awns.	Often red/purple base of sheath. Glumes almost as long as the spikelet.
Italian Ryegrass (<i>Lolium multiflorum</i>)	60-220 x 2-10	Shiny on one side,	Hairless	Flat	Jagged membrane, 4 mm long.	Large and narrow.	Rolled & overlapping	Hairless	Rolled	Small, 3-6 mm long.	Pale. Brown to yellow grey	Awned	Often red/purple base of sheath. Glumes less than half the length of the spikelet.
Perennial Ryegrass (<i>Lolium perenne</i>)	30-200 x 2-6	Shiny on one side,	Hairless	Flat	Small membrane 1-2 mm.	Large	Split to base	Hairless	Folded	Medium, 4-8 mm long	Pale. Brown to yellow grey	No awns	Glumes about half the length of the spikelet.

Aim: To identify some common pasture grass species in improved pastures.

Materials:

- Variety of different grass species. Plants should be between late vegetative to reproductive stage. (Plants can either be supplied, or ideally collected on a paddock walk).
- Buckets
- Spades
- Ruler
- Microscope/ magnifying glass (optional)
- Scalpel (optional)
- Tweezers (optional)

Method:

1. Collect buckets and spades and conduct a pasture walk.
2. Select different grass species from the paddock, dig specimens out and place them in buckets.
3. Return to classroom with specimens.
4. Inspect grass specimen using a microscope or magnifying glass.
5. Make observations in terms of:
 - Leaf blade
 - ✓ Use ruler to measure length x width (mm)
 - ✓ Surface (shiny, dull)
 - ✓ Hairiness
 - ✓ Leaf blade cross section
 - Ligule -present, not present, rounded edge, jagged edge, presence of hairs, length (mm)
 - Auricles- not present, present, overlapping, long, short
 - Sheath
 - ✓ Type- split, open, overlapping, rolled, closed, united
 - ✓ Hairiness – none, long hairs, short hairs
 - New leaf – folded, rolled, solid
 - Seed
 - ✓ Length- measure length x width (mm) with ruler
 - ✓ Colour
 - ✓ Features- presence of awn
6. Record results into Results Table.
7. Compare results to Table 1: Identification Key for Common Grasses and Grass-like Weeds
8. plant species des to identify the grass specimen.
9. Record scientific and common name into Results Table.
10. Complete steps 4-9 for each grass specimen separately.
 OPTIONAL-Select a tiller. Dissect stem vertically through base of crown to observe new leaf growth and developing seed head. Use a scalpel and tweezers.

Results Table:

Grass specimen	Leaf blade				Ligule Type (Round, jagged, hairs, length (mm))	Auricles Type (None, overlapping long, short)	Sheath		New leaf (Folded, rolled, solid)	Seed			Common and scientific name
	Length x width (mm)	Surface (shiny/dull)	Hairiness (hairy, no hair)	Cross section (Flat, twisted, rolled)			Type (Split, open, overlapping, rolled, closed, united)	Hairiness (None, long hairs, short hairs)		Length x width (mm)	Colour	Features (Presence of awn)	
1													
2													
3													
4													
5													
6													
7													
8													

(Add /remove rows as required)

Legumes

Glossary:

Head: A dense inflorescence of flower without stems.

Inflorescence: The arrangement of flowers on the floral axis.

Internode: Area of the stem between the nodes.

Node: The point on the stem where the leaves are attached.

Nodule: Swollen structures on legume roots, made up of modified plant root cells. Nodules house *Rhizobium* bacteria which, in return provide legume plants with plant available nitrogen for growth.

Petiole: The stalk of a leaf which connects the leaf to the stem.

Petioule: Extension of the petiole into the leaflets of a compound leaf.

Raceme: An inflorescence in which flowers are mounted on short stems along a central axis.

Rhizome: An underground stem which can produce new plants at the nodes.

Stipule: small, pointed, leaf-like structures at the base of the petiole.

Stolon: A prostrate above-ground stem which can produce new plants at nodes.

Tendrill: A slender, modified leaflet used for support.

Umbel: An inflorescence in which flowers are mounted on short stems all arising from a common point.

Variegation: A pattern of lighter coloured tissue on a leaf.

Legumes are dicotyledonous plants belonging to the *Leguminosae* (*Fabaceae*) family. Types of plants include trees, shrubs, vines and broad-leafed perennial and annual plants. Legumes are identifiable by their seed pods, stipules, and ability to fix nitrogen.

Legume species commonly grown in agriculture include:

- Pulse crops - Beans, peas, lentils, peanuts, soybeans, lupins, chickpeas
- Trees – Leucaenas (e.g. lucerne tree), Acacias (wattles), Ceratonias (e.g. carob tree)
- Pastures – Clover, medic, vetch, serradella, lucerne, cowpea, lablab

The legume content in a pasture is important because it increases the quality of the pasture mix. In the vegetative stage, legumes are highly digestible, and capable of supporting high levels of livestock production.

Legumes benefit pasture grass growth, as they add nitrogen to the soil through the process of nitrogen fixation.

Too much high-risk legumes such as clover in the diet of cattle can cause the metabolic disorder bloat. On the other hand, sheep grow well on high clover diets. Not enough clover or

legume content in a pasture can result in metabolic disorders such as Phalaris staggers (caused by toxic alkaloids) or grass tetany (low blood magnesium and calcium levels).

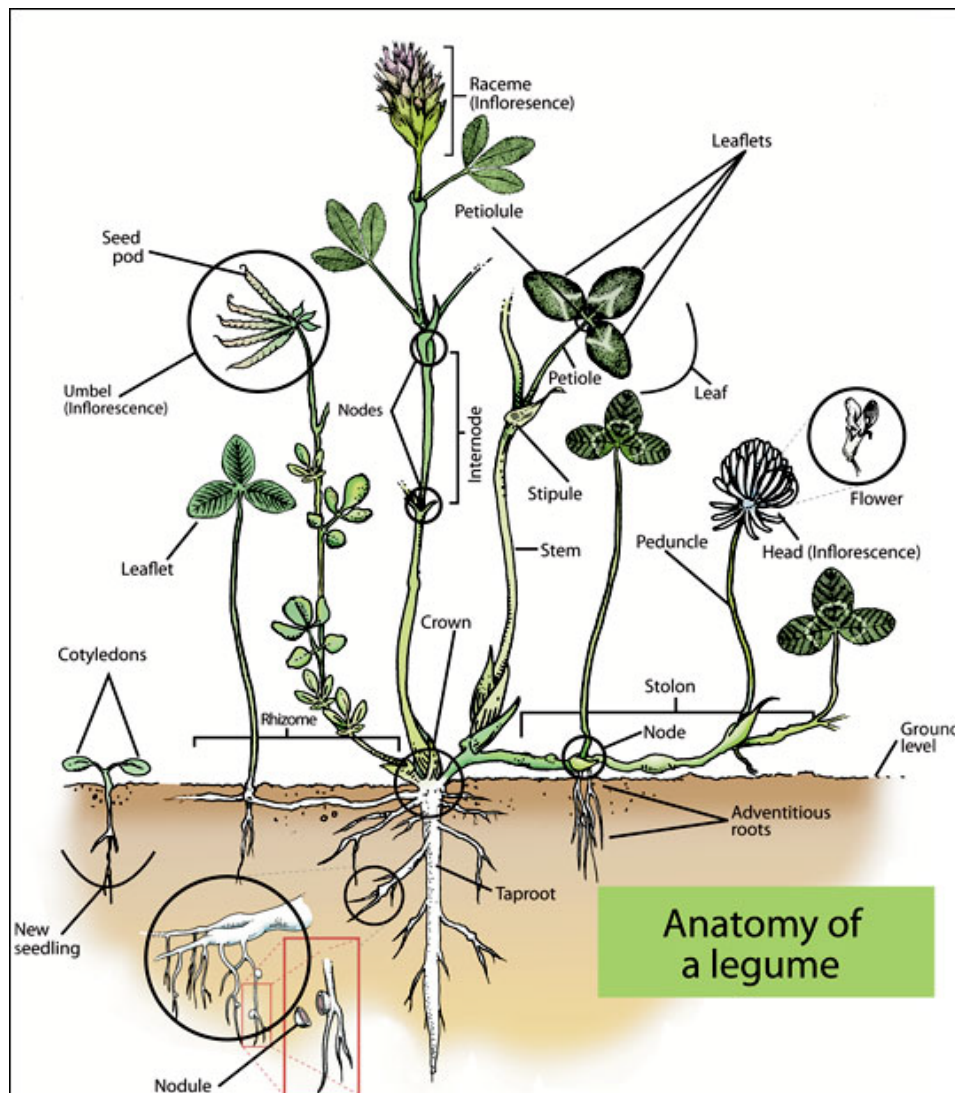
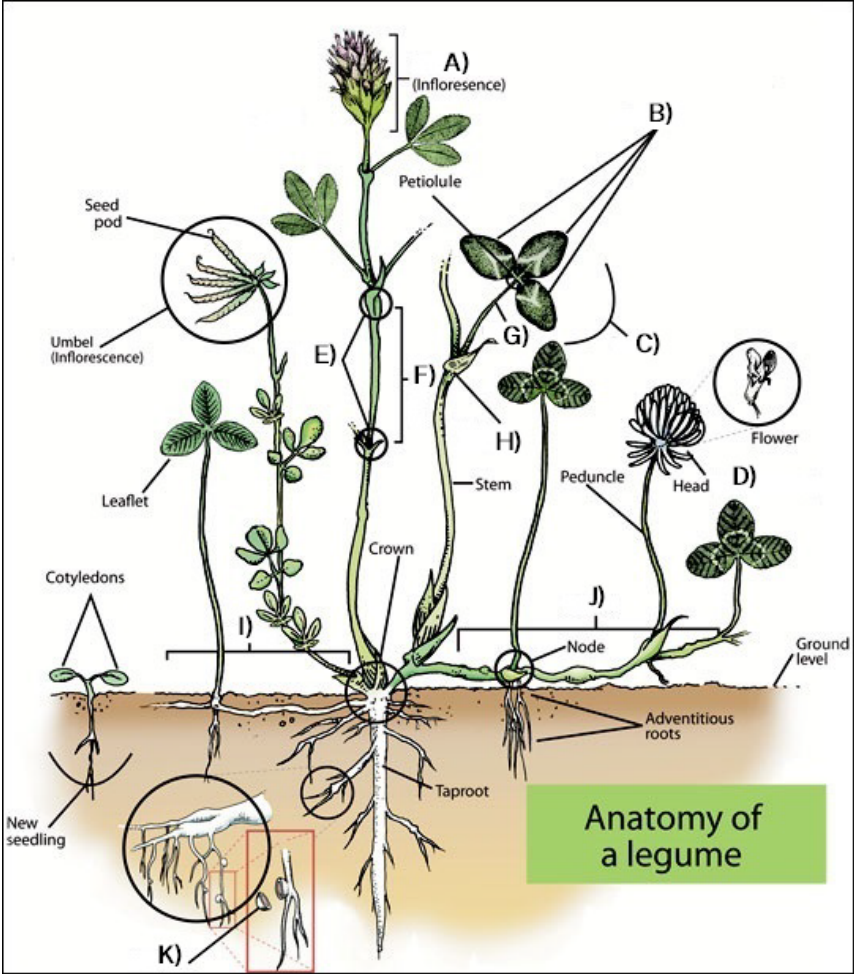


Figure 4 Parts of a pasture legume (clover) ([Source: Dairy grazing, Extension, University of Missouri](#))

Legumes grow differently depending upon whether they are annual or perennial. For annuals such as subterranean clover, growth is from seed with many stems developing from the crown above a taproot. After rapid early growth in autumn, development slows over winter with seeds setting after flowering in spring. Grazing of taller grasses to open up the pasture over winter and spring allows sunlight to the clover leaves and encourages seed production.

7. Label the missing parts of the following legume plant.



Plant part		Plant part	
A)		G)	
B)		H)	
C)		I)	
D)		J)	
E)		K)	
F)			

8. Compare the following structures:

a) Stolon and rhizome

b) Stem and petiole

c) Leaflet and leaf

Research activity

Metabolic disorders are conditions that disrupt the breakdown, digestion, absorption, and use of nutrients. They alter the body's processing and distributions of macro and micronutrients, proteins, fats and carbohydrates. Some common metabolic disorders in livestock include acidosis, ketosis, dystocia, milk fever, bloat, grass tetany, nitrate poisoning, prussic acid poisoning and botulism.

Select and research one of the following metabolic disorders that can be prevented through good pasture management:

- Bloat
- Grass tetany
- Phalaris staggers

For your chosen disorder complete the following:

- Name the disorder
- Identify what type/s of livestock are affected (includes particulars such as age of animals, production stages etc)
- Describe how the livestock are affected
- Describe the livestock symptoms (include images where possible)
- Describe how the livestock can be treated
- Describe how pasture management can be used to prevent the disease

Some useful pages include: [Bloat in cattle and sheep, Primefact](#), [Grass tetany in cattle-treatment and prevention, Primafact](#), [Phalaris staggers, LLS](#).

Practical activity: Clover identification

Background:

Profitable and effective grazing livestock management begins with understanding the forage (pasture) resource, including identifying the plant species present.

Learning to identify the names of pasture plants requires effort and time but can be a very useful tool for successful pasture management. The skill is developed through practice.

The following practical activity aims to develop skills in identifying some common temperate, improved-pasture legume species of NSW.

Students use their understanding of legume anatomy to identify temperate legume species.

Refer to the following excerpts from [Pasture Paramedic -Clover identification, MLA, 2020](#); to complete this activity.

Aim: To identify some common perennial clover species used in Improved pastures.

Materials:

- Assortment of different clover varieties. Plants should be between late vegetative to reproductive stage. (Late winter-early summer, before hot weather burns off clover). (Plants can either be supplied, or ideally collected on a paddock walk).
- Buckets
- Spades
- Ruler
- Microscope/ magnifying glass (optional)

Method:

1. Collect buckets and spades and conduct a pasture walk.
2. Select different clover species from the paddock, dig specimens out and place them in buckets.
3. Return to classroom with specimens.
4. Inspect clover specimen using a microscope or magnifying glass.
5. Make observations in terms of:
 - Leaf
 - ✓ Hairs present
 - ✓ Leaflet shape (oval, round, heart-shaped, pointed tip)
 - ✓ Leaflet margin (rounded, serrated)
 - ✓ Midrib (prominent, coloured, not prominent)
 - ✓ Hairs (present, not present)
 - ✓ Variegation (white, pale green, red, V-shaped, rounded, absent)
 - Stipules
 - ✓ Colour (Green, red, clear, purple)
 - ✓ Length x width (mm)
 - Veins (prominent)

- Stems
 - ✓ Colour
 - ✓ Hollow or solid
 - ✓ Width (thick, thin)
 - Petiole and petiolule- (extended, not extended)
 - Peduncle (flower stem)
 - ✓ Colour
 - ✓ Length (short, long)
 - Flowers
 - ✓ Colour (yellow, white, pink, purple)
 - ✓ Size
 - ✓ Arrangement
 - Burr- present, absent
 - Rhizomes- present, absent
 - Stolons – present, absent
6. OPTIONAL- Observe roots for nodules
 7. Record results into Results Table.
 8. Refer to [Pasture Paramedic -Clover identification, MLA, 2020](#). Analyse clover description and images to identify your clover specimen.
 9. Record common and scientific name into your Results table.
 10. Complete steps 4-10 for each clover specimen separately.

Results Table:

Clover specimen	Leaf						Stipules			Stems			Petiole and petiolule	Peduncle (flower stem)		Flowers (inflorescence)			Burr	Rhizomes	Stolons	Common and scientific name
	Hairs (present, absent)	Leaflet shape (oval, round, heart-shaped, pointed tip)	Leaflet margin (rounded, serrated)	Midrib (prominent, coloured, not prominent)	Hairs (present, not present)	Variegation (colour, V-shaped, rounded, absent)	Colour (Green, red, clear, purple)	Length x width (mm)	Venation (prominent)	Colour	Hollow or solid	Width (thick, thin)	Extended, not extended	Colour	Length (short, long)	Colour (yellow, white, pink, purple)	Size	Arrangement (globular cluster, calyx tubes)	Present, absent	Present, absent	Present, absent	
1																						
2																						
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

Add/delete rows as required



Main menu

Clover identification

Improved clovers

- + Sub-clover
- + White clover
- + Balansa clover
- + Persian clover
- + Strawberry clover
- + Arrowleaf clover

Commonly confused species

- + Medic
- + Nodding clover
- + Oxalis, soursob
- + Suckling clover

Oestrogenic sub-clovers

- + Yarloop
- + Dinninup
- + Dwalganup



Clover identification improved clovers

Sub-clover

Main menu

Species

Leaf appearance

Sub-clover

(*Trifolium subterraneum*)



Hairs on leaves, especially underside. Sometimes flecks or white or green markings on leaves.



Other distinguishing features

Produces runners in late winter (non-rooting horizontal stem).



Small white flower, sometimes with red pigmentation located across the flower tube.



Produces a burr.





Clover identification improved clovers

White clover

Main menu

Species	Leaf appearance
White clover <i>(Trifolium repens)</i>	No hairs. Leaf shape generally rounded with white crescents on upper leaf surface but can be variable.
	

Other distinguishing features

Perennial, so will grow during summer. Stolons with fibrous roots at nodes, some stolons may be buried.



Aerial seeder. Globular cluster of white-pink flowers on long stalks.



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Clover identification improved clovers

Balansa clover

Main menu

Species	Leaf appearance
Balansa clover <i>(Trifolium michelianum)</i>	No hairs. Trifoliate leaves vary greatly in size, shape and leaf markings. Leaflet margins are generally serrated.
	

Other distinguishing features

Hollow stem.



Aerial seeder. Globular cluster of white pinkish flowers on long stalks.



Stipules red.



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Clover identification improved clovers

Persian clover

Main menu

Species	Leaf appearance
Persian clover <i>(Trifolium resupinatum)</i> 	No hairs. No leaf markings. Leaflet margins can be smooth or serrated. Larger leaflets than balansa. 

Other distinguishing features

Hollow stem.



Aerial seeder. White pinkish to purple flowers. Flower petals flattened rather than forming a globular shape.



Green stipules, plants erect rather than spreading out.



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Clover identification improved clovers

Strawberry clover

Main menu

Species	Leaf appearance
Strawberry clover <i>(Trifolium fragiferum)</i> 	No hairs. Leaf shape generally pointed oval with little or no leaf markings. Veins closely spaced, and much branched, showing a curve from the midrib to the leaf edge which distinguishes it from white clover. 

Other distinguishing features

Perennial, so will grow during summer. Stolons with fibrous roots at nodes.



Aerial seeder. Flower head resembles a strawberry fruit. White pinkish flowers.



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Clover identification improved clovers

Arrowleaf clover

[Main menu](#)

Species	Leaf appearance
Arrowleaf clover <i>(Trifolium vesiculosum)</i>	No hairs on leaf. Distinct steep angled white arrow or V-shaped marking on upper leaf. Mature plants have pointed oval shaped leaflets.
	 

Other distinguishing features

Aerial seeder. Large white flowers which develop a pink tinge with maturity.



Flowering stems thick and red in colour. Stipules long narrow with prominent veins.



Clover identification commonly confused

Medic

[Main menu](#)

Species	Leaf appearance
Medic <i>(Medicago spp.)</i>	Stalk of middle leaflets longer than those of side leaflets. May have sparse hairs on leaves. Leaflets often serrated.
	

Other distinguishing features

Yellow flowers.



Produces a burr.





Clover identification commonly confused

Nodding clover, cluster clover

[Main menu](#)

Species	Leaf appearance
Nodding clover and cluster clover <i>(Trifolium cernuum and Trifolium glomeratum)</i>	Leaflets hairless. Leaflet stalks very short. Slightly serrated leaf margin.
	

Other distinguishing features

Plants hairless but occasionally a few hairs at the base of the leaflets and on the flower tube. Both species look identical with small pink flower head.

Nodding clover has flowers on short stems which turn down on maturity. Cluster clover clasps flower head close to the stem.



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Clover identification commonly confused

Oxalis, wood sorrel, soursob

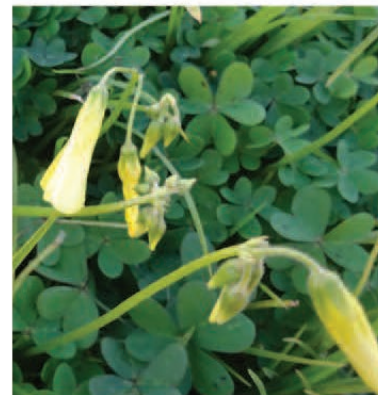
[Main menu](#)

Species	Leaf appearance
Oxalis, wood sorrel, soursob <i>(Oxalis pes-caprae and Oxalis corniculata)</i>	Heart-shaped leaves, sometimes with dark flecks. Few hairs on underside of leaf.
	

Other distinguishing features

Yellow tubular flowers on stalks.

Has bulbs (*Oxalis pes-caprae*) or tubers (*Oxalis corniculata*) which regrow each year.



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Clover identification oestrogenic Dinninup sub-clover

Main menu

Leaf

Green flattened crescent extends across most of the leaflet. May have small white arms, although only present under ideal conditions. Leaf stem hairy.



Stipule and runner hairiness

Distinct red veins and red pigmentation covering half of the stipule surface. Runners hairy.



Flower tube

Calyx tubes with red pigmentation covering one quarter to half of upper tube. Pigmentation fades with plant maturity. Flower stems hairy.



Other comments

Mt Barker is similar with red pigmentation on the calyx and stipule, which does not fade with maturity. It is also prone to blackish flecking on leaflets and a triangular shaped leaf marking.



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Clover identification oestrogenic Dwalganup sub-clover

Main menu

Leaf

Green triangle shaped crescent in leaf centre with white arms angled down from crescent to leaf margin edge. Hairy upper leaf and flower stem.



Stipule and runner hairiness

Veins on stipule red. Hairy to very hairy runners.



Flower tube

Calyx tube has no pigmentation or some are light pink on the tip of calyx tube. The flower stem is very hairy.



Other comments

Most similar in features to Dalkeith but Dalkeith has greater leaflet indentation, which gives the appearance of heart-shaped leaves.



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Practical activity- assessing effective nodulation of legumes in pastures

The following investigation is adapted from Meat and Livestock Australia (2021), "[How do I assess effective nodulation in legume pastures](https://www.mla.com.au/contentassets/ab149219e552408ab48ba9cc9eab833e/how-do-i-better-manage.pdf)",

<https://www.mla.com.au/contentassets/ab149219e552408ab48ba9cc9eab833e/how-do-i-better-manage.pdf>

Read the publication before conducting this investigation.

Background: Legumes, which include clovers and medics, are a family of broadleaf (dicotyledonous) plants that can produce their own nitrogen. They do this with the help of Rhizobium bacteria, which lives in nodules found on the plant's root system. Rhizobia capture (or 'fix') atmospheric nitrogen and convert it into a form that is available to plants. The relationship between the Rhizobium bacteria and legume plant is termed a symbiotic relationship.

Nodules are found mostly on legume roots but occasionally on stems. Nodules vary in shape and size, but all have structures and modifications from normal root cells that protect the oxygen-sensitive rhizobial enzymes from inactivation. They accomplish this while both delivering an energy supply to the bacteria and removing N-rich products.

Poor nodulation may limit nitrogen-fixation, which will limit plant growth and development, pasture quality and quantity and grazing livestock productivity. Improving legume nodulation can directly improve livestock production.

Legume seed must always be inoculated prior to sowing with a Rhizobium strain specific for the plant species. Legumes which are not inoculated well will have poor growth and may be light green-yellow coloured.

A well-nodulated plant will have at least 20 nodules on the root system. Healthy, active nodules will be pink in colour due to leghaemoglobin (see Figure 5) if they are effectively fixing nitrogen. If plants are assessed late in the growing season, effective nodules may appear dark pink to green in colour when cut open. White nodules can indicate the nodules contain ineffective strains of rhizobia and are poor at fixing nitrogen.

By dissecting a nodule, leghaemoglobin content can be seen. Leghaemoglobins are haem-proteins — crucial for supplying enough oxygen to root nodules for nitrogen fixation. The amount of leghaemoglobin in nodules shows how well the nodule is fixing nitrogen gas in the soil (N₂).



Figure 5 A cross section through multiple 'lupinoid' nodules on the root of *Lupinus angustifolius* showing strong leghaemoglobin content ([Source: Yates RJ, Abaidoo R and Howieson JG \(2016\) Field experiments with rhizobia. In: Working with rhizobia.](#))

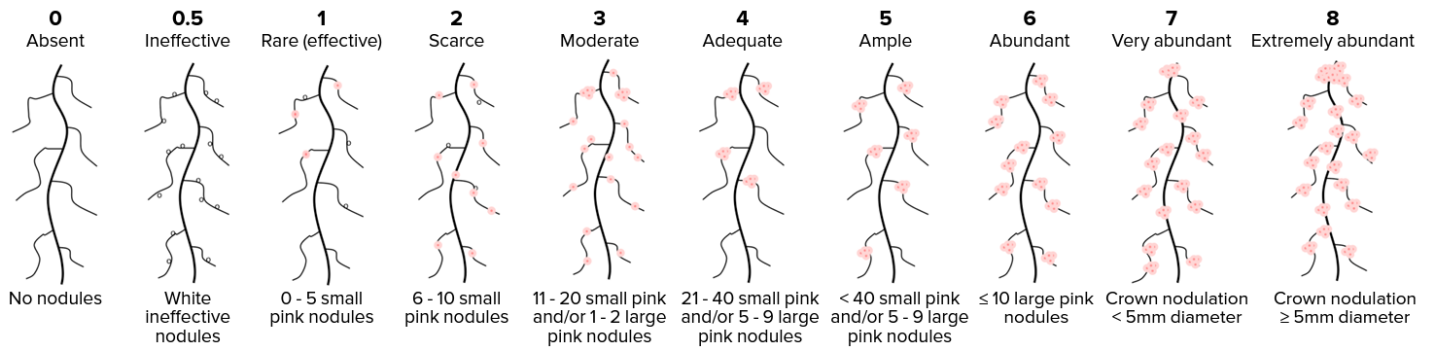
Aim: To observe and assess legume roots and nodules in a mixed pasture.

Materials:

- Pasture with legume content (approximately 20 legume plants)
- Shovel
- Bucket
- Water for washing plant roots.
- Ruler
- Tweezers
- Scalpel (or similar cutting equipment)
- Cutting board
- Microscope or hand lens (optional)

Method:

1. Assessment should occur a minimum of 12 weeks after germination (mid-late winter).
2. Randomly select 15-20 legume plants from a paddock.
3. For each plant: carefully dig out the plant including its entire root system (approximately width 30cm x depth 30cm). Do not pull plants out, as this will remove nodules and roots.
4. Collect plants in bucket and bring back to classroom.
5. For each plant -gently wash the root system, removing all soil. (Roots can be soaked in bucket overnight, to aid in cleaning roots).



6. For each plant, observe root system and nodules (use microscope or hand lens).

Figure 6 A nodulation scoring chart- applicable for both pulse and pasture legumes have <50 nodules per plant
(Source: [Meat and Livestock Australia \(2021\), "How do I assess effective nodulation in legume pastures"](#))

- Assess the number and colour of the nodules using the rating system in Figure 6. A well-nodulated plant will have at least 20 nodules on the root system and these nodules will be pink in colour due to leghaemoglobin (see Figure 5) if they are effectively fixing nitrogen. If plants are assessed late in the growing season, effective nodules may appear dark pink to green in colour when cut open. White nodules can indicate the nodules contain ineffective strains of rhizobia and are poor at fixing nitrogen.
- Use dissection equipment to dissect at least 5 nodules to observe evidence of leghaemoglobin. The brighter pink/red and larger the nodules the more leghaemoglobin present.
- Record observations into results table

Results table:

	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	(Insert more columns as required)
Number of nodules present									
Average nodule size									
Surface colour of nodules									
Inner colour of dissected nodules									
Leghaemoglobin present									

Discussion questions:

- 1) Three factors that limit legume nodulation are: soil pH, nutrient availability, and use of herbicides. Use research to identify and describe how these factors can be managed to improve legume performance, nodulation and nitrogen fixation. Hint: go to : [Meat and Livestock Australia \(2021\), “How do I assess effective nodulation in legume pastures”](#)

Native pastures

Australian native pastures have many benefits for both the environment and agricultural production.

Native grasses, legumes and forbs (herbaceous dicotyledons e.g. orchids and lilies) were the main vegetation in Australian grasslands for hundreds of thousands of years. Native grasses were the dominant species in these grasslands. Native grasses were most likely a mix of both tall, tufted warm-season (C4) and continually green (C3) perennials, such as kangaroo grass (*Themeda triandra*), wild sorghum (*Sorghum leiocladum*), spear grass (*Austrostipa* species) and *Poa* species. The dominant species varied with altitude, rainfall and soil type. Shorter grasses, such as red grass (*Bothriochloa macra*), purple wiregrass (*Aristida ramosa*), wallaby grass (*Austrodanthonia* species) and weeping grass (*Microlaena stipoides*) were mostly understory species.

The environment before European settlement featured highly weathered, shallow and infertile soils, regular drought, high summer temperatures and irregular grazing from highly mobile soft-footed herbivores.

Traditionally, Indigenous Australians used Firestick farming, a management technique of deliberately burning selected areas of vegetation. This encouraged new growth of native pasture plants and young shoots. The burns were low intensity, slow, cool burns, managed with firebreaks, and were dependant on seasonal conditions to prevent fires getting out of control. Repeated burning of the grasslands suppressed weed and tree growth.

Areas burned were alternated over years, which created a mosaic of vegetation at different stages of growth. Grazing rotations carried out today in agriculture have similar results.

Watch: [Considering Native Pastures](#) to see a cultural burning trial conducted on native pastures by the Kiewa Catchment Landcare group.



Unfortunately, much of our Australian native grasslands have been lost to urbanisation, tree clearing, changes to fire regimes and hydrology; introduced domestic and feral herbivores; introduced exotic plants; increased soil disturbance and changes to soil nutrient levels. Unfortunately, these impacts were not monitored, resulting in changes to the species and spread of native plants, with remnant patches of grasslands now solely remaining across the country.

Features of native grasses

Australian native grasses are adapted to soils that have weathered and eroded over millions of years and so are able to grow on soils that are more like subsoils in other parts of the world.

Australia regularly suffers from severe droughts and low rainfall. Australian native grasses are well adapted to this and are usually the first grasses to recover after a drought. They have a variety of mechanisms for tolerating drought, either by entering a long dormancy, or by having a below-ground crown which can survive drought and grazing. Once native grasses are established, they can survive with minimal watering or irrigation.

Both native and improved pastures have a place within a sustainable farm grazing system.

Benefits of native grasses in a mixed pasture:

- Adapted to thrive in our adverse climate conditions such as droughts, heavy rains and frosts.
- Many tolerate low fertility, acid soils, water stress, and are disease resistant.
- Different native species (e.g., warm season or cool season grasses) have growth periods at different times of the year, providing year-round green feed and the ability to provide quality feed during seasonal feed gaps (e.g., winter). Winter/spring active species flower and set seed in mid to late spring (e.g., wallaby grass and annual grasses) while summer growing species flower and set seed mid to late summer depending on rainfall (e.g., microlaena, red grass and kangaroo grass)
- Most have dense tillers and fibrous roots that hold the soil and maximise the use of soil moisture, help prevent soil erosion, nutrient leaching and water runoff.
- Some perennial native grasses can help control dryland salinity due to their deep root systems, which reduces groundwater recharge.
- They can provide a lower input grazing system, reducing the dependence on input of resources fertiliser, seed, fuel water etc.
- Increase biodiversity.
- Well suited to shallow soils such as drier slopes, stony outcrops and exposed hills.
- Some native species thrive under increased fertility and controlled grazing, eg *Microlaena* (Weeping Grass) and *Austrodanthonia* (Wallaby Grass), while others will decline, eg *Themeda australis* (Kangaroo Grass). Sustainable management must be based on the needs of the dominant perennial native grass species to ensure their survival.

Limitations of native grasses:

- Native grasses are unlikely to be more productive or outcompete improved pasture species.
- Some wild species have diverse genetic traits, flower over a long period, have lower seed yields or do not yield commercial quantities of viable seed.
- Some species are less palatable to stock due to coarse hairy leaves and have lower nutritional values and herbage yield.

- Difficult to establish through sowing with traditional sowing technologies.
 - Overgrazing can destroy the native species composition in a mixed pasture. When the populations are lowered by overgrazing, invasion by less desirable species through competition occurs with weeds species.
 - Nitrogen and phosphorous-based fertilisers can reduce productivity and even kill native species in a pasture. Only apply fertilisers to native pastures that contain a legume and are dominated by species which will respond to increased fertility, e.g., Microlaena, Spear Grass, Red Grass and Wallaby Grass.
 - Some native grasses, eg Microlaena and Wallaby Grass, are extremely sensitive to commonly used perennial grass weed herbicides, ie Flupropanate. Avoid boom spraying native pastures where possible and promote pasture density to minimise weed competition.
1. Complete the table to summarise advantages and limitations of including perennial native grasses in a mixed pasture.

Including native perennial grasses in a mixed pasture	
Advantages	Limitations

2. Use research to describe a minimum of two management techniques used to restore native grasses in a grazing system.

[illegible]

3. Use research to list a minimum of 5 native grasses indigenous to your local area and agro-ecological zone.

4. Describe the role of native pastures in pasture production systems.

[illegible]

Practical activity: Identify some common native perennial grasses.

Background: A better understanding of native grasses and their use in a grazing system has potential benefits.

Native grasses are the basis of historical Australian grasslands. A diverse and healthy native grass understorey in a mixed pasture can improve the biodiversity outcomes on any property.

Native grasses may be found in areas of any property that has been grazed but not recently cultivated, such as hilly country, remnant bushland, amongst rocky outcrops, along fence lines or on nearby roadsides.

Note: this activity should be adapted to suit native species in your local environment.

Alternative resources for native species identification around Australia include:

- [AusGrass: Grasses of Australia](https://keys.lucidcentral.org/search/ausgrass-grasses-of-australia/), <https://keys.lucidcentral.org/search/ausgrass-grasses-of-australia/>
- CSIRO, (2002), [Native Grasses: Identification handbook for temperate Australia](https://ebooks.publish.csiro.au/content/native-grasses). CSIRO Publishing - <https://ebooks.publish.csiro.au/content/native-grasses>

Adapt this activity to your Agro-ecological zone and resources available.

Aim: To identify some common temperate perennial native grasses.

Materials:

- Mixed temperate pasture with native species, in land that has not been cultivated.
- Access to EverGraze, (2013) [“Identifying native perennial grasses “](#) poster.
- Variety of different grass species. Plants should be between late vegetative – reproductive stage. (Plants can either be supplied, or ideally collected on a paddock walk).
- Buckets
- Spades
- Ruler
- Microscope/ magnifying glass (optional)
- Scalpel (optional)
- Tweezers (optional)

Method:

1. Collect buckets and spades and conduct a pasture walk.
2. Select different native grass species from the paddock, dig specimens out and place them in buckets.
3. Make a note of habitat and growth characteristics of each specimen collected.
4. Return to classroom with specimens.

5. Inspect a grass specimen using a microscope or magnifying glass.
6. Make observations in terms of:
 - Habitat
 - ✓ Soil type
 - ✓ Soil depth
 - ✓ Topography
 - ✓ Shade/sun
 - Growth characteristics
 - ✓ Height (cm)
 - ✓ Fine/coarse leaves
 - ✓ Upright/erect
 - ✓ Tussock/tufted grass
 - Seed head
 - ✓ Spike; panicle; spike-like panicle; whorled branches; digitate inflorescence; or cluster of spikelets in a spathe ([See Practical activity: Identify common improved-pasture grasses](#))
 - ✓ Seed head length (cm)
 - Leaf blade
 - ✓ Surface (shiny, dull)
 - ✓ Colour (grey, lime, green, bluish etc)
 - ✓ Fine/coarse leaves
 - ✓ Hairiness
 - ✓ Folded, rolled, flat
 - ✓ Leaf margin (smooth, serrated etc)
 - ✓ Any distinctive features
7. Record results into Results Table.
8. Compare results to EverGraze, (2013) [“Identifying native perennial grasses “](#) poster. (Following Results Table) to identify the grass specimen.
9. Record scientific and common name into Results Table.
10. Complete steps 4-10 for each grass specimen separately.

Results Table: (add rows as required)

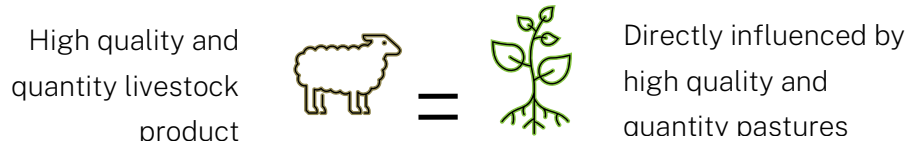
Grass specimen	Habitat				Growth characteristics				Seed head		Leaf blade						Distinctive features	Common and scientific name
	Soil type	Soil depth	Topography (hilly, slopes, creek flat etc.)	Incidence of shade/sun	Plant height (cm)	Fine/coarse leaves	Upright/erect	Tussock/tufted/ground-dwelling grass	Seed head type (panicle, etc.)	Seed head length (cm)	Surface (shiny, dull)	Blade colour	Fine/coarse leaves	Presence/amount of hair	Folded, rolled, flat	Leaf margin (smooth, serrated etc.)		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
etc																		

Identifying native perennial grasses

 Native Wheatgrass <i>Elymus scaber</i> Habitat: grows on most soil types, particularly in moist and shaded areas of paddocks. Growth Habit: a loosely tufted grass up to 100cm height; highly variable in appearance. Seed Head: a narrow spike to 25cm long, spikelets with many awned florets; awns straight when young and curved at maturity. Leaves: leaves often have a half twist; flag leaf (directly below seed head) sticks out at a right angle. Other Distinctive Features: auricles present. Cool season perennial	 Rough Speargrass <i>Austrostipa scabra</i> Habitat: widespread and common occurring on rocky outcrops, westerly aspects and lighter textured shallow or well drained soils; common in low ground cover positions with limited soil depth. Growth Habit: erect tufted grass to 80cm tall. Seed Head: a moderately contracted to open panicle to 30cm long, spikelets are 10-15cm long, sharply pointed with a long sickle shaped awn. Leaves: leaves are very fine, long and strongly rolled; leaves are rough to touch. Year-long green perennial	 Plains Grass <i>Austrostipa aristatum</i> Habitat: common to dominant in native/naturalised pastures on heavy clay (particularly black earth) soils of the north slopes and plains; prefers good moisture, high fertility and neutral to alkaline pH. Growth Habit: coarse and densely tufted to 180cm height; tussocks up to 30cm in base diameter. If underutilised, plants are often a mixture of tall senesced older growth and fresh green shoots. Seed Head: to 55cm long and loose whorled branches when mature, seed bases are sharply pointed with awns to 4cm long and twice bent. Leaves: to 40cm long, ribbed, generally hairless and often rough to touch. Year-long green perennial
 Wallaby Grasses <i>Antrodoranthia</i> spp. Habitat: widespread and common with a number of species occurring in NSW and Victoria; some species adapted to hard, shallow soils through to species on clay soils. Growth Habit: fine leaved tufted grass to 100cm tall. Seed Head: a contracted to open panicle; spikelets green, with pink tinges in early flowering, become fluffy white with maturity. Leaves: grey-green to dark green and often hairy; hairy fringe at the junction of the leaf blade and leaf sheath. Year-long green perennial	 Native Millet <i>Panicum decompositum</i> Habitat: mainly occurring on heavy clay soils, in depressions and along floodplains. Growth Habit: can form large, upright tussocks to 145cm in height; difficult to distinguish from other Panicum species including <i>P. queenslandicum</i> (Yabla grass). Seed Head: becomes a large, open branched panicle at maturity, with spikelets commonly paired and hairless; pollen sacs are deep orange; ripe seeds are 1.5-2mm long. Leaves: wide, mostly hairless, light blue-green (often with white mid-rib) to 50cm long and 12mm wide. Warm season perennial	 Common Windmill Grass <i>Chloris truncata</i> Habitat: widespread on many soil types; useful coloniser of bare areas following summer rain, relatively salt tolerant. Growth Habit: tufted grass, usually less than 20cm height; contains stolons (runners) that can root down at the node. Seed Head: windmill-like (digitate) seed head consists of 6-9 spikes that radiate out like spokes of a wheel from main stem; truncate spikelets are arranged in two rows on the underside of branches; black seeds are blunt and awned. Leaves: hairless, pale green-blue green in colour, short and narrow with an abrupt taper at the tip (boat shaped); new leaves are folded lengthwise along the mid rib. Warm season annual-perennial
 Kangaroo Grass <i>Themeda australis</i> syn. <i>Themeda triandra</i> Habitat: grows on most soil types; a widespread species often found in non-arable areas and landscapes that have been protected from grazing or only lightly grazed (e.g. roadsides and travelling stock reserves); considered a widespread and dominant species prior to European settlement. Growth Habit: an erect, densely tufted grass to 150cm height. Seed Head: contains leaf like structures (spathe) and fertile spikelets have long black awns. Leaves: blue-green in summer and rust purple after frothing; leaves are folded with long hairs at the leaf-sheath junction; sheath is hairy. Warm season perennial	 Warrego Summer Grass <i>Paspalum jubiflorum</i> Habitat: common in paddock depressions, swamps, most productive on heavier, fertile soils, responds well to flooding and inundation. Growth Habit: a leafy and slender tussock forming grass with erect stems growing from 30-120cm in height. Seed Head: a closed panicle; long and narrow with up to 16 branches (each up to 4cm long) pressed against the main stem, seeds are pale green to straw coloured, are round and have no awns. Leaves: smooth, flat and narrow, up to 25cm long, tapering to a long fine point. Other Distinctive Features: stem joints (nodes) and leaf sheaths are hairy and long hairs surround the ligule. Warm season perennial	 Curly Windmill Grass <i>Entropogon aciculatus</i> Habitat: occurs across a range of soil types; more common in conservatively grazed paddocks; good drought and flood tolerance, moderate frost tolerance. Growth Habit: potentially long-lived perennial with a dense, tussock forming habit to 110cm height. Seed Head: digitate, containing several and up to 15 branches that radiate out like spokes on a wheel across several planes. Spikelets are awned, light in colour and narrower than <i>Chloris truncata</i>. Leaves: broad and flat, variably hairy and often a distinct blue-green; older leaves become crumpled, curled or spiralled. Warm season perennial
 Hairy Panic <i>Panicum effusum</i> Habitat: most common in dry areas on sandy or shallow low fertility soils; found in low – moderate abundance in native pastures, woodlands or disturbed areas. Growth Habit: a short, tufted grass to 50cm height. Seed Head: is a wide open panicle with spikelets often paired at the end of branches. Leaves: are flat and dull green-grey colour; leaf sheaths and nodes are hairy; there are distinctive long glandular hairs along leaf margins. Warm season perennial	 Paddock Lovegrass <i>Eragrostis leptostachya</i> Habitat: found in woodlands, native pastures and naturalised pastures; widespread on low-moderate fertility soils. Growth Habit: a slender, tufted grass to 90cm height; prostrate growth habit common in grazed pastures. Seed Head: consist of open, spreading branches (panicle) that is more than twice as long as broad; branches and spikelets branching approximately at right angles; spikelets often lead pencil coloured with many divisions (toothed appearance). Leaves: leaf blades are rolled in the bud and smooth along the margins; leaf sheaths are hairy. Warm season perennial	 Redgrass <i>Bothriochloa macra</i> / <i>decipiens</i> Habitat: occurs on most soil types but often dominant on poor, lower fertility soils; frequently invades overgrazed or bare pastures when fertility levels decline; does not occur on highly acidic soils. Growth Habit: tufted grass with prostrate basal leaves & erect wiry stems to 100cm. Seed Head: 3-4 erect branches usually pressed together; branch bases are bare; spikelets are awned and often pitted. Leaves: leaf blades are rolled in the bud; sheath & blades have prominent mid rib. Other Distinctive Features: stems have red, hairless nodes turning dark red after seeds fall. Warm season perennial
 Snow or Tussock Grass <i>Poa sieberiana</i> Habitat: a widespread species often found in woodland and forest environments; more common on well drained upper slopes than lower drainage lines. Growth Habit: a densely tufted grass to 80cm height. Seed Head: pyramid – shaped and open, varying from green to purple in colour. Leaves: green to grey-green, long and fine; rough to touch and without a ligule. Year-long green perennial	 Weeping Grass <i>Microlaena stipoides</i> Habitat: common, especially in damp or semi-shaded areas; highly tolerant of soil acidity and exchangeable aluminium; resilient native species during drought. Growth Habit: a perennial grass of variable form often with a low growing, dense leafy tuft. Seed Head: narrow and weeping (raceme or panicle); spikelets have two straight awns to 20mm length. Leaves: flat lime or blue green with a boat – shaped tip and commonly a notch or pinch near the tip. Other Distinctive Features: small auricles present. Year-long green perennial	 Three-awned Wiregrass <i>Aristida ramosa</i> Habitat: grows on poor, shallow and sandy soils of low fertility. May exist on better soils that are poorly managed. Growth Habit: tufted up to 120cm high. Seed Head: spikelets have a sharply pointed base and distinct three – branched awn. Leaves: very fine, coarse, narrow and often pale coloured. Other Distinctive Features: stiff wiry stems that are often branched at the nodes (stem joint). Warm season perennial

Livestock production from pasture systems

The quality and quantity of animal product grown from pasture-fed livestock is directly linked to the quality and quantity of the pastures they graze. The nutrient requirements of animals are most economically met by grazing pastures.



The most critical factor in the productivity of grazing livestock is the amount of pasture the animals eat (intake). Intake is influenced by pasture quantity and quality.

Pasture quantity

Pasture quantity, or herbage mass, is expressed in kilograms of pasture dry matter per hectare (kg DM/ha). Herbage mass refers to the total amount of dry matter present, including both green and dead material. $\text{Herbage mass (kg DM/ha)} = \text{total green} + \text{dead material}$.

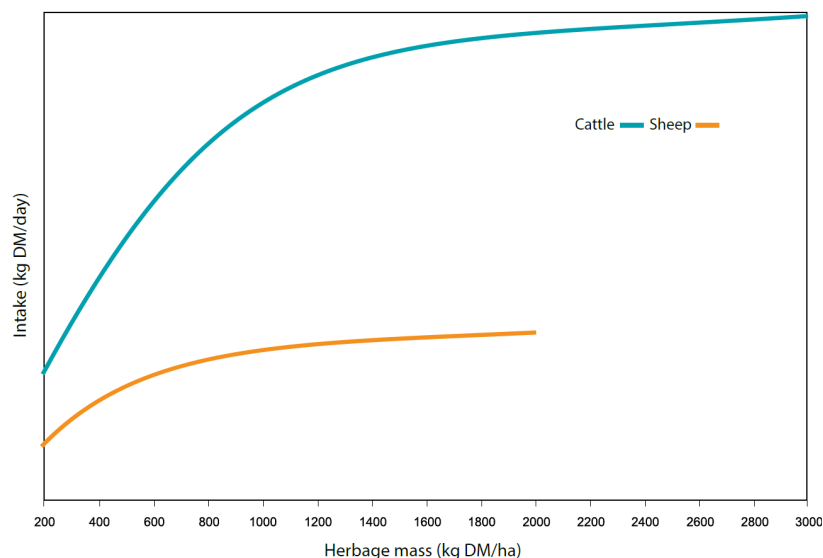


Figure 7 Influence of herbage mass on intake of sheep and cattle. ([Source: Prograze- Profitable, sustainable grazing, NSW DPI, 2017](#))

Herbage mass is expressed in terms of dry matter because the water content of pasture can vary depending on the time of day, different species and different stages of plant growth. For example, a young, leafy, rapidly growing pasture may contain 85% water (or 15% dry matter) while flowering grasses may be 50% water and 50% dry matter. Dead pasture on a hot summer day may be over 90% dry matter. While being vital for life, water itself has no nutritional value for livestock. When relating herbage mass to what the animal can eat and utilise, the water content is ignored.

If herbage mass drops below certain levels sheep and cattle are unable to consume enough pasture to maintain their weight. When herbage mass is low, animals must spend more time

grazing to meet their nutritional needs, since each bite of pasture harvests a smaller amount. In this case animals may be unable to consume enough pasture to satisfy their requirements.

Similarly, there is a point at which intake will not increase even if more pasture is made available because animals physically cannot consume more. They have reached their intake capacity for that quality of pasture.

The relationship between herbage mass and intake is described in Figure 7. For sheep, intake rises sharply as herbage mass increases to around 800 kg DM/ha and only small increases in consumption occurs.

When a paddock contains a greater herbage mass than required for the livestock class grazing it, stocking density should be changed to improve the grazing of pasture above 1600 kg DM/ha. With cattle these figures are 1200 and 2300 kg DM/ha.

1. Describe the relationship between animal production and pasture production in terms of quality and quantity.

2. List two factors which influence grazing livestock feed intake.

3. Define herbage mass?

4. Explain why herbage mass (kg DM/ ha) calculation does not include pasture water content.

6. Analyse Figure 7 to describe the trend between sheep and cattle intake and herbage mass.

Pasture quality

Pasture quality affects how much animals will eat. Digestibility, plant growth stage and the proportion of legume are useful measures of intake.

Digestibility

Digestibility, expressed as a percentage, can predict the proportion of the pasture that can be used by the animal for growth, development and maintenance. For example, if the digestibility of a pasture is measured at 70%, approximately 70% of feed consumed on a dry matter basis will be used by the animal for its growth and production requirements, while 30% will eventually pass as faeces.

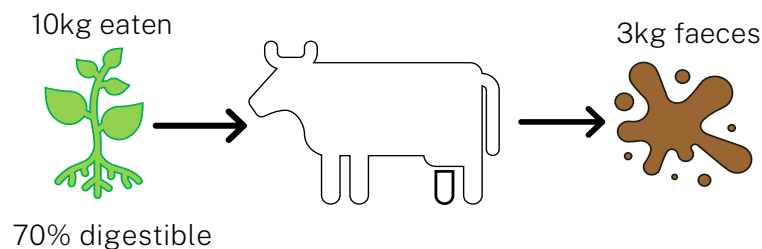


Figure 8 Digestibility measures the amount of pasture utilised by the animal

Digestibility influences the time feed spends being digested in the animals' stomach. A pasture with a high digestibility % will move quickly through the animal allowing it to consume more. More pasture consumed equals higher production.

In a pasture with low digestibility, even if there is plenty available (high quantity), stock cannot digest enough feed to meet nutritional requirements (low quality).

A digestibility target is equal or greater than 60%. Below 60% digestibility, all classes of livestock will lose weight.

Digestibility is a useful measure of quality because:

- It is directly related to the energy content of the pasture. Energy is needed by animals for body functions. Energy in feed is assessed as megajoules metabolisable energy per kg of dry matter (MJ ME/kg DM).
- Digestibility is positively related to protein content – when digestibility is high, protein content will also be high. However, there is variation between pasture species in protein content. For example, clovers are generally higher in protein than grasses.
- Digestibility directly relates to the speed of digestion and therefore the movement of feed through the animal. In general, pastures with higher levels of digestibility will be digested quickly, allowing increased intake and increased animal production.

Digestibility differs between pasture species, variety, plant part consumed and plant growth stage. Some examples:

- Pasture growth stage has a major influence on digestibility. Actively growing, green, vegetative growth has a higher digestibility than mature plants in the reproductive phase.
- Legumes usually have a higher digestibility than grasses. It is important to maintain legumes in a mixed pasture. A rule of thumb targets 70% grass: 30% legume content.
- At the same digestibility % the intake of legumes can be expected to be greater than the intake of grasses
- Perennial grasses are more digestible for a longer period than annuals as annuals die off after seed production.
- Leaf material has a higher digestibility % than stem.
- Burrs and pods (seed plus fibrous casings of legumes) have low digestibility compared to leafy green growth.
- Pasture species impacts digestibility. The digestibility of tropical pastures is 10% below temperate pasture at the same growth stage (See Figure 9).

Plant growth stage

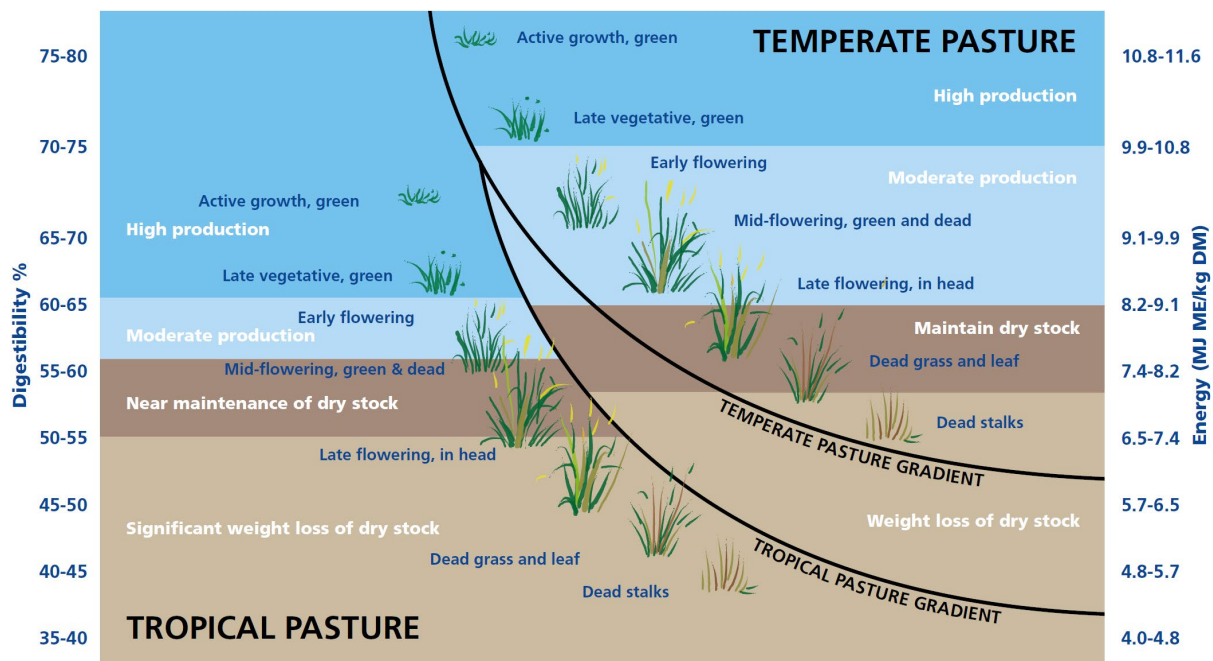


Figure 9 A guide to digestibility decline as pastures mature ([Beef Calendar of Operations, Local Land Services, 2020](#)).

Plant growth phase may be described as vegetative or reproductive.

Vegetative growth includes seed germination, leaf production and stem extension in legumes, or tillering in grasses. Reproductive growth stages (anthesis) include bud development in legumes or head growth and development in grasses, flowering, grain or fruit/pod development, seed development. If the plant is an annual, biannual, or ephemeral it will then enter senescence which involves cell decay and plant death.

Young, actively growing plants, in the vegetative stage, have the highest digestibility. Digestibility decreases as plants mature, particularly as they enter their reproductive phase and prepare to flower (anthesis).

Following flowering the plant enters senescence and digestibility declines rapidly. Senescence is indicated by declining green herbage and a rapid increase in dead herbage. In this type of pasture, digestibility (55–60%) has reached a point where the pasture will barely maintain the weight of stock even if herbage mass is not limiting intake.

In dead pastures, if a high amount of leaf remains, particularly clover leaf, digestibility should be in the range of 50–55%. Where the dead leaf has largely disappeared from the pasture, intake will be too low to maintain animals, and weight loss will occur (digestibility of 40–50%).

The digestibility of cereal straws is likely to be in the range of 35–40%. A dry crop or frosting can result in stubbles of up to 50% digestibility. Rain on dead standing feed will cause a drop in digestibility, and the feed value of the dead pasture.

For high livestock production, grazing management should aim to keep pastures in the vegetative growth phase for as long as possible, delaying the onset of flowering and the

decrease in digestibility. This is achieved through grazing management, slashing or fodder conservation.

Legume content

The amount of legume in the pasture is the third influence of pasture quality. Legumes are critical in good pastures, being the major source of nitrogen for pasture grasses (nitrogen fixation). Legumes are also important to livestock production.

Legumes at the same stage of growth will often have a higher digestibility than grasses. So, intakes can be expected to be higher on pastures containing more legume (selective grazing). Protein levels of legumes are usually higher than grasses, especially as they approach maturity.

1. Define digestibility.

2. List the digestibility % target. What happens to livestock under this digestibility %?

3. Label the statements as True =T or False= F

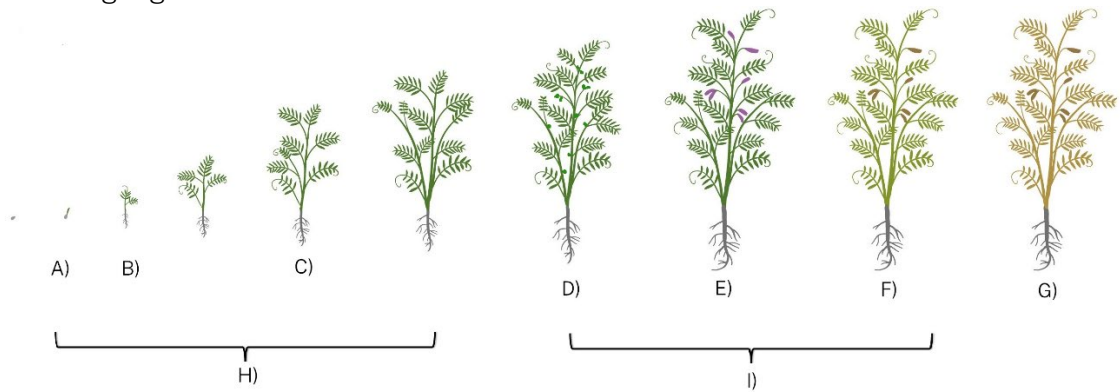
- a) Digestibility influences the time feed spends being digested in the animals' stomach. A pasture with high a digestibility % will move quickly through the animal allowing it to consume more.
- b) On a pasture of high digestibility, even though plenty may be available, stock cannot digest enough feed, to meet nutritional requirements (low quality).
- c) Energy is needed by animals for body functions. Energy in feed is assessed as megajoules metabolisable energy per kg of dry matter (MJ ME/kg DM).
- d) Digestibility is always the same between pasture species and varieties, parts of a plant and for the stage of growth of the plant.
- e) Perennial grasses are less digestible for a longer period than annuals because perennials die off after seed production.
- f) Leaf material has a higher digestibility % than stem.
- g) Digestibility declines as pasture matures.

4. A pasture has 40% digestibility. An animal consumes 20kg. Calculate the amount (kg) the animal uses for production and the amount (kg) passed as faeces.

5. List the plant growth and development stages included in vegetative growth for grasses and legumes.

6. List the plant growth and development stages included in reproductive growth for grasses and legumes.

8. Apply your understanding to label the growth and development stages for the following legume.



	Growth and development stage		Growth and development stage
A)		F)	
B)		G)	
C)		H)	
D)		I)	
E)			

9. Explain how a manager could optimise livestock weight gain through pasture management.

[illegible]

Pasture quantity and quality interactions

Pasture quantity (herbage mass) and pasture quality (digestibility) are linked. At low herbage mass, with high digestibility, livestock intake will be limited due to small bite size.

Livestock production in a pasture with low herbage mass and high digestibility is not improved by reducing the stock numbers in a paddock (lowering stocking density).

Due to the link between herbage mass and digestibility there can be trade-offs between the two to achieve the same production in livestock. For example, animals with lower nutritional requirements such as dry cows or ewes for maintenance can be matched to a lower quality and quantity pasture to meet production targets.

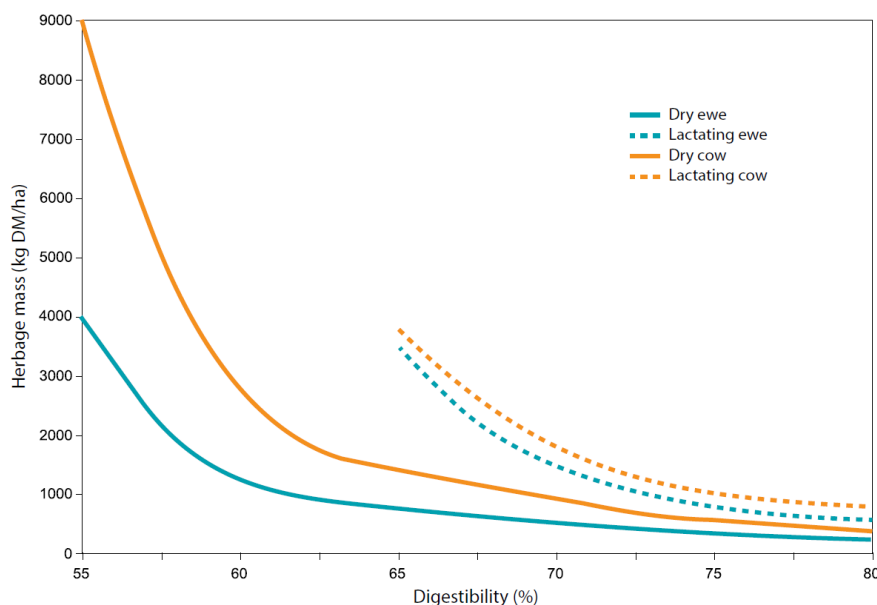


Figure 10 Trade-off between digestibility and herbage mass. (Source: [Prograze- Profitable, sustainable grazing, NSW DPI, 2017](#)).

Figure 10 shows the interaction between digestibility, herbage mass and livestock production from four classes of livestock. Dry sheep require a herbage mass of 2200 kg DM/ha at 57% digestibility to maintain weight. At 70% digestibility, only 500 kg DM/ha is required.

Below 55% digestibility, it does not matter how much herbage mass is available – dry stock will lose weight. In the case of lactating cows, 3800 kg DM/ha at 65% digestibility achieves the same production level in the same cows as 1050 kg DM/ha at 75% digestibility.

Where high production levels are required, there is less opportunity for trade-offs between availability and digestibility. Digestibility of the green component needs to be above 70% and the amount of green for sheep around 1500 kg green DM/ha; for cattle around 2500 kg green DM/ha.

Pasture benchmarks

Pasture benchmarks indicate how much green herbage mass is required to satisfy the nutritional requirements of stock at various production stages and for growth.

Benchmarks provide rough estimates for the minimum green herbage mass to which stock can graze and still have satisfactory levels of production. Factors determining herbage mass are pasture height, pasture density and dry matter %. The 'sample pasture' on which the benchmarks are based is one which is green, reasonably dense; the first 3 cm of height is equivalent to about 1000 kg DM/ha, with each centimetre after that equivalent to about 200 kg DM/ha.

Table 1 Minimum herbage mass (kg green DM/ha) in temperate pastures to maintain satisfactory production levels in sheep.

Sheep classes		Pasture digestibility (green)		
		75%	68%	60%
Dry sheep		400	600	1200
Pregnant ewe	Mid	500	700	1700
	Last month	700	1200	Not sufficient
Lactating ewe	Single	1000	1700	Not sufficient
	Twins	1500	Not sufficient	Not sufficient
Growing stock, % of potential growth	30 (116g/day)*	400	700	1700
	50 (194g/day)	600	1000	Not sufficient
	70 (270g/day)	800	1700	Not sufficient
	90 (340g/day)	1600	Not sufficient	Not sufficient
* Predicted growth rates in brackets are based on a weaned 4-month-old, crossbred lamb of approximately 32 kg from a ewe with a standard reference weight of 55 kg.				

Table 2 Minimum herbage mass (kg green DM/ha) in temperate pastures to maintain satisfactory production levels in cattle.

Cattle classes		Pasture digestibility (green)		
		75%	68%	60%
Dry cow		700	1100	2600
Pregnant cows	(7-8 months, not lactating)	900	1700	Not sufficient
Lactating cow	Lactating cow + 2-month old calf	1100	2200	Not sufficient
Growing stock, % of potential growth	30 (0.45 kg/day)	600	1100	2900
	50 (0.76 kg/day)*	800	1600	Not sufficient
	70 (1.07 kg/day)	1200	2600	Not sufficient
	90 (1.37 kg/day)	2200	Not sufficient	Not sufficient
*Predicted growth rates in brackets are based on a weaned 13-month-old steer of approximately 320 kg from a cow with a standard reference weight of 500 kg.				

Stock management based on benchmarks should ensure animals' nutritional requirements needs are met. Sometimes this is not possible or even desirable. When this occurs, supplementary feeding, selling, agisting or paddock rotation are essential. Sometimes, controlled weight loss can be a sound management option. For example, when ewes are fat at the end of joining, it is desirable that they lose body weight slowly during early pregnancy. This can be achieved by grazing pasture below the maintenance (dry sheep) benchmark, or by providing a higher herbage mass that has a lower digestibility. The same principle applies to over-fat heifers in late pregnancy.

- Complete the sentences by filling in the missing words:
Pasture _____ (herbage mass) and pasture _____
(digestibility) are linked. At _____ herbage mass, with
_____ digestibility, livestock intake will be _____ due to
_____ bite size.

- Explain what pasture benchmarks are?

- Apply your understanding from this section to complete the following activity.

Scenario- A mixed farming system with three enterprises: grower cattle, prime lambs and hay making. Allocate each paddock to the livestock group or management practice. Make your choices based solely on matching the herbage mass and digestibility to the production groups.* Hint not every paddock might be suitable to production.



Livestock groups:

- Overweight yearling heifers
- Yearling steers
- Dry ewes
- Ewes with single lambs
- Ewes with twin lambs
- Management objective – select one paddock to cut for hay

Paddock 1 • Native pasture • Herbage mass: 9000kg/DM/ha • Digestibility: 56%	Paddock 2 • Naturalised pasture-kikuyu dominant • Herbage mass: 1250kg/DM/ha • Digestibility: 60%	Paddock 3 • Microlaena/ white and subterranean clover • Herbage mass: 480kg/DM/ha • Digestibility: 78%
Paddock 4 • Phalaris /white and subterranean clover • Herbage mass: 2000kg/DM/ha • Digestibility: 75%	Paddock 5 • Grazing oats • Herbage mass: 7800/DM/ha • Digestibility: 74%	Paddock 6 • Phalaris /white and Microlaena • Herbage mass: 2200kg/DM/ha • Digestibility: 68%
Paddock 7 • Grazing oats • Herbage mass: 380kg/DM/ha • Digestibility: 70%	Paddock 8 • Medic based improved pasture. • Herbage mass: 2000kg/DM/ha • Digestibility: 74%	Paddock 9 • Perennial rye and Lucerne • Herbage mass: 700kg/DM/ha • Digestibility: 76%

*in real life, a feed budget would be developed based on stock numbers and potential pasture regrowth. This activity is solely about matching production targets to pasture benchmarks.

Match the livestock group/s or management practices best suited to each paddock in the table below.

Paddock 1	Paddock 2	Paddock 3
Paddock 4	Paddock 5	Paddock 6
Paddock 7	Paddock 8	Paddock 9

4. Are all paddocks suited to production? If no, which one/s and why?

5. Identify and explain a management practice that uses paddocks unsuited to production?

[illegible]

Practical activity- Measuring herbage mass (pasture quantity) assessment using a quadrat.

Recommendation – Carry out this practical along with [Practical activity- Estimating herbage mass \(pasture quantity\) using a MLA pasture ruler](#) to compare between both methods.

Background: Pasture assessment is the key to making better grazing decisions. To get the benefit of feed budgeting, it is essential to know:

- **Quantity:** the mass of pasture available for livestock
- **Quality:** the feed value of the pasture. From this the stock rate can be estimated; length of time with available feed and stock growth rate can all be estimated. Feed budgeting can determine the number of stock needed to buy or sell with changing seasonal conditions; or how much supplementary feed will be needed.

Pasture quantity, or **herbage mass**, is expressed in kilograms of pasture dry matter per hectare (**kgDM/ ha**). Herbage mass refers to the total amount of dry matter pasture present, including both green and dead material.

Herbage mass is determined by pasture height, pasture density and percentage of dry matter (the non-water component).

There are many methods to measure herbage mass. This activity uses the median quadrat method.

A quadrat is typically a square frame constructed of plastic or PVC pipe, metal rod, or wood that is placed directly on top of the vegetation. Quadrats are also commonly called "plots."

Quadrats do not have to be square but their area and conversion factor (cm^2/ha) must be known.

Quadrats are required for estimating several vegetation analysis including:

- **Density** - for counting the number of objects within the unit area of the quadrat.
- **Herbage mass (Biomass)** - achieved by "clipping" all the material of a given type (e.g., grass, shrub or forb) or species within a quadrat.
- **Cover** - often achieved by estimating the area of a quadrat that is covered by a plant's canopy.
- **Plant frequency** - the proportion a species occurs in a quadrat is called frequency.

When conducting herbage mass assessments using a quadrat, make sure to take unbiased samples. For example, take 20 steps and drop quadrat at toe, or throw quadrat and walk to it. If bias is not removed results will not be accurate. The best method might be to walk across the paddock in a zigzag pattern for a pre-determined number of steps in each direction and placing the quadrat at your toe.

Aim: To determine what quantity of herbage mass is available, using the quadrat technique.

Materials:

- Pasture
- 1.5 m × 0.5 m, median quadrat or 0.5m x 0.5m quadrat. It is important that the dimensions are accurate if building your own (see Figure 11).
- Battery operated or manual shears
- Paper bags
- Bucket
- Fan forced or microwave oven
- Digital scales capable of weighing to a gram
- Forceps/tweezers
- Pen and paper

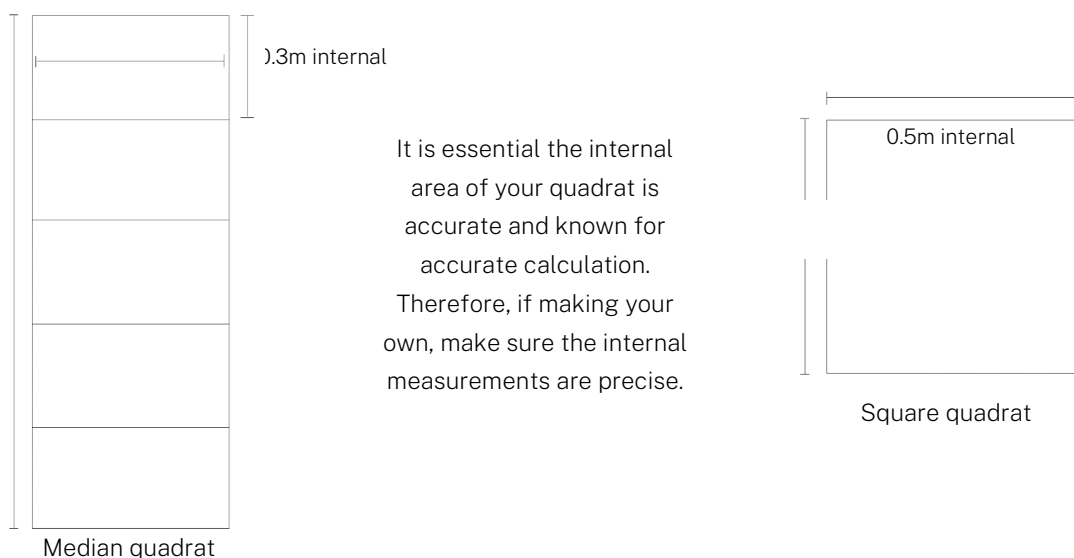


Figure 11 Dimensions for Square and Median quadrats

Method:

1. **Collect herbage samples.** Choose the area of pasture to be assessed. An area that represents the paddock will be critical for an accurate assessment. Before selecting the representative area, Check all parts of the paddock to identify the paddock's variation. The area selected should represent average yield (herbage mass) and composition (green, dead, legume and weed) of the whole paddock.
2. Walk a set number of paces from the boundary of the area being sampled. Either place the quadrat directly at you toe or throw quadrat in a random direction. Herbage bent over by the quadrat should be straightened. (Use the median technique of identifying the median growth between 5 quadrats and sample the median quadrat- only for median quadrat).
3. Using shears cut area inside of quadrant to ground level.
4. Collect all debris and herbage matter into a bag and label bag with sample number e.g. Sample 1, Sample 2 etc.
5. Place sample into a bucket.
6. Repeat steps 2-5 for each sample but walk a set number of steps between each sample.

7. Bring all samples in a bucket to the classroom. Use digital scales to record the weight of herbage in each bag to the nearest gram. (Ensure bag weight is not included).
8. Record weights of each sample into the Average herbage mass calculation (Table 3).
9. Calculate average herbage mass (g). Total the sample weights to calculate the average weight of green herbage. Record in results table.
10. Dry sample. Bulk the herbage from all bags.
11. Thoroughly mix all herbage so it appears uniform throughout. Split the herbage into four equal amounts. Discard the two diagonally opposite portions. Recombine the two remaining portions. (This removes bias and increases the validity of the test and results).
12. Repeat step 10-11 until a sample remains 150 grams (size of a large dinner plate). Weigh and record the weight of this sample. This is the 'wet weight' Record in Table 4.
13. To remove the water from the sample and determine a dry matter weigh a couple of techniques could be used including: ovening or microwaving the subsample. Be very careful not to burn the subsample.
 - Microwave -place a cup of cold water in the microwave with the sample. Replace the water when it begins to boil. Repeatedly heat sample (maximum power, 5 minutes at a time). Turn over and loosen sample between microwave heating and weigh the sample. Keep re-heating sample until the weight is constant between two consecutive heating.
 - Oven - place sample in an oven at approximately 70°C. Weigh at 24 & 48 hours. Samples are dry when the weight is constant for two consecutive readings. The time required will vary with the water content of the sample. An oven gives more accurate results.
14. Record final dry matter weight (same weight at two consecutive readings). (Table 4)
15. Calculate the dry matter percentage by using the following formula:
 Dry matter (DM) % = $\frac{\text{Weight of dry sample (g)} \times 100}{\text{Weight of wet sample (g)}}$
 Record into Table 4
16. Calculate the Herbage mass (kg DM/ha) by using the following formula:

$$\text{Herbage mass (kg DM/ha)} = \frac{\text{Average wet weight of green herbage (g)} \times \text{dry matter \%} \times \text{quadrat conversion factor (see below)}}{100}$$

 The quadrat conversion factor is:
 - Median quadrat (30 cm × 50 cm) = (0.15 m² or 1/66,666th ha), × 67 to get kg DM/ha
 - Square quadrat (50 cm × 50 cm) = (0.25 m² or 1/40,000th ha), × 40 to get kg DM/ha.
 Record results in Table 5.
17. Calculate pasture composition (percentage legume, percentage green and percentage dead). Take the oven-dried sample (steps 10-14).
18. Use forceps/tweezers to sort the sample into fractions of interest: green legume, dead legume, green grass, dead grass, green and dead other.
19. Weigh each fraction using the digital scales.
20. Record results and calculate pasture component % into Table 6.

Results tables:

Table 3 Average herbage mass calculation

Herbage mass calculation table Step 8 calculations	
Paddock name:	
Date sampled:	
Sample number	Herbage wet weight (g)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10 - Add more rows as required	
Total weight (g)	
Average wet weight of green herbage (g)	

Table 4 Calculate Dry Matter %

Calculate Dry Matter (DM) % Steps 12 15 calculations	
Wet sample weight (g) (this is the final sample to be dehydrated- step 12)	
Dry sample weight (g)	
$DM\% = \left(\frac{\text{Dry sample weight (g)}}{\text{Wet sample weight (g)}} \right) \times 100\%$	

Table 5 Calculate the Herbage mass (kg DM/ha)

Calculate the Herbage mass (kg DM/ha) Step 16 calculations	
Average wet weight of green herbage (g) (Table 3)	
Dry Matter % (Table 4)	
Herbage mass (kg DM/ha) $= \frac{\text{Average wet weight of green herbage (g)} \times \text{dry matter \%} \times \text{quadrat conversion factor} * (\text{see below})}{100}$	
Quadrat conversion factors: *Median quadrat = 67 *50 cm × 50 cm square quadrat = 40	

Table 6 Pasture composition

Pasture composition Steps 17 20			
Component	Dry weight (g)	Percentage of total (%)	Herbage mass (kg DM/ha) (use Table 6 formula)
Green legume			
Green grass			
Green other			
Dead legume			
Dead grass			
Dead other			
Total			
Total legume			
Total grass			

Practical activity- Estimating herbage mass (pasture quantity) using an MLA pasture ruler

Schools are encouraged to order a class set of MLA pasture rulers before this activity at [Meat and Livestock Australia, 2019, Pasture rulers, sticks and meters](#).

Recommendation - carry out this activity along with [Practical activity- Measuring herbage mass \(pasture quantity\) assessment using a quadrat](#) to compare between both methods.

Activity adapted from Meat and Livestock Australia (2021), 'Improving pastures use with the MLA pasture ruler'. Tips and tools, Feed base and pastures, <https://publications.mla.com.au/go/eqSRU1SGcRszsXqK>

Background:

Pasture assessment is the key to making better grazing decisions. To get the benefit of feed budgeting you must know:

- **Quantity:** the mass of pasture available to livestock
- **Quality:** the feed value of your pasture.

From this, managers can estimate the number of livestock to carry, for how long, and how well they are likely to grow. With feed budgeting managers can determine when and how many stock to buy or sell with changing seasonal conditions, or alternatively, how much supplementary feed will be needed.

The Meat and Livestock Australia's (MLA) pasture ruler is a quick and easy way to estimate pasture herbage mass (quantity) and quality. These estimates become a guide to the expected performance from grazing animals.

The pasture ruler works as an estimate as there is a correlation between green pasture height and herbage mass. Relationship between green pasture height and the 'indicative' herbage mass in temperate pastures.

Average plant height (cm)	'Indicative' herbage mass (kg green DM/ha)
2	700
4	1200
6	1600
8	2000
10	2400
12	2800
14	3200

Pasture growth stage, species, pasture density, and legume content all affect actual results.

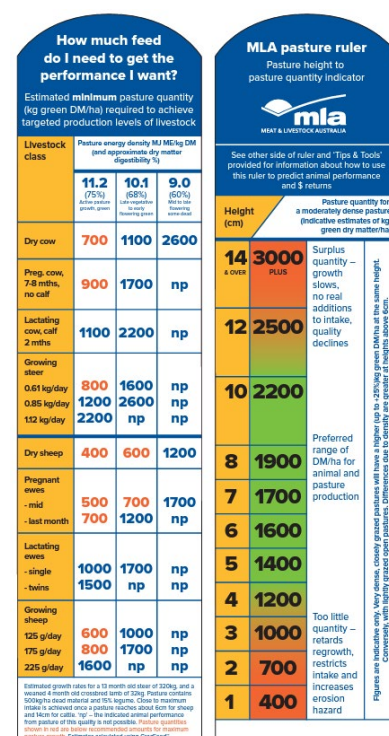


Figure 12 MLA pasture ruler

Before completing the practical activity, read: Meat and Livestock Australia (2021), '[Improving pastures use with the MLA pasture ruler](https://publications.mla.com.au/go/eqSRU1SGcRsZsXqK)'. Tips and tools, Feed base and pastures, <https://publications.mla.com.au/go/eqSRU1SGcRsZsXqK>

Aim: Use the Meat and Livestock Australia (MLA) pasture ruler to estimate herbage mass (kg DM/ha). Compare results to previous [Practical activity Measuring herbage mass using a quadrat](#).

Materials:

- Pasture
- MLA pasture ruler
- Recording material

Method:

- 1) Place the MLA pasture ruler vertically onto the soil surface. Do not push it into the ground or sit it on top of dead pasture.
- 2) Slide your thumb down the ruler until it touches green leaves. The measured height will generally be less than that of the taller leaves in the pasture.
- 3) Do not measure dead stems or leaves or unpalatable weeds, as stock do not readily eat these. If no green pasture is present, height is recorded as zero.
- 4) Measure the height of the green pasture at a few sites to get a good representative sample of the pasture availability. Depending on the physical features of the paddock (e.g., slopes and aspect), the best method might be to walk across the paddock in a zigzag pattern, tossing the ruler out in front of you as you go (to account for variations in pasture height and density), taking measurements where the ruler lands and recording the observations.
- 5) To convert from the average pasture height in the paddock to kilograms of green dry matter per hectare, simply read the kg green DM figure from the adjacent column on the MLA pasture ruler.
- 6) Record results into results table.
- 7) **Optional-** conduct this practical along with the previous [Practical activity - Measuring herbage mass using a quadrat](#). Contrast results between both herbage mass calculation methods.

Results Table:

Pasture height to pasture quantity estimate		
Paddock name: Date sampled:	Pasture height (cm)	Estimated kg/DM/ha
Sample number		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10 - Add more rows as required		
Total kg/DM/ha		
Average kg/DM/ha		

Herbage mass and carrying capacity

After learning to calculate pasture quantity and estimate pasture quality, the next important step is to learn how to interpret this information to determine stocking rates and carrying capacities.

The term Dry Sheep Equivalent (DSE) is used to describe the amount of feed or herbage mass (kg DM/ha) required to maintain a 45-50 kg wether or non-lactating (dry) ewe per day.

DSE are used as a standard to compare different classes of livestock and determine stocking rates and carrying capacity of a property.

One DSE requires 1kg of DM per day to maintain body weight. When expressed in energy required for livestock maintenance, 1DSE= 7.6MJ/day.

Different classes of livestock have different energy requirements needs depending on age, frame size, liveweight, condition score, maturity type, genetics, breed and production purpose. The DSE and other stock equivalent systems are only approximations. Feed requirements of livestock vary with their liveweight, level of production, physiological state, genetics, and topography and climatic conditions. DSEs are based on the energy requirements of animals and do not account for differences in the protein or mineral requirements of individual animals. The DSE is an estimate of average feed requirements, ignoring variations between animals of the same class due to genetic differences or management practices.

DSE for different classes of sheep and beef cattle based on daily energy requirements.

Livestock	Class of stock	DSE at Specified liveweights	
Sheep-merino	Weaned lambs	15kg	25kg
	Gaining 100g/day	0.9	1.2
	Gaining 200g/day	1.4	1.8
	Mature sheep	40kg	50kg
	Dry ewes, wethers (store)	0.9	1.1
	gaining 50 g/day	1.2	1.4
	gaining 100 g/day	1.5	1.7
	Pregnant ewes last 6 weeks bearing singles	1.4	1.6
	Pregnant ewes last 6 weeks bearing twins	1.8	2.0
	Ewes with single lamb at foot	2.4	3.1
	Ewes with twin lambs at foot	2.8	3.3
	Weaned calves	200kg	250kg
	Gaining 0.25kg/day	5.5	6.5

Beef cattle (<i>Bos taurus</i>)	Gaining 0.75kg/day	8.0	9.0
	Yearling	300kg	350kg
	Gaining 0.25kg/day	7	8
	Gaining 0.75kg/day	10	11
	Mature cattle	400kg	500kg
	Dry cows, steers (store)	7	8
	Gaining 0.25kg/day	8	9
	Bullock (store)	8	9
	Gaining 0.75kg/day	12	14
	Cow with 0-3 month calf	14	18
	Cow with 4-6 month calf	18	22
	Cow with 7-20 month calf	22	25
Dairy cattle	Weaned calves	200kg	250kg
	Gaining 500g/day	7.0	8.0
	Heifer	350kg	450kg
	In calf (last 3 months)	9.0	10.5
	Mature cow	Jersey (400kg)	Holstein (550kg)
	Dry cows maintaining weight	7	9
	Dry, pregnant last 3 months	9	12
	Lactating, maintaining weight producing 40% of peak milk	13	16
	Lactating, maintaining weight producing 60% of peak milk	16	20
	Lactating, maintaining weight producing 80% of peak milk	19	24
	Lactating, maintaining weight at peak milk production	22	28
	Bulls	Jersey (560kg)	Holstein (770kg)
	maintaining weight	10	14

Source: [Mclaren, Colin. \(1997\). Dry Sheep Equivalents for Comparing Different Classes of Livestock.](#)

Suggested extension practical activity:

Use the MLA [Stocking rate calculator](#) to determine the number of cattle or sheep (stocking rate) for a paddock at your school.

Pasture composition - why improve pastures?

The aim of pasture improvement is to grow species that will increase both the quantity and quality of pasture, particularly during feed gaps, to meet livestock production needs.

Improved pastures are made up of a mix of perennial legumes and grasses. This results in:

- Higher carrying capacity (improved perennial pastures are 150% more productive than annual pastures and up to 300% more productive than native pastures)
- Higher quality and quicker turn off of livestock/products
- Increased enterprise flexibility
- Greater production reliability
- Filling of feed gaps
- Greater profit from increased production
- Greater ground cover which minimises soil degradation issues and maximises moisture use
- Extends the growing season which can reduce the need for supplementary feeding ([Improved perennial pastures, MLA, 2024](#)).

A feed gap typically occurs when pasture quality does not meet the energy needs of livestock. In temperate zones, feed gaps often occur mid to late winter through to early spring, when days are cooler and sunlight (day length) shortens, resulting in slower pasture growth. In winter, livestock require more energy for maintenance and production, which coincides with the winter feed gap. Another feed gap occurs late Summer to Autumn when hot dry weather affects feed quality. Livestock quickly lose condition when energy requirements are not met.

The 'ideal' improved perennial pasture contains a balanced mixture of perennial grass and perennial legume species. An often quoted 70:30 grass: legume mix. Grasses and legumes contribute differently to a pasture's performance. Combinations for the best production usually contain a minimum of 1-3 grass species with 1-2 legume species.

Advantages of an improved perennial pasture include continual feed throughout the year and greater production where conditions vary such as:

- Changes of soil types and fertility within a paddock
- Changes of aspect in a paddock (e.g. dry Northerly aspect vs wetter Southerly aspect)
- Waterlogging within a paddock
- Yearly seasonal changes

Some pasture species are not compatible due to competition or allelopathy. [Allelopathy](#) refers to a negative effect on one type of plant, by a chemical naturally produced by another type of plant.

To find the best combination of species for your area contact a local pasture agronomist, [LLS](#) or [NSW DPIRD pasture advisor](#).

Legume benefits:

- Increasing pasture yield by providing nitrogen which improves all plant growth
- Increase pasture quality, which is essential for animal growth and production
- Building plant available soil nitrogen through nitrogen fixation
- Deep perennial taproots provide stability and organic matter to soils which improve structure, reduce erosion, reduce water and nutrient recharge into the water table. Perennial legumes are very important to reduce soil degradation.

Grass benefits:

- Increase total yield (herbage mass) compared to a legume-only pasture
- Reduce danger of bloat in ruminants
- Perennial grass pastures increase protection from erosion and weed invasion
- Perennial grasses play an important role in reducing soil degradation.

Establishing improved perennial pastures can be costly and it can take several years to recover. But it is profitable in the long-term due to potential increases in stocking rate and productivity; resilience in a changing climate and improved natural resource management.

Indicators of healthy improved perennial pastures

Successful and productive perennial pastures have:

- up to 40% legume content and at least 40-60% perennial grasses during the peak growing season
- ground cover of more than 70% year-round
- at least 1000kg of dry matter per hectare at the point of autumn break
- at least 15-20 desirable perennial plants per m² (50/m² for newly-sown pasture)
- best use of pasture growth through tactical grazing, with evenness of grazing, better species composition and high seasonal dry matter content
- higher soil fertility - according to species composition and soil test results

1. Define what an improved pasture is? Include the target composition and species ratio.

2. List five advantages of improved pastures.

3. Complete the table to summarise the benefits of perennial legumes and grasses in an improved pasture

Legume benefits	Grass benefits

Managing pastures

Producers must closely manage pastures to get high production. They should be long-lasting to be profitable and sustainable. If pastures are not effectively managed, they will rapidly decline.

Pasture decline occurs through:

- Overgrazing
- plant nutrient deficiencies through inadequate fertiliser application
- pest and weed establishment and competition.

Management to maintain a productive improved pasture include:

- Stocking rate and stocking density
- stock type
- grazing method
- grazing pressure
- fertiliser use
- soil management (pH, retained organic matter, soil moisture)
- ground cover
- control pests, disease and weeds
- species selection suited to soils and climate.
- livestock production pattern (e.g., backgrounding, feed lotting, self-replacing herd etc).

Establishing pastures

Establishing new pastures can cost well over \$300 per hectare, so it is important to do everything you can to get a good result. The most expensive pasture is one that fails to establish properly. Such pastures have reduced productivity, carrying capacity, are prone to pest and weed invasion, and have reduced capacity to combat soil degradation.

Reliable establishment is vital for high levels of production and longevity from perennial pastures. Perennial pasture seeds are generally small, with slow-growing seedlings compared to most crops and many weeds. Greater care and attention to detail is needed to establish perennial pastures successfully.

There are eight critical management steps involved with successfully establishing a pasture.

1. *'Select, assess and plan early'*- planning should start at least 8-12 months before sowing. Assess the existing pasture, soil fertility weed, disease and pest risks. Select pasture varieties well adapted to the local climate and livestock enterprise. Consider the sowing equipment. Create a budget to determine short and long term benefits of pasture establishment. Include costs: paddock preparations and sowing, herbicides, insecticides, seed, fertilised. Budget for fertiliser in subsequent years and extra livestock required to graze extra feed grown.
2. *Weed and pest control before pasture establishment*- reduce weed seed reserves in the soil and insect pests by using techniques such as spray-graze, spray fallow, pasture-topping, spring fodder crop and integrated pest and weed management (IPM) procedures. This step must start in the previous spring for autumn/winter sowing to prevent annual weed seed set.
3. *Pre- sowing cultivation or grazing*. Manage the paddock for 3-4 months before sowing to reduce trash and maximise weed germination.
 - Conventional sowing- use cultivation in conjunction with herbicides.
 - Direct drill or surface sowings – graze leading up to the sowing period to keep pastures short. Sheep graze 1-2cm high and cattle 3-4cm high.
4. *Absolute weed and pest control- the most important factor for success*. Allow full weed germination after the break of the season. Either cultivate or graze weeds to keep them small, while waiting for the right sowing conditions. Redlegged earth mite and Blue oatmite hatch after the Autumn break, especially when maximum day temperatures are below 20°C. They start laying eggs 6-8 weeks after hatching (lifecycle). See Figure 13.
5. *Adequate soil moisture to maximise quick germination and pasture seedling survival*. A firm moist seedbed allows close contact between the soil and seed. Sow only when conditions match these needs.
 - Temperate perennials, sow from autumn – early spring
 - Subtropical species, sow late spring – early autumn
6. *Accurate seed placement - depth and spacing*. Only use certified seed and check germination % before sowing. For mixed pasture either match seeds that need the same sowing depth or sow multiple times. Ensure legume seed is inoculated with the

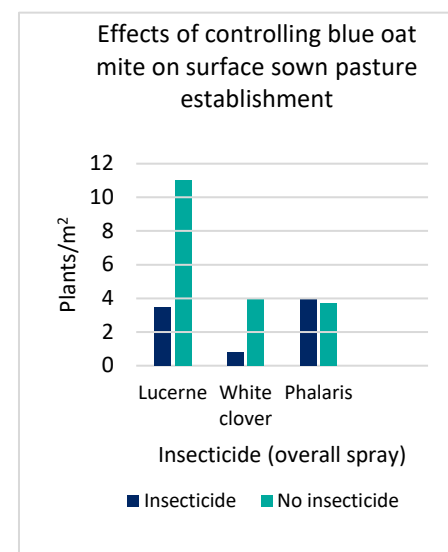


Figure 13 Effect of controlling blue mite on pasture establishment

correct strain of *Rhizobia* and if required, lime pelleted. Banding fertiliser near the seed is four times more effective than broadcasting fertiliser.

- Direct drilling- average furrow depth 25mm, provided the furrow remains open with 1-2cm of loose soil over the seed. Use inverted 'T' sowing points, don't use harrows or rollers. Use nitrogen fortified (compound) fertilisers for direct drill sowing.
 - Conventional sowing- do not sow too deep particularly if seedbed is loose and fluffy. Rolling can enhance seed:soil contact but beware of surface crusting in some soils.
7. *Regular monitoring of weeds and pests after sowing.* Regularly check pastures for pests and treat immediately if detected. There is greater chances of pasture pests arising in direct drilled pastures as compared to conventionally sown. Control weeds immediately with selective herbicides or grazing.
 8. *Initial and subsequent grazing.* Wait till pasture is 10-15cm tall, well anchored with adequate soil moisture before first graze. A quick first graze at this stage promotes tillering and root development. Do not graze to less than 2.5cm high. Always allow new perennial pastures to set seed in the first year- do not cut for hay. Once established rotationally graze.

Extension activity – use the [MLA/ EverGraze Pasture improvement calculator](#) to calculate the cost and return involved in resowing a pasture at your school/in your local area.

Watch: [Guidelines for successful pasture establishment, LLS.](#)



Conserving pastures

A common practice involves conserving (harvesting) excess pasture growth or specially grown fodder crops in the form of hay or silage.

The four main options for conserving fodder include:

- Round bales or large rectangular hay bales
- Round bale silage or tube-line silage
- Small rectangular hay bales
- Pit silage

Hay- is the most common fodder conservation practice. Most crops and pastures can be made into hay of various quality. All successful hay making relies on wilting the cut pasture to a moisture or dry matter level that is dry enough not to ferment but wet enough not to shatter when baled (approximately 12% dry matter). If hay is baled with too much moisture it can ferment or grow mould leading to spoilage and heat generation which may become a fire risk.

Hay stored undercover can maintain its quality for more than 12 months, but stored outdoors without cover will show significant reductions in quality, dry matter and nutrients over time.

Watch [Vetch hay making Australia 2021](#) to see the machinery and process of making hay from start to finish.



Silage- is made by [ensiling](#) (fermenting) pastures. It generally produces better quality feed than hay. This is due to the smaller interval between cutting and conserving feed. The longer the time between cutting and conserving the greater the nutrient loss. Silage can be used to assist weed control and pasture management.

The production and storage of silage relies on the anaerobic (air-free) environment. This promotes the desired fermentation process and reduces decay. It is critical that an air-free environment is maintained from the time the silage is made until it is fed out. It takes 3-6 weeks for the ensiling process, depending on moisture content and chop length.

Storage life is influenced by the plastic wrap used and ability to keep silage airtight. Stretch wrap plastic will give a storage life of 12 months (if not punctured), while plastic sheet can last 2-3 years. Silage pits have been known to sustain quality for decades. Never leave silage exposed to the air more than two days during feeding. This is especially important for pit silage and tube-line silage.

Watch [Making corn silage for dairy cows, Maryland farm and harvest.](#)



Feed quality of conserved fodder

The quality of the original material is critical when making quality hay or silage. Both preserving processes (drying hay or ensiling) involves a loss of nutrients. It is impossible to improve the value of fodder after it is cut, by storing it. The palatability changes, but not feed quality.

Plant growth stage and plant species affect the fodder quality. Maturing legumes such as lucerne and clover have higher protein levels and maintain quality better than grasses. Winter grasses such as ryegrass or oats have excellent quality when in the green vegetative stage and reduced quality as they mature to the reproductive stage.

1. List ten management actions which maintain productive improved pastures.

2. List the eight critical management steps involved with successfully establishing a pasture. For each, mention when it should be carried out e.g., pre-sowing, post-sowing, post-germination.

3. Describe the process involved with making hay (mention machinery where possible).

4. Describe the process involved with making silage (mention machinery where possible).

[illegible]

5. Complete the table to contrast the advantages and disadvantages of hay and silage

Hay		Silage	
Advantages	Disadvantages	Advantages	Disadvantage

Calendar of operations activities

6. Figure 14 shows notes from a manager's paddock book and need to be put into their correct order to create a calendar of operations for the farm. Use the notes to complete the table (Figure 15) summarising the calendar of operations. Make sure to match operations specific to kikuyu or ryegrass operations.

Figure 14 Paddock notes for calendar of operations

January- February

- Book in contractors for sowing ryegrass and making kikuyu silage

October

- Kikuyu - Lock up perennial pasture for seed set. Rotate different paddock/s each year.
- Both - soil testing on any paddocks NOT fertilised within past 3-4 months

April

- Ryegrass- Contractors direct drill annual ryegrass (temperature below 15°C) into kikuyu/clover pastures
- Both - Apply lime/gypsum as per soil test results

July

- Both - Identify paddocks to lock up for hay/silage production and lock in contractors
- Both - rotational grazing

August

- Both - Monitor for weed seedlings, pests E.g. (red-legged earth mite) and diseases (e.g. rust)- treat as required
- Both - Rotational grazing

May

- Ryegrass - Rotationally graze at 2.5-3 leaf stage (before pasture lodges).

March

- Kikuyu- Make excess feed into silage or heavily graze. Mob-graze the paddock then top-dress with nitrogen. Leave 3-5 weeks growth then cut and ensile.

September

- Ryegrass - Prepare for harvest- early maturing ryegrass starts flowering- cut when seed heads first appear after flowering

June

- Ryegrass -Top dress with Nitrogen (80kg urea/ha) after every second grazing
- Both Rotational grazing

November- December

- Rotationally graze kikuyu paddocks to maintain legumes. Slash if needed after grazing to remove old, rank pasture growth
- Both - rotationally graze paddocks to prevent pastures reaching seed set (reduced nutritional quality)

Figure 15 Beef and pastures calendar of Operations- monthly summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Summer Hot temperatures, stormy weather for coastal areas		Autumn Temps cool down, reasonably reliable rainfall			Winter Generally drier and cold temps, slow pasture growth			Spring Warmer temperatures, rainfall can be unpredictable and variable – stored moisture rapidly used by pastures.			Summer
Bulls				Drench: Flukicide		Buy replacement bulls if required		Pre-join physical examination for bulls	Vaccinate: 7- in-1 booster, pestivirus and vibrio	Join bulls with cows and heifers		Remove bulls from cows and heifer
Cows	Target 2.5 fat score. Drench: flukicide Monitor for pink eye Dry years: assess breeder condition – early wean if required	Monitor for 3-day sickness Pregnancy test breeders Sell empty breeders when necessary	Fat score breeders at weaning. Aim to reach fat score 2.5-3.5 at point of calving	Drench: Flukicide	Fat score breeders. Assess pasture for nutritional requirements for last trimester pregnancy (rising plane of nutrition)		Calving Monitor for milk fever and grass tetany		Vaccinate: 7- in-1 booster and Pestivirus booster	Joining 6-9 weeks		Remove bull Worm test and drench if required
Heifers (yearlings)				Drench worms and flukicide						After first calving go to Cow- October	Joining 6 weeks only	
Calves			Wean calves (7-8 months) Depending on season/market, sell young stock as weaners or grown out to heavier weights							Vaccinate 5- in-1 (1 st dose) 3 months of age	Vaccinate: 5-in- 1 booster (4-6 weeks later). Mark/tag/ dehorn/ NLIS	
Heifers (weaners/ vealers)			Vaccinate: 5-in-1 booster Drench (worms/fluke)			Select replacements	Vaccinate: Pestivirus (1 st dose)		Vaccinate: Pestivirus (2 nd) Go to heifers (yearlings) October			
Target growth weights	Ensure heifers reach critical mating weights (60-65% mature cow weight. (British breeds minimum 330kg. Other breeds may be heavier)											
	Summer – Autumn: weight gain target 0.7-0.89kg/day					Winter: weight gain target 0.2-0.3 kg/day			Spring: weight gain target 1.0-1.5 kg/day			Summer
Steer (weaners/ vealers)			Vaccinate 5-in-1 booster Drench (worms and fluke)									Worm test (drench if required)
	Weight every 6 weeks to monitor performance and confirm steers weights are meeting market specifications. Target >0.7kg/day											
Steer yearlings		Sell as 18-month- old target weight 450 kg										
	Target >0.7kg/day											

Figure 15 Beef and pastures calendar of Operations- monthly summary

	Target >0.7kg/day											
Pastures - kikuyu/clover												
Pastures- annual ryegrass, clover												

7. What season and what months do the cows and heifers calve?

8. What season and what months are weaners sold?

9. What season and what months are 18-month-old steers sold?

10. Select one of the beef cattle operations from Qu 7-9. Explain why the timing of the beef cattle operation occurs, in terms of pasture production.

Seedling establishment activities- Calculating the germination percentage:

This is a useful activity for determining seed viability.

Aim: calculate the germination percentage of different seed species or varieties.

Method:

1. Randomly allocate 50 seeds from each seed variety/sample to be planted.
2. Lay four sheets of paper towel on top of each other and moisten, don't drench.
3. Place 50 seeds 10 mm apart on the paper towels.
4. Roll up, sandwiching the seeds between the moist paper towels.
5. Soak a hand towel in water and ring out, then wrap it around the rolled-up paper towel and loosely secure with rubber bands.
6. Place in a plastic bag, seal and place in a warm spot, such as near a window, and leave for 5 to 7 days.
7. Unwrap and count the number of seeds that have not germinated.
8. Count and use the calculation:
9. Germination % = [(number of seeds tested – number of seeds that didn't germinate) ÷ 50] × 100.
10. Repeat five times and determine an average

Germination percentage		
Germination count	Seed type 1	Seed type 2
Replicate 1		
Replicate 2		
Replicate 3		
Replicate 4		
Replicate 5		
Average		

Discussion:

- Discuss the importance of seed viability for pasture establishment.

Determining optimal sowing depth for different methods of seed establishment

Aim: to identify the optimal sowing depth at your location and contrast different sowing techniques and tillage implements. Plants need to be assessed at the one to two leaf stage. This is helpful for finding the best sowing depth for your specific soil type, plant variety and machinery.

Method:

1. Obtain random samples of at least 150 seeds of the same species or variety for each replication of the trial.

2. Sow 50 seeds at recommended sowing depth (control), 50 seeds at soil throw (zero till) and 50 seeds at deep furrow depths. Other treatments to consider include aerial sowing, direct drilling, conventional sowing etc.
3. Repeat step 2 for different soils/paddock if necessary.
4. Record the days until germination and days until 2 leaf stage for each seedling
5. Carefully dig up all plants along a row, including the seed and roots, for each sample
6. Measure the depth from the seed to the soil surface – where the coleoptile ends and the green stem begins.
7. Observe the impact of deep furrows on seed placement and emergence
8. Record the coleoptile length of the 50 plants from each group and calculate the averages for each group see below table.

Discussion:

- Identify and discuss the best sowing depth for your location
- Discuss the impact of zero till and implications for emergence.
- Discuss the impact of deep furrows on seed placement and emergence
- Discuss how soil type affected emergence for treatments zero till and deep furrow
- Identify and discuss ways in which sound experimental design could be better in this experiment in terms of randomisation, replication, standardisation and use of a control.

Determining optimal sowing depth for different seed establishment types

	Recommended sowing depth				Zero till			Deep furrow				
	Days till germination (days)	Days until 2 leaf stage (days)	Depth of seed from soil surface (mm)	Coleoptile length (mm)	Days till germination (days)	Days until 2 leaf stage (days)	Depth of seed from soil surface (mm)	Coleoptile length (mm)	Days till germination (days)	Days until 2 leaf stage (days)	Depth of seed from soil surface (mm)	Coleoptile length (mm)
Seedling 1												
Seedling 2												
Seedling 3												
Repeat rows for seedling 4-47 etc												
Seedling 48												
Seedling 49												
Seedling 50												
Average												

Current technologies

The agricultural sector faces many challenges including changing climate, changing markets and consumer expectations; increased accountability for the use of resources and sustainability; reduced land area for farming due to urbanisation and population growth. To meet these challenges, producers and industry are always adapting to increase production while minimising the use of resources. Farm technology and innovation is rapidly being developed and adopted to help achieve this.

Technological improvements in pasture production fall into the areas:

- Biological e.g., CRISPR, SNPS and genomics for cultivar development that increase production while matching environmental conditions and market requirements using selective breeding or gene technologies. Biosecurity technologies for managing pests, diseases and weeds.
- Digital technology: precision agronomy devices including machinery, automation, artificial intelligence, remote sensors, soil sampling by location, telematics in machinery, variable rate technology, robotics, drones, autonomous vehicles, GPS guidance.
- Data collection – on farm data collection used to inform management decisions. For example, weather information, historical yield, soil pH, soil fertility, fertiliser and irrigation data.
- Management technologies e.g. integrated electronic real-time marketing, finance, infrastructure, climate forecasts, pasture and herd management software and applications.

Benefits of implementing technology:

- Input cost saving e.g., equipment and management (reducing the use of pesticides, fertilisers, fuel and water)
- Minimising resource usage
- Performance monitoring
- Greater production from livestock
- Increased pasture production yield and quality
- Improved environmental, economic, and social outcomes and performance.

Case Study – Hunter Smarter Farming: irrigating for profit.

The [Hunter Smarter Farming: Irrigating for Profit](#) project aims to improve the capabilities of the Hunter's dairy irrigators to increase profits by optimising dry matter (DM) production and utilisation throughout the irrigation season, concentrating on efforts to start irrigation at the right time and rate to avoid seasonal soil moisture deficits.



Watch [Irrigation for Profit, Local Land Services, NSW](#) to observe a range of pasture technologies trialled by two dairy farmers involved in the project. The technologies give a vast amount of real time data which is used to make management decisions regarding irrigation for plant water needs to maximise production efficiency and sustainability.

Technology mentioned throughout the clip includes [EM38 soil mapping](#), [EnviroPro capacitance probe](#) (soil moisture probes), [Adcon NextG field telemetry logger](#), [RGP Rain Gauge Precipitation Hyquest](#) (weather station).

1. Select a plant industry-specific technology to research. Use the internet to compile a 1- 2-page report on your selected technology.

Your report should include:

- Name of the technology
- Origin of the technology
- Images of the technology
- Thorough description of how the technology works
- Description of how the technology is used to improve production efficiency
- A table contrasting the advantages and disadvantages associated with using the technology
- Evaluate the impact of your chosen technology on sustainability.

Use the following scaffold to help to structure your evaluation.

“Evaluate: make a judgement based on criteria: determine the value of”

Description of features/issues:

Points for (advantages):

-
-

(add as many points as needed)

Points against (disadvantages):

-
-

(add as many points as needed)

Criteria:

-
-
-

(add as many points as needed)

Judgement (of each point/issue against criteria):

Pastures and sustainability

Good pastures are profitable and sustainable. They can provide an economical source of livestock feed, reduce inputs (e.g., labour, fertilisers, water), build soil structure, build soil organic matter content and fertility, reduce erosion, and reduce invasions of noxious and poisonous weeds.

Case Study - Managing pastures to reduce livestock methane emissions

Watch “[How feed additives could cut methane emissions from livestock by 90 percent](#)”, ABC Landline

Across Australia, livestock are the third largest source of greenhouse gas emissions after the energy and transport sectors. In NSW, agriculture contributes about 14% of the State’s total greenhouse gas emissions, with livestock methane accounting for over 80% of the total agricultural emissions. Most of this methane is produced by the digestive processes of ruminant livestock (cattle, sheep, goats) with about 10% released from manure management. As a greenhouse gas (GHG), methane is relatively short-lived, but potent, having a global warming potential around 30 times higher than the more persistent carbon dioxide (CO₂).



The six major GHGs of concern are:

- nitrous oxide (N₂O)
 - carbon dioxide (CO₂)
 - methane (CH₄)
 - fluorinated gases (hydrofluorocarbons and perfluorocarbons)
 - sulphur hexafluoride (SF₆)
- } GHGs of concern to agricultural

Although there is debate over the climate impact of methane, changes can be made to reduce livestock methane on-farm. These changes can significantly contribute to climate change mitigation. The relatively high proportion of GHG emissions from livestock means significant research and adoption is needed to reduce GHG emissions from grazing animals to maintain market access.

Apart from the climate change impact, methane emissions also represent lost energy in livestock production. Some studies have shown as much as 10% of the energy in feed may be lost due to methane emissions from ruminant digestion. That lost energy is a waste of resources and reduces profits. Many practices that reduce livestock methane make good economic sense because they can increase animal growth or the efficiency of production.

Livestock management strategies that NSW primary producers can use to reduce methane emissions while also improving productivity and animal health include:

- early breeding,
- retaining high performing animals,
- enhancing fertility,
- improving animal health,
- genetically selecting animals that produce less methane, and
- providing methane-reducing feed supplements or feed alternatives.

There is potential to reduce enteric (intestinal) methane (CH₄) through use of several classes of feed additives, including oils, nitrates, phytochemicals, essential oils, methane inhibitors, macroalgae, such as red seaweed (*Asparagopsis taxiformis* and *Asparagopsis armata*), and 3-nitrooxypropanol (3-NOP) and low methanogenic pastures. Feed additives are a potentially good option for more intensive feedlot systems. For extensive pasture-based systems providing a feed additive is difficult, due to supplying correct doses/animal and supply and price of supplements.

Pasture species, including a large number of legumes, grasses and herbs, can produce bioactive compounds that reduce enteric CH₄ emission (reduce the amount of methane produced when a ruminant digests food).

The NSW DPIRD is conducting research to determine promising anti- methanogenic pasture species to:

- Reduce enteric (intestinal) CH₄ emissions
- Support livestock production goals– investigating highly productive species suitable for improved pasture production systems
- Offer anti-methanogenic pasture species options at a regional level
- Ultimately reduce greenhouse gas emissions.

Table 7 lists temperate pasture species being investigated for their potential to reduce methane emissions in ruminants.

Benefits of including different species into a pasture system to mitigate CH₄:

- Species such as Biserrula and chicory with high potential to reduce CH₄ emissions are readily available and do not require producers to implement new seeding methods and/or invest in new equipment.
- Pastures are already mostly mixtures of species, generally containing an annual or perennial legume combined with one or more grass species. Adding a different, currently available species (e.g. Biserrula or chicory) will value add to current production.
- Livestock often prefer a ‘choice’ of pasture species when grazing to satisfy a range of forage (for quality, quantity, roughage, etc.) Livestock grazing mixes of species are likely to have decreased rates of CH₄ emissions.

- Pastures made up of mixed species maximise the productivity of a pasture system by extending the growing period.
- Potential to reduce on-farm carbon emissions, which in the future may contribute to market access and potential income through carbon offsetting.
- Environmentally sustainable management.

Future challenges from including different species into a pasture system to mitigate CH₄:

- Significant future research and adoption must occur before broadscale adoption of pasture species for Greenhouse gas emission reductions can occur.
- Meeting the emission reduction targets of total greenhouse gas emissions is important but not at the expense of livestock productivity.
- Accurate system of measuring farm carbon emissions must be developed.
- New breeding programs are required to develop plant cultivars that have increased anti-methanogenic properties. Even with plant 'speed breeding' technology it will be many years (>10 years) before new cultivars become commercially available.

1. List the three main GHGs of concern to agricultural production.

2. Methane gas is a by-product of ruminant digestion. Explain how it is both a problem environmentally and a reflection of inefficient livestock production.

[illegible]

3. Refer to Table 7 to answer the following:

a) Identify the perennial legume species that has the greatest potential to reduce methane emissions (average).

Identify the annual legume species that has the greatest potential to reduce methane

b) Identify the annual legume species that has the greatest potential to reduce methane emissions (average CH₄).

- c) Identify the perennial herb species that has the greatest potential to reduce methane emissions (average CH₄).

- d) Identify a pasture species with the greatest potential to reduce methane emissions (average CH₄), in a moderate-low rainfall climate with a high pH soil.

- e) Identify the three pasture species with the greatest potential to reduce methane emissions (average CH₄), and have high levels of persistence and production.

4. Compare the short-term and long-term effects of upgrading a pasture to include anti-methanogenic pasture species for production and sustainability.

Extension activities

Go to [Badgery, W., \(2022\) Reducing enteric methane of ruminants in Australian grazing systems- a review of the role for temperate legumes and herbs, Crop and Pasture Science, CSIRO](#) to complete the following activities.

5. Outline the plant bioactive compounds and metabolites that suppress methane production. For each compound/metabolite explain how it reduces methane production, and identify which plants contain them.
6. Assess the research recommendations from this review.

Table 7 Temperate pasture species with the potential to reduce ruminant methane emissions. Source [Badgery, W., \(2022\) Reducing enteric methane of ruminants in Australian grazing systems- a review of the role for temperate legumes and herbs.](#)

Group	Pasture species	Average percentage CH ₄ change relative to perennial ryegrass (control)	Minimum rainfall (mm)	Soil conditions tolerated	Production /5	Persistence /5
Perennial legumes	<i>Lotus</i> spp. Big trefoil	-38	1000	Acidic soils, waterlogging	2	2
	<i>Lotus</i> spp. Birdsfoot trefoil	-38	650-750	Moderately acidic soils	2	2
	Sainfoin	-13	350	Alkaline, sandy soils	2	2
	Lucerne	-4	375-400	Moderately acidic to neutral, well-drained	5	4
	Red clover	-2	700	Well-drained, slightly acidic to neutral	2	2
	White clover	-2	750	Slightly acidic to neutral soil	3	3
	Sulla	-32	400-800	Neutral to alkaline	3	1
Annual legumes	Arrowleaf clover	+1	400-500	Slightly acidic to neutral	4	2
	Bladder clover	+1	350-800	Well-drained soil	3	2
	Subterranean clover	+1	375-600	Well-drained soil	4	5
	Biserrula	-77	400-525	Acidic soil	4	5
	Burr medic	+11	300-700	Slightly acidic	2	4
	French serradella	+7	375-475	Well-drained, acidic soils, high Aluminium	4	4
	Yellow serradella	+7	400-450	Sandy, acidic, well-drained soils, high aluminium	4	4
Perennial herbs	Chicory	-11	600-750	Acidic soil, good fertility	4	3
	Plantain	-18	500-650	Low fertility soils	3	3

Regenerative agriculture – a sustainable ag approach

Australian agricultural systems and landscapes face several challenges due to pressure on soil and landscape health, farm profitability and increasing climate variability. There is also an increasing interest and emphasis on not only providing agricultural commodities but increasing environmental benefits for the broader community. Regenerative agriculture is one potential solution to many of the challenges.

Regenerative farming is one of the many sustainable farming approaches carried out in Australian agriculture.

Regenerative agriculture can be challenging to define, and there are many definitions. Fundamentally regenerative agriculture is a philosophy that focuses on using a range of methods that sustain financially viable farming enterprises, restore and improve ecosystem function on farms and landscapes and help farmers achieve their social and lifestyle objectives. The goals are to improve soil health and water retention and increase biodiversity through holistic management.

Regenerative agriculture has been around for decades. It is important to note that many farmers who do not identify as ‘regenerative farmers’ seek, and achieve, similar sustainable production and environmental outcomes.

Common features of regenerative agriculture

- Goals are clearly set to improve the health of the farming systems, landscape and business.
- Progressive improvement of natural capital on farms - soil, water and biodiversity.
- Creating landscape- and climate-specific farming decisions that work over varying landscapes, time and climate.
- Developing links between producers, industry, consumers and the public.
- Developing communities and farming businesses that are flexible and resilient under a changing and variable climate.
- Holistic and sustainable approach to management and production.

Outcomes of regenerative agriculture

Environmental, economic and social outcomes often associated with regenerative agriculture include:

- Enhanced ecosystem services, including increases in soil organic carbon.
- Improved soil function (i.e., better microbial processes for nutrient supply and improved soil structure).
- Improved plant root growth which contributes to increased ‘plant carbon’ (i.e. root exudates).

- Enhanced farming system resilience, recovery and stability under short- and long-term climate variations (drought and climate change).
- Connecting individual farms and farmers within farming landscapes (community supported agriculture).

Watch [“Regenerative agriculture has been around for decades, but there’s still a lot to learn”](#) Landline 2023.



Common regenerative farming practices

There is no definitive list of regenerative agricultural practices, however some practices include:

- Adaptive grazing management e.g. cell, rotational and strategic grazing.
- Less reliance on agricultural chemicals (ranging from reduced inputs to organic amendments, microbial inoculants, to no inputs).
- Integrated pest and weed management.
- Mixed species planting in grasslands, pasture phases and cover crops.
- Biodiverse plantings across the farm which promote biodiversity.
- No-till farming.
- Stubble retention.
- Water ponding.

Case Study - Paddock to pastures using Soilkee Renovator, multispecies pastures and rotational grazing.

This clip investigates a Tweed River Landcare project using tillage technology and management techniques to improve soil fertility, carbon sequestration, pasture diversity, resilience, and profitability on farms in the catchment. It used funding from the Australian Government Smart Farms Small Grant. The project trailed one method of converting compacted cattle grazing paddocks to productive pastures to fill the winter feed gap and improve soils, in order to improve drought resilience.



Paddocks to pastures using the Soilkee Renovator, multispecies pastures and rotational grazing

1. Define regenerative agriculture.

3. List five common management practices associated with regenerative agriculture.

4. Compare sustainable farming and regenerative farming.

[illegible]

Integrated pest and disease management (IPDM)

Integrated pest and disease management (IPDM) is an approach used to control and manage a target pest or disease in a holistic and sustainable manner. Each program is specifically developed to a target pest and uses a range of targeted control methods for that pest or disease.

This approach aims to minimise the impact of pests and disease to livestock, crops or pastures while reducing reliance on chemical interventions.

Programs typically involve a combination of various strategies, including:

- **Biological Control:** Introducing or increasing natural predators and parasites to control pest populations. Biological control is an economical, effective and environmentally sound method, but is a long-term technique with extensive development and establishment phases. Biocontrol *does not eradicate a weed, pest or disease*, but can *reduce, or suppress* the target organism to an acceptable level where it can be controlled with other methods.
- **Cultural Practices:** Implementing farming practices that reduce the risk of pest and disease outbreaks, such as crop rotation, intercropping, and effective irrigation.
- **Mechanical and Physical Control:** Physical control is the removal of weeds or pests by physical or mechanical means, such as mowing, grazing, mulching, tilling, burning or by hand. The method used often depends on the area to be managed, what the land is used for, physical characteristics such as topography, and the value of the land.
- **Chemical Control:** If necessary, using pesticides judiciously and selectively to minimise harm to non-target organisms and the environment. Although the use of chemicals is not always essential, pesticides can be an important and effective part of any pest control program. In some situations, chemicals offer the only practical, cost-effective and selective method of managing some target pests. In weed control herbicides reduce the need for cultivation, can prevent soil erosion and water loss, and are widely used in conservation farming.
- **Monitoring and Early Detection:** Regularly monitoring crops for signs of pests and diseases and taking early action when necessary to prevent outbreaks.

IPDM is a more sustainable and environmentally friendly approach compared to relying solely on chemical interventions.

IPDM is defined by the Food and Agriculture Organisation (FAO) as “the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides to levels that are economically justified and reduce or minimise risks to human health and the environment”.

IPDM emphasises the growth of a healthy crop or pasture with the least possible disruption to agro-ecosystems and encourages natural pest control. IPDM involves evaluating pest problems and then developing a systems approach to manage the problems in pasture production.

Programs can be complex as thought must be given to the impacts on the whole farm system and side effects such as other pests and diseases becoming problems. A well-run IPDM program will result in reduced use of synthetic pesticides.

Pests in IPDM refer to vertebrate and non-vertebrate pests. Diseases in IPDM include disease-causing pathogens. Pathogens include viruses, fungi, bacteria, protozoans, macro-parasites and [prions](#).

Pest and diseases adversely affect pastures, both directly by decreasing herbage and seed yields, and indirectly by reducing nitrogen fixation, photosynthesis and ability to compete with weedy non-pasture species.

Table 8 Some common pests and diseases of NSW pastures

Diseases:	Insect pests:
Cucumber mosaic virus (CMV)	Aphids (<i>Aphidoidea</i>)
Bean yellow mosaic virus (<i>Potyviridae</i>)	Blue Oat Mite (BOM) (<i>Penthaleus spp.</i>)
Take-all disease (<i>Gaeumannomyces graminis</i>)	Red Legged Earth Mite (RLEM) (<i>Halotydeus destructor</i>)
Ergot (<i>Claviceps purpurea</i>)	Lucerne flea (<i>Sminthurus viridis</i>)
Phytophthora -root rot (<i>Phytophthora clandestine</i>)	Cutworms (<i>Agrotis</i>)
Crown rot (<i>Colletotrichum trifolii</i>)	Sitona weevil (<i>Sitona discoideus</i>)
Stem rust (<i>Puccinia graminis</i>)	Budworm (<i>Heliothis</i>)
Rust (<i>Uromyces trifolii</i>)	Grey field slug (<i>Deroceras reticulatum</i>)
Downy mildew (<i>Sclerophthora macrospora</i>)	Snails e.g., small pointed snail (<i>Prietocella barbara</i>)
Powdery mildew (<i>Erysiphe graminis</i>)	African Black beetle (<i>Heteronychus arator</i>)
Pepper spot (<i>Leptosphaerulina trifolii</i>)	Cockchafer e.g. Black headed cockchafer (<i>Aphodius tasmaniae</i>)
	Cabbage white butterfly (<i>Pieris rapae</i>)
	Grasshoppers and locust e.g. Australian plague locust (<i>Chortoicetes terminifera</i>)

Monitoring pests using remote sensing and unmanned aerial vehicle (UAV) technologies

There is the potential for various autonomous or remote sensing technologies to help with monitoring many organisms including:

- multispectral, nano-spectral or hyperspectral sensors
- autonomous robotic vehicles
- drones, UAVs or remote-piloted aircraft systems
- light aircraft (manned or unmanned)
- satellites.

There are also smart insect traps, lure-based technology, suction traps and molecular technologies for identifying pests. These methods will not replace the need for ground monitoring and scouting, but will complement existing methods, increase the effective area that can be monitored, and indicate high risk areas in paddocks for pest attacks. This will lead to a better picture of what is happening, can be used to map areas of higher risk and give historical records for recurring pests.

These are emerging technologies, some already in the early stages of commercialisation. Advantages include greater accuracy in monitoring and identifying insects, and detecting potential problems earlier, which results in easier decision making.

Watch '[Parabug Ag Innovations Conference Video](#)' for the release of Biocontrol Lacewing insects a biocontrol agent for aphids using UAV's.



Watch [Andrew McConnachie-
Research Leader for Weed](#)

[Biocontrol](#) to learn about use of UAV's for surveillance of Hudson pear and the impact of biocontrol agent Hudson Pear cochineal

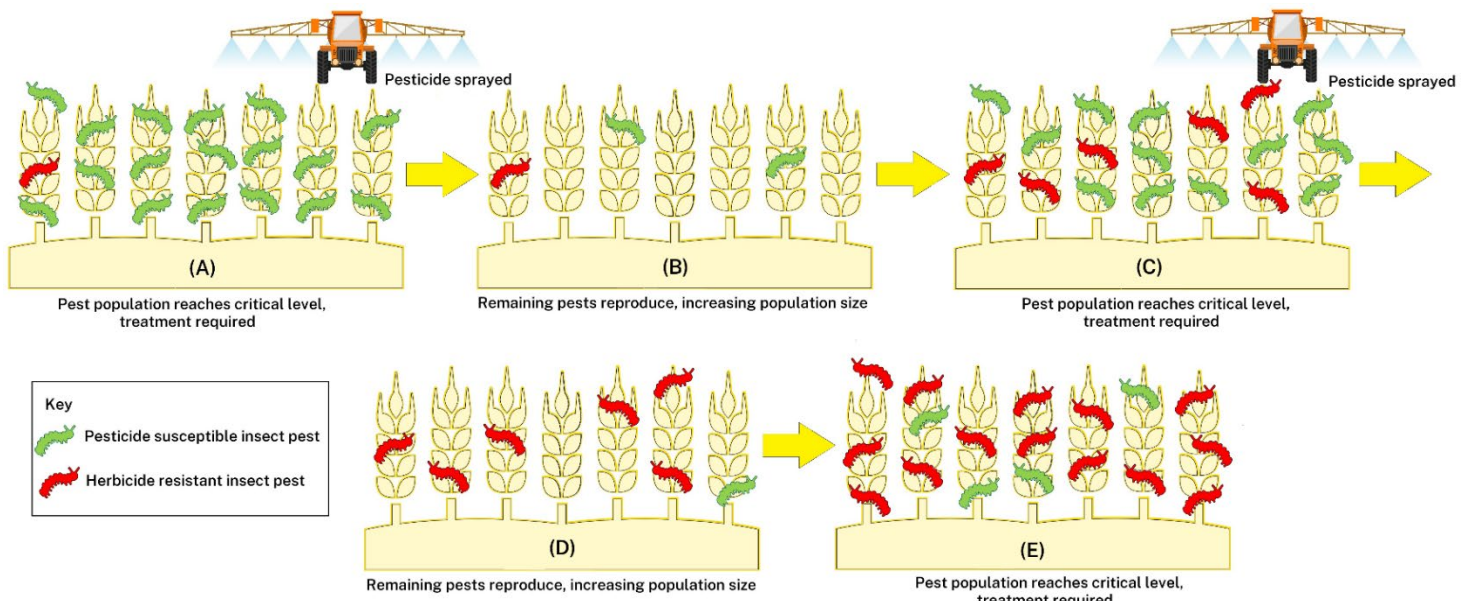


1. List four autonomous or remote sensing technologies with potential to help with pest monitoring in plant production systems.

2. Recall the benefits of using remote sensing and unmanned aerial vehicle (UAV) technologies in pest and disease monitoring.

[illegible]

The following diagram illustrates how pesticide resistance in an insect population develops in a producer's paddock over time. Analyse the diagram to answer the following:



3. Describe what happened at labels A)-E) in terms of the pesticide resistant pest population.

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.

4. What should the producer have done to prevent the pesticide resistant population scenario at part E). Give examples.

5. Explain why it is important to not only use chemical control for pest and disease control.

6. In an Integrated Pest Management (IPM) program, should any one strategy (biological, cultural, physical and chemical) be used on its own to suppress a weed? Why or why not?

Pasture pest case study: Red Legged Earth Mite (RLEM)

Source: [Redlegged earth mote, Agriculture Victoria](#)

The red legged earth mite (RLEM) (*Halotydeus destructor*) is a major pest of broadleaf crops and pastures, in regions of Australia with cool wet winters and hot dry summers. The RLEM was accidentally introduced into Australia from the Cape region of South Africa in the early 1900s. These mites are commonly controlled using pesticides. However, non-chemical options are becoming increasingly important due to evidence of resistance and concern about long-term sustainability.

Identification

Adult RLEM are 1 mm in length and 0.6 mm wide (the size of a pin head) with eight red-orange legs and a completely black velvety body. Newly hatched mites are pinkish-orange with six legs, are only 0.2 mm long and are not generally visible to the untrained eye. The larval stage is followed by three nymphal stages in which the mites have eight legs and resemble the adult mite but are smaller and sexually undeveloped.

Other mite pests – in particular blue oat mites, Bryobia mites and Balaustium mites – are sometimes confused with RLEM in the field.



Adult RLEM

Distribution



Distribution of RLEM around Australia

The RLEM is widespread throughout most agricultural regions of southern Australia. See map.

Genetic studies have found high levels of gene flow and migration within Australia. Individual adult RLEM only move short distances between plants in winter, while long-range dispersal occurs by the movement of eggs in soil adhering to livestock and farm machinery or by transporting fodder and plant material. Movement also occurs during summer when over-summering eggs are dispersed by wind.

Biology and Lifecycle

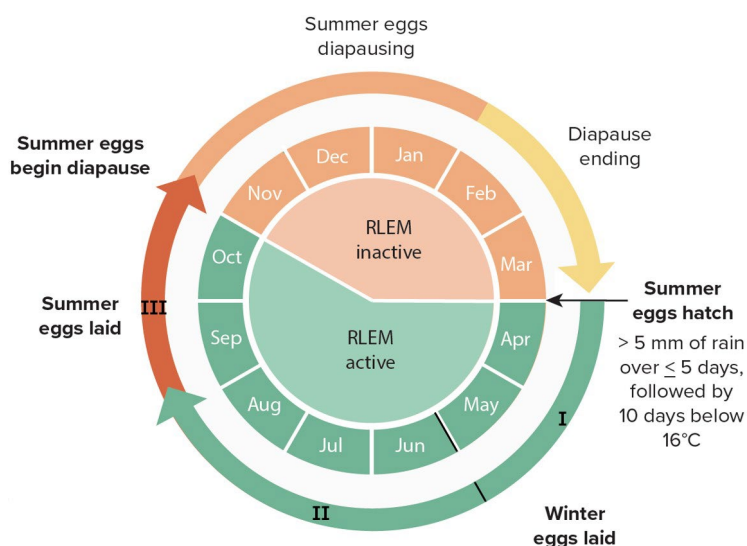
RLEM are active in the cool, wet part of the year, usually between April and November. During this period, RLEM may pass through up to four generations. Each generation survives six to eight weeks.

RLEM eggs hatch in autumn following cooler temperatures and adequate rainfall. It takes approximately two weeks of favourable temperature and moisture for over-summering eggs to hatch. This releases swarms of mites, which attack delicate crop seedlings and emerging pasture plants.

RLEM eggs laid during the winter-spring period are orange in colour and about 0.1 mm in length. They are laid singly on the underside of leaves, the bases of host plants (particularly stems) and on nearby debris. They are often found in large numbers clustered together. Female RLEM can produce up to 100 winter eggs, which usually hatch in eight to ten days, dependant on conditions.

Towards the end of spring, physiological changes in the plant, the hot dry weather and changes in light conditions combine to start the production of over-summering or 'diapause eggs'. These are 'stress-resistant' eggs that are retained in the dead female bodies. Diapause eggs can withstand the heat and dry of summer and give rise to the autumn generation the following year. See image below.

RLEM reproduce sexually, with an adult sex ratio that is female biased. Reproduction occurs when the male RLEM (which is smaller than the female) produces webbing, usually on the surface of the soil. It then deposits spermatophores on the threads of this webbing, which the female mite picks up to fertilise her eggs.



Lifecycle of RLEM

Behaviour and Damage

The RLEM is called an earth mite because it spends 90% of its time on the soil surface, rather than on the foliage of plants. The mites feed on the foliage for short periods and then move to ground before settling at another feeding site. Other mites are attracted to volatile compounds released from the damaged leaves, which results in feeding aggregations.

Typical mite damage appears as 'silvering' or 'whitening' of the attacked foliage. Mites use adapted mouthparts to lacerate the leaf tissue of plants and suck up the discharged sap. The resulting cell and cuticle damage promotes desiccation, retards photosynthesis and produces the characteristic silvering that is often mistaken as frost damage.

RLEM are most damaging to newly establishing pastures and emerging crops, greatly reducing seedling survival and development. In years with a late 'break of season' or with late-sown crops and pastures, seedlings can emerge in the presence of established populations of RLEM, which can cause significant damage and in severe cases, entire crops may need re-sowing following RLEM attack.



RLEM damage- silvering of leaves

RLEM have a very broad host range, including canola, wheat, barley, oats, lupins, sunflower, faba beans, field peas, poppies, lucerne and vetch, as well as pasture legumes and grasses. While RLEM are less of a concern in cereal crops and in some pulses, they can cause some economic damage in some years. RLEM also feed on a range of weed species including Paterson's curse, skeleton weed, variegated thistle and capeweed.

RLEM feeding reduces the productivity of established plants and has been found to be directly responsible for reduction in pasture palatability to livestock.

Economic threshold

Economic thresholds (ET) occur when the plant production economic loss due to a pest population causing damage is equal to the cost of control (pesticide plus application). ' Such a population is known as the 'critical' or 'break even' population.

The ET for establishing annual medic pastures: 20-30 mites per 100 cm²

Some crops can compensate for Redlegged earth mite damage, highlighting the importance of applying thresholds prior to the use of insecticides/miticides. For example canola and wheat are susceptible at early growth and development but tolerate damage in later vegetative stages. Economic thresholds for Redlegged earth mites vary across crops.

For a full list go to [Cesar Australia: Red legged earth mite](#)

IPM options

Biological French Anystis mites can suppress populations in some pastures. Snout mites and other predatory mites are also effective natural enemies. Leaving shelterbelts or refuges between paddocks will help maintain natural enemy populations.

Cultural Do not sow highly susceptible crops (e.g. canola) into pastures or paddocks known to contain high mite numbers. Rotate paddocks with non-preferred crops (e.g. chickpeas and lentils). Pre- and post- sowing weed management (particularly broadleaf weeds) is important. Heavy pasture grazing in spring can help to reduce mite numbers the following autumn.

If it is necessary to sow susceptible crops in in higher risk paddocks, early sowing can help to avoid damage because plants will be larger by the time the Redlegged earth mites hatch.

Chemical Resistance to synthetic pyrethroid and organophosphate chemicals has been detected in parts of Western Australia and South Australia.

Key components of a resistance management strategy are to use thresholds (where available) to determine if spraying is warranted and rotate insecticide mode of action (MoA) groups. Insecticides/miticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults commence laying eggs. Insecticides/miticides do not kill mite eggs. Border spraying can be an effective way to control mites, as mites will often move in from crop edges and roadside vegetation. Carefully timed spring-spraying using TIMERITE® will reduce mite populations the following autumn, but could also exacerbate other mite problems.

In paddocks where resistance is known, growers should not apply synthetic pyrethroids to control mites. Redlegged earth mites possess a very high level of resistance to all pyrethroid chemicals. Applications of pyrethroids (even at rates above the registered label rate) will not control mites where resistance is found.

For moderate to high mite populations, insecticide/miticide seed dressings are an effective method but should be avoided if the risk of damage from mites and other establishment pests (e.g. green peach aphid) is deemed low.

Watch: [Redlegged Earth Mite – resistance evolution](#), GRDC. Watch this clip to learn more about the impact of Red legged earth mite to plant systems in Australia and the evolution of their chemical resistance.



Refer to the [‘Pasture pest case study: Red Legged Earth Mite \(RLEM\)’](#) to answer the following:

7. List the RLEM scientific name.

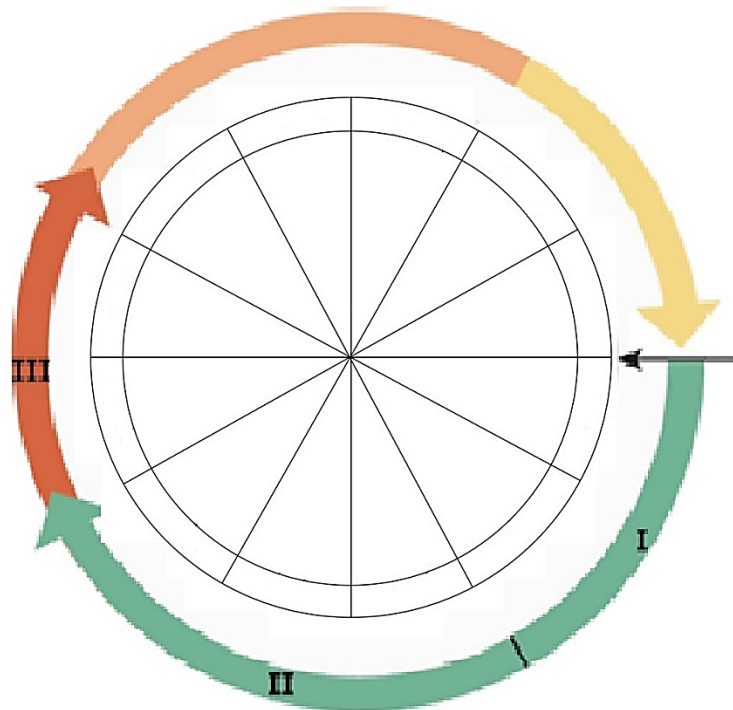
8. List the RLEM mature size.

9. Describe its colour/s and physical appearance.

10. Identify its distribution throughout Australia.

11. Recount how RLEM spread.

12. Create a diagram summarising the RLEM life cycle.



13. Identify the symptoms of RLEM damage in plants.

[illegible]

Extension activity - Pasture disease investigation

Select a pasture disease that affects your local area to investigate (Refer to **Table 8** for ideas). For your chosen disease, use research to complete the following:

- Common name (pathogen)
- Scientific name (pathogen)
- List the susceptible pasture plant/s:
- Describe how the disease affects the plant/s:
- List all hosts for this disease.
- Summarise how it spreads.
- Identify where it is found (a map could be used).
- Describe how it affects production, the environment or the economy.

Make an Integrated Weed management calendar of operations for a chosen weed in your local area. Your calendar must include:

- A timeline for a minimum of one year (dependant on the weed).
- Highlight when different control strategies are carried out to suppress the target weed.
- Brief explanation as to why each control method is carried out at that time of year.
- Include multiple control methods from each of the categories biological, cultural, physical and chemical.

Compile your findings into a digital report, for example a brochure or weed fact sheet.

Recommended website for research: [NSW Weedwise](https://www.dpi.nsw.gov.au/weedwise), Department of Primary Industries

Suggested practical activity: Monitoring for pests and disease in pastures

Adapted from [AUSVEG Monitoring tools for crop protection](https://www.dpi.nsw.gov.au/ausveg)

Monitoring is essential for an effective Integrated Pest Management (IPM) program. The purpose of monitoring is to gain a good understanding of insect pest, mite, and beneficial insect activity in your crop and to assess the severity of any disease and weed outbreaks. It is also important to understand how the weather impacts pest pressure, and to follow weather forecasts.

How to monitor/scout a crop

Effective monitoring includes assessing the numbers of insect pests, mites and beneficials in a crop, as well as the incidence of diseases, weeds and damage by any invertebrate/vertebrate pests.

Recording this information and any control actions taken helps to better understand crop management practices. A record of this information allows previous monitoring results to be referred to and the effectiveness of control decisions to be made. Scouting involves moving through paddocks to find pests and beneficials, measuring populations, and then using this information to make pest control decisions.

The information helps a grower know if a pest control treatment is needed, where it is needed, and what options are available and practical. Scouting each area of a block regularly, twice a week in warmer weather and once a week in winter gives a picture of the beneficials, insect pests, diseases, virus, and weed levels in a crop. When scouting, it is essential to thoroughly cover a section of a block, as pest problems can occur in patches at one end or side of a block or at the crop edge. There may also be 'hot' spots in different areas of a block.

For some pests, there are specific recommendations for thresholds and the number of plants to check. When scouting, it is advisable to get a random sample, using sampling patterns such as a zigzag or an 'M' pattern over a paddock. Ideally check at least three plants at a minimum of 10 random sites.

Types of monitoring tools:

A number of tools are available to assist crop scouts and growers monitor pests and beneficials, and predict pest pressure, including:

- Sweep nets in pastures and in standing crops that you can easily walk through.
- Sticky traps for small flying insects e.g., yellow sticky traps for a broad range of flying insects and blue sticky traps for thrips and leaf miners.
- Pitfall traps for mobile ground-dwelling insects and spiders.
- Suction samplers for small mites and insects on plants or soil.
- Shelter traps for slugs and snails.
- Delta traps (pheromone) to attract males from specific pests e.g., codling moth or light brown apple moth (LBAM) and *Heliothis* moth.
- Light traps for nocturnal flying insects.
- Beat sheets for standing crops hard to walk through (cotton, canola, thick pastures and soybeans).
- Fruit fly traps (with different attractants).
- Leaf wetness sensors.
- Forecasting models.
- Disease prediction models.
- Insect development models.

These tools will provide information about the range and activity of pests and beneficials in your crop. Data collected from these traps can be recorded to identify flights, or periods of peak activity. This data will assist in determining how frequent is the need for crop scouting. Note that during peak production periods, it is important to check traps more frequently. There is a variety of recording sheets that can be used as well as some designed specifically for particular crops. A diary note can also be a useful way of recording these pest monitoring results.

For a list of materials and methods to conduct plant monitoring in your school go to:

["Monitoring tools and techniques" Grains and Research and Development Corporation and Department of Agriculture and Fisheries, Queensland](#)

Plant production careers

When you think about careers in Agriculture – the first job you probably think of is a farmer, right? Think again.

There are hundreds of jobs which – quite literally – could change the world in which we live.

From scientific breakthroughs to designing autonomous robots, campaigning for change within the walls of Westminster to environmental engineering, careers in Agriculture are at the forefront of innovation.

Of course, farming remains at the heart of the industry, but the job of a farmer is massively different today from the stereotypical image of an old man wearing dungarees, chewing straw.

Agriculture is in a time of exciting change. It is now one of the most fast-paced and dynamic industries to work in, giving young people plenty of options to pick from.

Tech development is enabling agriculture to lead the way in tackling many global challenges – such as feeding a growing world population, battling climate change and protecting the environment.

A career in Agriculture also offers great quality of life, the chance to help others, to make a difference, and it can pay generously.

There really is more to Agriculture than you think.

Think Careers? Think Agriculture.

Source: [This is agriculture](#)

Follow this link to find out more about careers in agriculture at “[This is agriculture – How agriculture is changing the world](#)”



If you like gardening, plants, and the science of how things grow, this career pathway may be ideal for you. People who work in the Plant Systems pathway study plants and how they impact our world.

Plant Systems professionals help feed our growing population by monitoring the quality and safety of our food and helping consumers make sensible nutritional decisions. They also solve problems by developing crops and cultivars that are resistant to insects and develop ways to grow more food with less space. Others work to conserve our natural resources. Technology advancements in equipment and biotechnology keep this field evolving new and exciting career opportunities ([AgExplorer](#), [Agcareers.com](#), 2020).

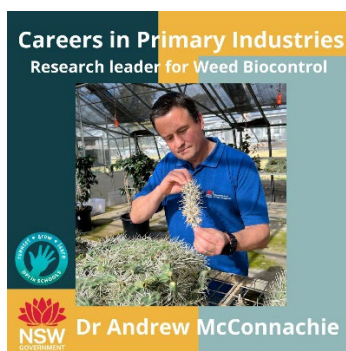
The following is a list of NSW Department of Primary Industries roles associated with plant production to get you thinking.

- Agricultural Landuse Planning Officer
- Agronomy pathologist
- Biosecurity officer
- Business analyst
- Climate researcher
- Communications officer
- Crop development officer
- Crop Genetics & Low Rainfall Agronomy manager
- Crop Physiologist
- Development Officer Temperate Fruits
- Drone technician
- Economist
- Entomologist
- Environmental scientist
- Farm assistant
- Farm manager
- Geneticist
- Horticulture development officer
- International engagement officer
- Irrigation specialist
- IT technician
- Mechanical/trade engineer
- Pasture production specialists
- Pastures development officer
- Plant pathologist
- Research and Development agronomist
- Research Horticulturist
- Research Officer Grazing Applications
- Research Officer Plant Pathology
- Research Officer Soils
- Research Physiologist Viticulture
- Research scientists
- Soil technician
- Technical assistant
- Technical Officer Insecticide Resistance
- Technical specialist grain services
- Technical Specialist horticulture
- Technical Specialist Oils & Pulses

Watch the NSW DPI careers in Primary Industries short clips to see what a career working with plants could look like.



[Research Officer- Pastures](#)



[Research Leader for Weed Biocontrol](#)



[Viticulture Development Officer](#)

18. Use the internet and other sources to investigate a plant production-related career of your choosing. For this career find out the following:

- Title of the career/job
- Role description
- Personal qualities
- Skills required (if formal courses or education is required, find out where you could train and the timeframe to complete the course)
- Salary or wage range
- Identify opportunities for job progression in the role

Useful sites to help you with your research include:

- [Career Harvest](#)
- [Plant systems, Ag Careers.com](#)
- [Agriculture robots: the future of job creation](#)
- [How to become a robotics engineer](#)

Agricultural Technology Years 7-10 Syllabus, 2019

Outcomes	Content
AG5-1 explains why identified plant species and animal breeds have been used in agricultural enterprises and developed for the Australian environment and/or markets AG5-3 explains the interactions within and between the agricultural sector and Australia's economy, culture and society AG5-2 explains the interactions within and between agricultural enterprises and systems AG5-4 investigates and implements responsible production systems for plant and animal enterprises AG5-6 explains and evaluates the impact of management decisions on plant production enterprises AG5-8 evaluates the impact of past and current agricultural practices on agricultural sustainability AG5-9 evaluates management practices in terms of profitability, technology, sustainability, social issues and ethics AG5-12 collects and analyses agricultural data and communicates results using a range of technologies	Core A: Introduction to Agriculture - identify the characteristics of animal breeds and plant types specific to chosen enterprises, for example: – identify pasture types – associate plant growth patterns with local climate patterns - collect climatic data that affects plant and animal production and relate it to the selection of plants and animals for a particular location, for example: (ACTDEK044) – Bureau of Meteorology website – actual rainfall and temperature recordings for the school – characteristics of Bos indicus cattle related to tropical environments - identify the impact of a range of cultures, including those of Aboriginal and/or Torres Strait Islander Peoples, on Australian agricultural production, for example: (ACTDEK040) – Aboriginal land management - research a range of current and future employment opportunities in agriculture - research the required assets, infrastructure and management techniques required for plant and animal production (ACTDEK047) - evaluate intensive and extensive production systems Plant Production 1 - identify plants relevant to agricultural production, for example: – important plant crops in Australia, eg wheat, barley, oats – importance of legumes in pastures – commercially grown bush plants eg wattle, sandalwood - identify and describe common plant pests and diseases - evaluate strategies for the management and control of plant pests and diseases (ACTDEP050) - investigate current agricultural systems and Aboriginal land management practices - explore the effect of European and Aboriginal agricultural practices on agricultural production and environmental sustainability, for example: (ACTDEK040) - evaluate current agricultural methods relevant to the chosen plant enterprise in terms of environmental sustainability, for example: (ACTDEK044) - research an agricultural issue relevant to the plant enterprise chosen and propose possible solutions, for example: (ACTDEK044) - collect accurate evidence and record relevant data relating to the plant enterprise

AG5-11 designs, undertakes, analyses and evaluates experiments and investigates problems in agricultural contexts

AG5-14 demonstrates plant and/or animal management practices safely and in collaboration with others

- conduct a controlled agricultural experiment based on a plant-related hypothesis
- work collaboratively to perform plant enterprise management activities (ACTDEP050, ACTDEP052)

Plant Production 2

- identify and select technologies to assess the effectiveness of plant production practices, for example: (ACTDEK047)
- investigate timing and impact of relevant operations in a plant production cycle, e.g. sowing
- evaluate the impact of current technologies on sustainability, for example: (ACTDEK041, ACTDEK044, ACTDEP051)
- compare short-term and long-term effects of agricultural production systems on sustainability, for example: (ACTDEK044)
- draw conclusions from evidence and the analysis of data, for example: (ACTDEP051)
- formulate a solution to an agricultural issue (ACTDEP048)
- examine and analyse data from a range of sources
- communicate an understanding of trends, patterns and relationships in data to a specified audience