Department of Primary Industries

Industry insights - Pasture production

Supporting document

NSW DPI Schools Program

Answer guide

www.dpi.nsw.gov.au

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

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

Contents

Agricultural pastures of NSW - ANSWER GUIDE

This resource was developed as a part of the Industry Insights – poster and workbook series. It has been designed to work in conjunction with the Agricultural pastures of NSW poster and matching Agricultural Pastures of NSW workbook.

Sample answers have been provided for learning activities where applicable. The following suggested answers should be used as a guide. Note that these are suggested answers only, and not necessarily the very best answer, nor are they the only possible answers.

What is Agronomy?

Classification of agronomic crops and pastures

1. Define agronomy.

Agronomy can be defined as the science that deals with the principles and practices of field management concerning major field crops and pastures with its central theme being 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. Sciences holistically dealt with include 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.

2. Complete the table by giving examples of species for the following crop and pasture categories. Use the NSW DPI Schools Program 'Agricultural crops and pastures of NSW' poster for assistance.

Crop / pasture category	Examples
Cereal crops	Wheat, barley, oats, triticale, maize, cereal rye
Fibre crops	Hemp, cotton
Oilseed crops	Canola, sunflower, safflower, soybean
Pulse crops	Chickpea, faba/broad bean, field pea, lentil, lupin, mungbean
Fodder shrubs	Tagasaste, saltbush
Forage grasses (C4 plants)	Sugarcane, millet, forage sorghum
Summer forage legumes (C4 plants	Lablab, cowpea
Forage brassicas	Forage rape, turnip, kale
Pasture legumes	Arrowleaf clover, balansa clover, barrel medic, burr medic, lucerne, strawberry clover, subterranean clover, white clover, woolypod vetch, yellow serradella
Pasture grasses	Bluegrass, soft brome, cocksfoot, couch, kangaroo grass, kikuyu, Mitchell grass, panic, paspalum, Phalaris, prairie grass, reed canary grass, Rhodes grass, perennial ryegrass, annual ryegrass, fescue, wallaby grass
Narcotic crops	tobacco, cannabis
Beverage crops	coffee, tea, cocoa, beer (barley)
Medicinal crops	echinacea, garlic, ginseng, chamomile, Saint John's wort, valerian

Group research task – answers will vary.

Agro- Ecological zones

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

Answers will vary. Example: Orange – Temperate, seasonally dry slopes and plains.

2. Go to CSIRO, The eleven agro-ecological regions. Describe the agro-ecological zone where you live.

Answers will vary. Example: Orange – Temperate, seasonally dry slopes and plains.

The temperate Seasonally Dry Slopes and Plains is a diverse region. It is the southern sheep/wheat/cattle belt which extends from the Eastern Highlands to the Riverina plains of the Murray-Darling, across the Mallee to the Eyre Peninsula, and to the Southwest Western Australia. The climate is characterised by hot summers, cool winters and winter dominant rainfall. The natural vegetation of Casuarina, Eucalypt and Acacia woodland and forest along with chenopod, mixed and acacia shrubland, has been widely cleared for cereal cultivation and temperate pastures. Throughout the eastern region, irrigation farming and horticulture are very important, particularly along the Murray, Murrumbidgee and Goulburn rivers.

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

- Climatic factors- rainfall, temperature, wind, humidity, sunlight etc.
- Physical factors – soil, topography, river systems/water source etc.

4. Explain the trend between climate and geographical distribution of intensive and extensive production systems around Australia.
   The geographical distribution of intensive and extensive production systems in Australia is closely linked to climate. Australia's vast landmass spans a wide range of climatic zones, from arid deserts to temperate coastal areas, and this diversity strongly influences the type of agricultural and livestock production that can be sustained in different regions.

   Intensive Production Systems:

   - Crops: Intensive cropping systems often require reliable rainfall or irrigation. Therefore, they are more common in temperate and Mediterranean climates where rainfall is relatively evenly distributed throughout the year or concentrated in the winter.
   - Livestock: Intensive livestock production, such as feedlots, and prime lamb/beef production, tend to be located in regions with more predictable access to water/rainfall and where it's possible to grow or import large quantities high quality pasture. This occurs in temperate to subtropical climates.

   Extensive Production Systems:

   - Crops: Extensive cropping systems are found in areas with less reliable rainfall. Farmers in arid and semi-arid regions often practice rainfed agriculture with crops that are adapted to dry conditions.
   - Livestock: Extensive livestock systems are more common in arid and semi-arid areas where natural pastures can support lower stocking densities due to limited rainfall and vegetation growth.

5. Go to the NSW DPI Categories of pasture plants webpage. Apply your understanding of agro-ecological zones to complete the following question.
   Make a list of plant species and variety categories which are suited to your agro-ecological zone. Read the descriptions to help you match the plant types. For example, Temperate grass, Tropical grass, legumes, natives grasses etc.

Answers will vary. Example: Orange – Temperate, seasonally dry slopes and plains.

- Temperate grass (cool season, C3 species)
- Temperate legume (cool season, C3 species)
- Native grass
- Pasture herb
- Forage shrub

Pasture production systems

Go to Categories of pasture plants on the NSW DPI webpage to complete questions 1-3.

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

Perennial species regrow from root reserves each year while annuals grow a new plant from a seed each year. In areas of higher rainfall, perennials can have the advantage of being established and therefore able to respond to favourable seasonal conditions throughout the year. In contrast, annuals can be sown (or may naturally re-sow themselves) to achieve a specific feeding goal, without the need to survive a harsh summer or winter.

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

Legumes, which include clovers and medics, are a family of broadleaf (or dicot) plants that can produce their own nitrogen. They do this with the help of *Rhizobium* bacteria, which live 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.

3. Contrast native introduced and naturalised species.

Native grasses have evolved in Australia, whereas introduced, or exotic species have evolved elsewhere. Naturalised species are those that originate overseas but are now established in parts of Australia, where they persist without human intervention.

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
Growth period	Cool season or yearlong	Warm season
Light requirements	Lower	Higher
Temperature requirements	Lower	Higher
Moisture requirements	Higher	Lower
Frost sensitivity	Lower	Higher
Feed quality	Higher	Lower
Production	Lower	Higher
Examples	weeping grass and common wheatgrass	kangaroo grass, red grass and wire grass

5. List three advantages of C3 plants

C3 plants are adapted to cool season establishment and grow in either wet or dry environments. They also have greater tolerance of frost compared to C4 grasses.

6. List three advantages of C3 plants

C4 plants are more adapted to warm or hot seasonal conditions under moist or dry environments. They generate more bulk or dry matter than C3 plants and feed quality is often higher in comparison.

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

Answers will vary. Assessments could address:

- Nutritional composition: Different plant species have varying nutrient profiles and growth patterns. A mixed pasture provides a wider range of forage options throughout the year. This diversity can improve the overall nutrition of the livestock, ensuring they receive a balanced diet with a variety of vitamins, minerals, energy (grasses) and proteins (legumes).
- Improved Grazing Efficiency: Ruminants prefer different types of forage at different stages of growth and production. By having a mix of species, you can extend the grazing season and reduce the risk of overgrazing or selective grazing. This can lead to better overall forage utilisation and less pasture degradation.
- Soil health: Mixed pastures can contribute to improved soil health. Different plants have different root structures (monocotyledons vs. dicotyledons, annual and perennial), which break up compacted soils, increase water infiltration, and promote nutrient cycling, increase soil carbon and microbial activity. This, in turn, can lead to better overall pasture productivity and animal health and production.
- Reduced metabolic diseases: Mixed pastures can reduce incidence of seasonal metabolic disorders such as bloat, milk fever, grass tetany, ketosis, acidosis etc.
- Biodiversity and Resilience: Mixed pastures can support a diverse ecosystem of plants, microbes, insects, and wildlife. This biodiversity can provide natural pest control and improve the overall resilience of the pasture to environmental stresses such as drought or disease outbreaks.
- Seasonal Adaptation: Different plant species have varying tolerances to environmental conditions. Having a mix of species can increase the pasture's ability to adapt to changing weather patterns and climate fluctuations.
- Reduced Erosion: The roots of various plant species help hold soil in place, reducing wind and water erosion and the loss of topsoil.
- Economic Benefits: Improved livestock nutrition and health can result in better growth rates, higher production, and increased reproductive efficiency. Additionally, reduced reliance on chemical inputs like fertilisers and pesticide controls can lead to cost savings.
- Environmental Sustainability: Mixed species pastures often have a lower environmental impact compared to monoculture pastures. They can reduce the need for synthetic fertilisers and pesticides, promote carbon sequestration in soils, and enhance overall ecosystem services.

While mixed species pastures offer numerous benefits, they also require careful planning and management. Proper species selection, rotational grazing strategies, and monitoring are essential to make the most of this approach. Additionally, the specific benefits may vary depending on the region, climate, and the goals of the livestock enterprise.

Types of pastures- grasses and legumes

Grasses

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

	Plant part		Plant part
A)	Spike	G)	Internode
B)	Spikelet	H)	Blade
C)	Collar	I)	Sheath
D)	Ligule	J)	Stolon
E)	Auricle	K)	Roots
F)	Node	L)	Rhizome

1. Describe auricles

   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.

2. Describe ligules

   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.

3. Describe tillers
   Tillers allow a plant to become larger. They are new shoots which emerge from the plants crown. Each tiller has approximately 3-5 leaves.

4. Explain how grazing management is used to influence plant growth.
   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 via photosynthesis.

5. Describe the impact a well managed pasture has on the water table.
   Well managed perennial grass-based pastures, use soil water to depth and 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.

Legumes

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

	Plant part		Plant part
A)	Raceme	G)	Petiole
B)	Leaflets	H)	Stipule
C	Leaf	I)	Rhizome
D)	Inflorescence	J)	Stolon
E)	Nodes	K)	Nodule
F)	Internode		

7. Compare the following structures:

a) Stolon and rhizome
   Stolons and rhizomes are modified stems for vegetative reproduction. While stolons grow above the ground, rhizomes grow beneath the ground.

b) Stem and petiole
   The petiole is the stalk that supports a leaf in a plant and attaches it to the stem. The stem is the part of the plant that serves as the main source of support and produces nodes and roots.

c) Leaflet and leaf

A leaf is composed of one continuous blade and has buds at it's base. A leaflet does not occur on a main plant stem or branch, but rather on a petiole or a branch of the leaf. A leaflet is a compound leaf. A group of leaflets make up a single leaf.

Native pastures

1. Complete the table to summarise advantages and limitations of including perennial native grasses in a mixed pasture.

Including native perennial grasses in a pasture	
Advantages	Limitations
Native grasses are mostly perennials Some have nutritive characteristics similar to introduced pasture species. Adapted to adverse climate conditions such as droughts, heavy rains and frosts. Many tolerate low fertility, acid soils and water stress, and are more resistant to disease. Different native species have growth periods at different times of the year, providing the potential for year-round green feed for seasonal feed gaps Dense tillers /roots hold the soil to prevent soil erosion and nutrient runoff. Can help control dryland salinity due to their deep root systems, and summer dominant perennial growth Provide a lower input grazing system, reducing the dependence on resources. Increase biodiversity. Well suited to shallow soils Attract beneficial insects to improve crop health.	Under conditions where improved pasture species perform adequately, native grasses are unlikely to be more productive or be able to compete with improved pasture species. 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 nutritive values and herbage yield. They are difficult to establish through sowing with traditional sowing technologies. Overgrazing can decimate 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.

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

Answers will vary- could include:

- Controlled grazing management, that matches the timing of grazing or resting of a pasture to an appropriate growth stage of the desired pasture grass will provide positive selection pressure for the species. For example, withholding grazing from spring to late summer allows desirable perennial plants to set seed and conserve energy, leading to higher recruitment rates of new plants and plant tillers in autumn and winter. Grazing heavily after annual grass stem elongation, but before seed head emergence, followed by resting over spring and summer, will increase the amount of seed produced by perennials, while reducing the seed from undesirable annuals.
- Use of controlled burns to reduce dead biomas, remove undesirable annual species and promote new growth from desired native perennial species.
- Use of fertiliser matched to native grass requirements.

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

Answers will vary, dependant on location. Could include red grass (*Bothriochloa macra*), purple wiregrass (*Aristida ramosa*), wallaby grass (*Austrodanthonia* species) and weeping grass (*Microlaena stipoides*) etc.

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

Answers will vary- should include the benefits and limitations from table above formatted into a written response.

Livestock production from pasture systems

Pasture quantity

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

The quality and quantity of animal product derived from pasture fed livestock is directly related to the quality and quantity of the pastures they graze.

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

Pasture quantity and pasture quality

3. Define herbage mass?

Herbage mass refers to the total amount of dry matter of pasture present, including both green and dead material minus water content. Herbage mass (kg DM/ ha) = total green + dead material.

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

Water content of plants species constantly changes e.g. throughout the day, dependants on growth stage etc. Also water (although critical for livestock) gives no nutritional benefit for production, therefore is left out.

5. Analyse Figure 5 to describe the trend between sheep and cattle intake and herbage mass.

Sheep- Intake (kg DM/day) quickly increases when herbage mass is between 200~800(kg DM/ha), after which intake plateaus.

Cattle- Intake (kg DM/day) quickly increases when herbage mass is between 200~1600(kg DM/ha), after which intake plateaus.

On the pasture with the same herbage mass, cattle intake will be greater than sheep.

Pasture quality

1. Define digestibility.

Digestibility, expressed as a percentage, provides a prediction of the proportion of the pasture consumed which is used by the animal for growth, development and maintenance. For example, if the digestibility of a pasture is said to be 70%, approximately 70% of that consumed on a dry matter basis will be used by the animal for its own nutritional requirements, while 30% will eventually pass as faeces.

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

Digestibility target= >60%. Below 60% digestibility, all classes of livestock will lose weight.

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. More pasture consumed equates to higher production. True

b) On a pasture of high digestibility, even though plenty may be available, stock cannot digest enough feed, to meet nutritional requirements (low quality). False
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). True
d) Digestibility is always the same between pasture species and varieties, parts of a plant and for the stage of growth of the plant. False
e) Perennial grasses are less digestible for a longer period than annuals as perennials die off after seed production. False
f) Leaf material has a higher digestibility % than stem. True
g) Digestibility declines as pasture matures True

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.

- Animal used (kg) + faeces (kg) = amount consumed(kg) = 20kg consumed
- Digestibility=40%
- 40/100 x 20kg = 8kg (used by animal for production)
- 20- 8= 12kg passed as faeces

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

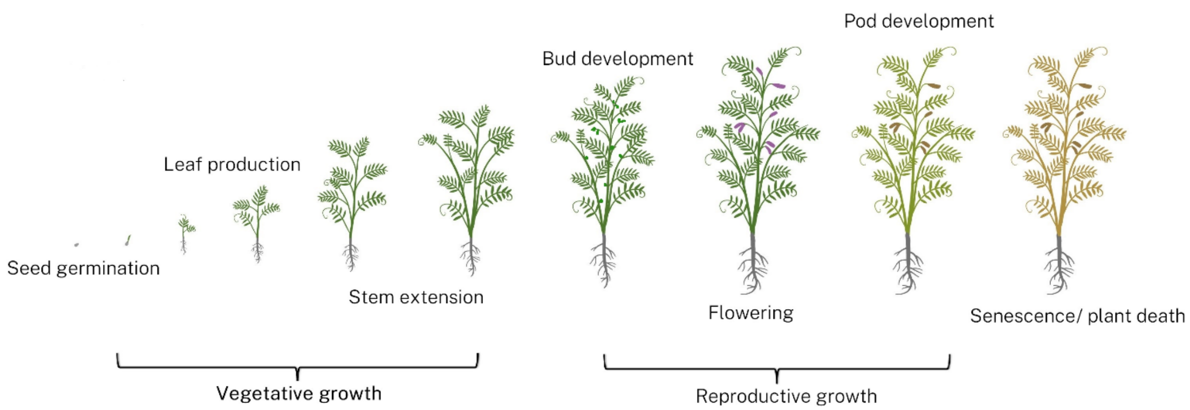
Vegetative growth stages includes seed germination, leaf production and stem extensions in legumes, or tillering in grasses.

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

Reproduction 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.

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

See following diagram



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

Answers will vary but should include setting up a grazing management system that keeps pastures in the vegetative growth state for as long as possible to maximise pasture digestibility and livestock production. This could be achieved through strip grazing, pasture rotation, increased stocking numbers in a controlled pasture rotation etc.

Pasture quantity and quality interactions

1. Complete the sentences by filling in the missing words:
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.
2. Explain what pasture benchmarks are?

Pasture benchmarks indicate how much green herbage mass is required to satisfy the nutritional requirements of stock at various stages of their reproductive cycle, and for growth. They are a management tool allowing managers to match livestock types and their specific production and nutritional requirements to paddock suitability dependant on pasture digestibility.

3. Apply your understanding from this section to complete the following activity.
Scenario- A mixed farming system with 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.

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

Paddock 1 • Native pasture • Herbage mass: 9000kg/DM/ha • Digestibility: 56% None- animals will lose weight- fat heifers for short term to rapidly lose weight.	Paddock 2 • Naturalised pasture- kikuyu dominant • Herbage mass: 1250kg/DM/ha • Digestibility: 60% Dry ewes	Paddock 3 • Microlaena/ white and subterranean clover • Herbage mass: 480kg/DM/ha • Digestibility: 78% Dry ewes
Paddock 4 • Phalaris /white and subterranean clover • Herbage mass: 2000kg/DM/ha • Digestibility: 75% Ewes with twin lambs or grower high production yearling steers	Paddock 5 • Grazing oats • Herbage mass: 7800/DM/ha • Digestibility: 74% Best paddock to cut for hay, but suited to all growth production groups	Paddock 6 • Phalaris /white and subterranean clover • Herbage mass: 2200kg/DM/ha • Digestibility: 68% Ewes with single lambs
Paddock 7 • Grazing oats • Herbage mass: 380kg/DM/ha • Digestibility: 70% Nothing- Herbage mas currently not sufficient for production goals	Paddock 8 • Medic based improved pasture. • Herbage mass: 2000kg/DM/ha • Digestibility: 74% Ewes with twins, singles or steers	Paddock 9 • Perennial rye and Lucerne • Herbage mass: 700kg/DM/ha • Digestibility: 76% Yearling steers

4. Are all paddocks suited to production? If no, which one/s and why?
- Paddock 1 – high herbage mass, insufficient digestibility- animals will rapidly lose weight.

- Paddock 7 – high digestibility %; insufficient herbage mass. Animals will rapidly lose weight.

5. Identify and explain a management practice which could be implemented to utilise paddocks unsuited to production?

Answers will vary- two possible examples:

Supplementary feeding- provision of a feed source that meets production requirements in terms of energy and protein requirements to supplement roughage in a low digestibility type paddock.

Paddock rotation grazing management- better utilisation of paddocks managed to prevent overgrazing and herbage mass being unsuitable for grazing.

Pasture composition- why improve pastures?

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

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

2. List five advantages of improved pastures.

List any five of the following:

- Higher carrying capacity (150% more productive than annual pastures and up to 300% more productive than native pastures)
- Higher quality and quicker turn off of livestock
- Increased enterprise flexibility
- Greater production reliability
- Filling of feed gaps
- Greater profit from increased production
- Greater ground cover which minimises soil degradation issues
- Extension of the growing season which can reduce the need for supplementary feeding

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

Legume benefits	Grass 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.	• Increase total yield (herbage mass) compared to a legume only pasture • Reduce danger of bloat in ruminants • Increase protection from erosion and weed invasion with a solely perennial pasture • Reduce the rate of soil acidification and soil salinity. Perennial grasses are very important to reduce soil degradation issues.

Managing pastures

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

- 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
- Pasture species selection suited to soils and climate
- Livestock production pattern (e.g. backgrounding, feed lotting, self-replacing herd etc)

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.

- 'Select, assess and plan early'
- Weed and pest control proceeding pasture establishment
- Pre- sowing cultivation or grazing management pre- sowing
- Absolute weed and pest control pre- sowing
- Adequate soil moisture to maximise quick germination and pasture seedling survival at sowing.
- Accurate seed placement (depth and spacing at sowing
- Regular monitoring of weeds and pests after sowing
- Initial and subsequent grazing – post germination and ongoing

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

Hay making relies on wilting the cut pasture to a moisture or dry matter level where it is dry enough not to ferment, but wet enough not to shatter when baled. (approximately 12% dry matter). Hay is cut with a mower, then raked into piles or windrows and left to dried in the paddock, it is then baled into either larges bales or rectangles or small rectangular bales. A hay tedder may be used in conjunction with raking to evenly dry out hay. It can take up to a week.

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

Answer will vary as to whether describing pit of bale silage.

For both pasture is cut when actively growing. Baled silage is similar to hay making, pasture is mowed and raked into windrows but is not raked multiple times. It is baled straight away with a high moisture content. It is then wrapped individually or with a tube wrap. For pit silage, pasture is cut and chopped using a forage harvester. The chop is fed into a wagon and dumped into a pit fully lined with plastic sheet. Chop is compacted to remove oxygen and wrapped up. Ensile process take 3-8 weeks.

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

Hay		Silage	
Advantages	Disadvantages	Advantages	Disadvantage
• Efficient to transport • Does not require specialised loading or feeding equipment. • Lower baling cost/tonne • More palatable than silage • No issues with non-ruminant consumption	• Prone to weather damage which degrades quality • Limited 'lifetime'	• High quality feed value as compared to hay • Less exposed to weather damage • If stored and made correctly has a much longer 'lifetime' as compared to hay • Free of weed seeds • Valuable long term fodder conservation option	• Higher baling cost/tonne than hay • Plastic wrap can be easily damaged. • Single use plastic wrap poses an environmental issue

Calendar of operations activities

6. Figure 14 shows notes from a managers paddock book and need to be transferred 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. – see following table for suggested answer
7. What season and what months do the cows and heifers calve?
   July-August (late winter)
8. What season and what months are weaners sold?
   March (early Autumn)
9. What season and what months are 18-month-old steers sold?
   February (late Summer)
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.

Answers will vary. Could include.

All beef cattle operations are timed to match optimal use of pasture quantity and quality. Calving is timed to late winter, just before the Spring/Summer flush of high quality and quantity of pasture, influenced by the warmer temperatures. Cows lactation production peaks approximately 8 weeks after calving. The late winter calving allows calves to get on top of the milk before lactation peaks, which has higher nutritional requirements timed with feed (pasture) quality and availability. As calves grow and begin grazing the high quality and quantity spring pastures also match the calves' high nutritional requirements for growth and development.

Sale of weaners and 18-month-old steers between February- March (late Summer – early Autumn) are timed to match pasture production. Pasture growth and production will decline with declining temperatures in Autumn. Animals have higher nutritional requirements as temperatures lower. Stock are sold prior to animals losing weight and pasture quantity and quality reduction. Any excess feed is harvested as silage. The reduced stocking rate also allows the farmer to select paddocks to lock up and sow to rye grass which will be utilised winter (feed gap) to Spring.

Answer guide

	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} dose) 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)
			Weigh 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											

Answer guide

Pastures - kikuyu/clover	Book in contractor for making kikuyu silage	Contractors make excess feed (selected paddocks) into silage or heavily graze with stock, then top dress with nitrogen prior to silage being made.	Apply lime/gypsum as per soil test results	Rotational grazing	Rotational grazing	Identify paddocks to lock up for hay/silage production and lock in contractors Rotational grazing	Monitor for weed seedlings, pests E.g. (red-legged earth mite) and diseases (e.g. rust)- treat as required Rotational grazing		Lock up perennial pasture for seed set. Rotate different paddock/s each year. Soil test any paddocks NOT fertilised within past 3-4 months	Rotationally graze kikuyu paddocks to maintain legumes. Slash if needed after grazing to remove old, rank pasture growth
Pastures- annual ryegrass, clover	Book in contractor to sow ryegrass- order seed		Apply lime/gypsum as per soil test results Contractors direct drill annual ryegrass (when temperature below 15°C) into kikuyu/clover pastures	Rotationally graze at 2.5-3 leaf stage (before pasture lodges).	Ryegrass -Top dress with Nitrogen (80kg urea/ha) after every second grazing Rotational grazing	Identify paddocks to lock up for hay/silage production and lock in contractors Rotational grazing	Monitor for weed seedlings, pests E.g. (red-legged earth mite) and diseases (e.g. rust)- treat as required Rotational grazing	Prepare for harvest- early maturing ryegrass starts flowering- cut when seed heads first appear after flowering	Soil test any paddocks NOT fertilised within past 3-4 months	Rotationally graze paddocks to prevent pastures reaching seed set (reduced nutritional quality)

Pastures and sustainability.

1. List the three main GHG's of concern to agricultural production.
   - nitrous oxide (N2O)
   - carbon dioxide (CO2)
   - methane (CH4)

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

Methane gas is a GHG that is short-lived but has a global warming potential (temperature and radiation insulation within the Earths' atmosphere) 30 times higher that CO2. Meaning it is attributing to global warming.

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

3. Refer to Table 7 to answer the following:
   a) Identify the perennial legume species which has the greatest potential to reduce methane emissions (average)?
   Lotus spp. Big trefoil and Lotus spp. Birdsfoot trefoil (-38)

   b) Identify the annual legume species which has the greatest potential to reduce methane emissions (average CH4)?
   Biserrula (-77)

   c) Identify the perennial herb species which has the greatest potential to reduce methane emissions (average CH_4)?
   Plantain

   d) Identify a pasture species with the greatest potential to reduce methane emissions (average CH_4), in a moderate-low rainfall climate with a high pH soil?
   Sulla

   e) Identify the three pasture species with the greatest potential to reduce methane emissions (average CH_4), and have high levels of persistence and production?
   Biserulla, Chicory and Plantain

4. Compare the short-term and long-term effects of upgrading a pasture to include anti-methanogenic pasture species in term of production and sustainability.
   Answers will vary. They could address.

   Upgrading a pasture to include anti-methanogenic pasture species can have both short-term and long-term effects on production and sustainability, with a focus on mitigating methane emissions from livestock. Methane is a potent greenhouse gas, and its reduction is crucial for addressing the issue of climate change. Here's a comparison of the short-term and long-term effects:

   Short-Term Effects:

   - Production Impact: Positive: Anti-methanogenic pasture species may lead to improved digestion in livestock, potentially enhancing feed efficiency and nutrient utilization, resulting in increased productivity.

Negative: There might be an initial adjustment period for livestock to adapt to the new forage, impacting feed intake and weight gain. Anti-methanogenic species may not support production to the same previous levels.

- Methane Reduction: Positive: Short-term reduction in methane emissions is possible due to the introduction of anti-methanogenic plants, which can have a quick impact on the overall carbon footprint of the livestock.
- Costs and Inputs: Negative: Initial costs associated with transitioning to anti-methanogenic pasture species, including acquiring new seed, potential changes in management practices, and training for staff.
- Soil Health: Variable: Changes in soil health may occur, depending on the specific anti-methanogenic species. Some plants may have positive effects on soil structure and nutrient cycling, while others may require adjustments in nutrient management.

Long-Term Effects:

- Production Impact: Positive: Over the long term, improved livestock performance may continue, with the potential for increased resistance to diseases and better adaptation to the new pasture conditions.
- Methane Reduction: Positive: Continued reduction in methane emissions as anti-methanogenic species establish and become integrated into the pasture ecosystem. Long-term benefits in terms of sustainability and environmental impact.
- Biodiversity: Variable: Over time, the introduction of new pasture species may impact local biodiversity. Careful selection of anti-methanogenic species and management practices can mitigate potential negative effects.
- Economic Sustainability: Positive: As the benefits of reduced methane emissions and improved livestock performance continue, there may be long-term economic sustainability for farmers through improved efficiency and market positioning.
- Soil Health: Positive: Depending on the chosen anti-methanogenic species, long-term improvements in soil health may occur, contributing to sustainable pasture management.
- Adaptation and Resilience: Positive: Over time, the pasture ecosystem may become more resilient to environmental changes, contributing to long-term sustainability.

In conclusion, while there may be some short-term challenges and adjustments, upgrading a pasture to include anti-methanogenic species can offer significant long-term benefits for both production and sustainability, with positive impacts on methane reduction, soil health, and economic viability. However, careful planning and management are crucial to ensuring a successful transition and maximising the positive outcomes.

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 supress methane production. For each compound/metabolite explain how it reduces methane production, and identify which plants contain them.

   Answers will vary but list and discuss:

   - Tannins e.g. Lotus, Sainfoin, Sulla, Red clover, White clover, Arrowleaf clover, Bladder clover, Subterranean clover, Chicory, Plantain
   - Saponins e.g. Sulla, Lucerne, Red clover, White clover, Burr medic, Chicory, Plantain

- Polyphenolic compounds (phenolic acids, flavonoids, xanthones, lignans and stilbenes). e.g. Sainfoin, Lucerne, Arrowleaf clover, Bladder clover, Subterranean clover, Biserrula, Burr medic, French serradella, Yellow serradella, Chicory

6. Assess the research recommendations from this review.

Answers will vary, but will be based on Research gaps and future direction section of reading.

Regenerative agriculture – a sustainable ag approach

1. Define regenerative farming.

Fundamentally regenerative agriculture is a philosophy that focuses on implementing a diverse range of approaches that sustain financially viable farming enterprises, restore and enhance 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.

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

List any five of the following:

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

3. Compare sustainable farming and regenerative farming.

Answers will vary. Answers could discuss:

Sustainable farming and regenerative farming are two approaches to agriculture that prioritize environmental health, biodiversity, and long-term productivity. While they share some common goals, there are differences between the two concepts.

Sustainable Farming:

- Resource Management: Sustainable farming aims to use resources efficiently and minimize negative environmental impacts. This includes optimizing water usage, reducing chemical inputs, and promoting soil health.
- Biodiversity: Sustainability in farming often involves maintaining biodiversity by preserving natural habitats, promoting crop rotation, and using cover crops to prevent soil erosion.
- Community and Social Considerations: Sustainable farming takes into account social and community aspects, such as fair labour practices, community engagement, and support for local economies.
- Technology Use: Sustainable farming may incorporate modern technologies, but the emphasis is on responsible use to avoid negative environmental consequences.

- Certifications: There are various sustainability certifications, such as organic certification, that farmers may pursue to demonstrate their commitment to sustainable practices.

Regenerative Farming:

- Holistic Approach: Regenerative farming takes a more holistic approach, aiming not just to sustain but to actively improve the health of ecosystems. It focuses on regenerating soil health, enhancing biodiversity, and promoting ecosystem services.
- Soil Health: A central tenet of regenerative farming is the emphasis on soil health. Practices such as cover cropping, reduced tillage, and the use of organic matter are employed to improve soil structure and fertility.
- Carbon Sequestration: Regenerative farming often places a strong emphasis on carbon sequestration, aiming to capture and store carbon in the soil. This contributes to mitigating climate change.
- Integrated Livestock: Some regenerative farming models integrate livestock into the system, promoting rotational grazing and utilizing animal manure to enhance soil fertility.
- No-Till Farming: While sustainable farming may reduce tillage, regenerative farming often promotes no-till or minimal tillage practices to preserve soil structure and microbial communities.
- Adaptation to Local Conditions: Regenerative farming encourages farmers to adapt practices based on local conditions, considering factors such as climate, soil type, and ecosystem dynamics.

In summary, while sustainable farming seeks to maintain and balance ecological, economic, and social aspects, regenerative farming takes a more proactive stance by focusing on restoring and enhancing ecosystem health. Both approaches contribute to more environmentally friendly and resilient agricultural systems, but regenerative farming goes a step further in actively improving the land and soil over time.

Integrated pest and disease management (IPDM)

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

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

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

The use of remote sensing and UAV technologies in pest insect and disease monitoring will not replace the need for ground monitoring and scouting, but will complement existing monitoring for pests, the effective area that can be monitored, and indicate high risk areas within paddocks for pest attacks. This will lead to a better picture of what is actually happening, can be used to map areas of higher risk and give historical records for endemic pests.

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

Answers will vary. Example answer:

a) A paddock has a weed population with one pest with pesticide resistance. The paddock is sprayed.

b) Some pests have survived which naturally occurs, due to a range of environmental factors which could include incorrect chemical dosage, missed application etc. The remaining pests (both pesticide susceptible and the one pesticide resistant) grow and reproduce over time. The herbicide resistant insect pass on their genes to the offspring. The lack of genetic diversity in subsequent populations due to the selection pressure of using the chemical, means that subsequent populations will have greater likelihood of carrying the herbicide resistance gene.

c) The pest population has reached the critical point that the producer needs to treat again. The number of pesticide resistant insects have increased to six. The paddock is sprayed.

d) Some insects have survived which naturally occurs. The six herbicide resistant pests are still present, and one pesticide susceptible insect pest. The remaining pests (both herbicide susceptible and herbicide resistant) grow and reproduce over time. The lack of genetic diversity in subsequent populations due to the selection pressure of using the chemical, means that subsequent populations will have greater likelihood of carrying the herbicide resistance gene.

e) The pest population has reached the critical point that the producer needs to treat again. The number of pesticide resistant insects have exploded and increased to fourteen. The pesticide resistant population has now reached a point that the producer cannot use pesticide application for pest control. The producer will now have to look at a pesticide with a different mode of action (MoA) or more correctly, should immediately use a range of IPM strategies to reduce the resistant population.

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

Answers will vary. Example answer:

The producer should have developed and applied an integrated pest management program much earlier, rather than solely relying on chemical control. The producer could have used:

- Biological – introduction of a biological control agent (fungi, insect, or bacteria) or a beneficial predatory organism specific for the pest
- Physical control strategies such as using lures and traps, soaps, oils and detergents burning, grazing, or cultivating the paddock (dependant on the pest)
- Cultural control practices such as pasture and crop rotations over time in the paddock- replacing the susceptible crop/pasture with something less susceptible, or planting companion crops.

These strategies should have been used in conjunction over time rather than sole reliance on chemical control.

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

Answers will vary. Example answer:

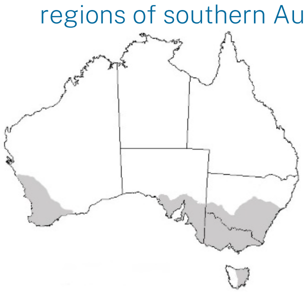
It is crucial to not solely rely on chemicals as a control strategy, because chemical resistance occurs naturally and can develop within a population. Once resistance occurs to a certain type of pesticides mode of action, that pesticide type becomes unusable. As there are only a finite number of pesticide types (dependant on their mode of action) it is crucial to prevent pests developing resistance. Effective pest management requires an integrated approach using a range of biological, cultural, physical, and chemical strategies specifically developed to treat the target pest. If chemicals must be used within the IPM or IWM strategy, then correct dosage and application is crucial and herbicide types must be rotated when used.

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

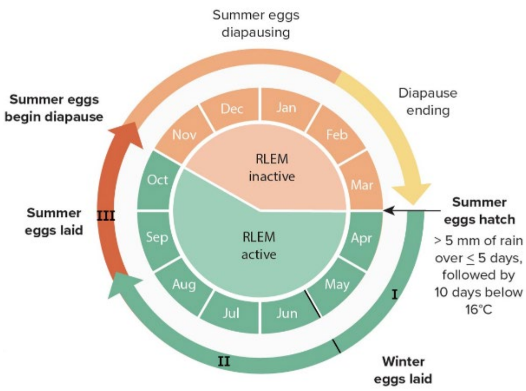
Example answer:

No, IWM is a multi-strategy approach that aims to reduce and supress weed populations using a range of strategies that are sustainable, cost efficient and environmentally sustainable. The whole purpose of using a range of control methods is to eradicate, supress or prevent a weed to a viable level which allows for cheapest treatment using a range of strategies. Any one strategy by itself is not effective or sustainable. For these reasons, an IWM program does not use only one control strategy.

7. List the RLEM scientific name: *Halotydeus destructor*
8. List the RLEM mature size: 1mm in (L) x 0.6 mm (W) wide (the size of a pin head)
9. List its colour/s and physical appearance: eight red-orange legs and a completely black velvety body
10. Identify it's distribution throughout Australia: RLEM is widespread throughout most agricultural regions of southern Australia, with wet winters and dry summers. See map



11. Recount how RLEM spread.
    Individual adult RLEM only move short distances between plants in winter, while long-range dispersal occurs via the movement of eggs in soil adhering to livestock and farm machinery or through the transportation of fodder and plant material. Movement also occurs during summer when over-summering eggs are dispersed by wind.
12. Create a diagram summarising RLEM life cycle:



13. Describe the symptoms of RLEM damage in plants:

Damage seen as silver or white patches on plant leaves.

14. Describe how RLEM affect plants:

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 feeding reduces the productivity of established plants and has been found to be directly responsible for reduction in pasture palatability to livestock. Young plants are most susceptible. In sever infestations whole crops may need re-sowing.

15. List host plants:

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 Patersons' curse, skeleton weed, variegated thistle and capeweed.

16. List the economic threshold requiring RLEM control, for establishing pastures:

20-30 mites/100 cm^2

17. Describe a RLEM IPM program. Include the time of year strategies are carried out.

Answer will vary- should include.

Monitoring: Carefully inspect susceptible pastures and crops from autumn to spring for the presence of mites and evidence of damage. It is especially important to inspect crops regularly in the first three to five weeks after sowing, as this is when crops/plants are most susceptible.

Biological control: At least 19 predators and one pathogen are known to attack RLEM in eastern Australia. The introduced French Anystis mite can effectively suppress populations in pastures. Snout mites and other predatory mites are also effective natural enemies, along with small beetles, earwigs and spiders. Leaving shelterbelts or refuges between paddocks will help maintain natural enemy populations. Introducing biocontrol species at times of peak population e.g. Autumn-Spring will have best impact on RLEM population.

Continuous- Natural enemies residing in windbreaks and roadside vegetation have been demonstrated to suppress RLEM in adjacent pasture paddocks. When insecticides with residual activity are applied as border sprays to prevent mites moving into a crop or pasture, beneficial insect numbers may be inadvertently reduced, thereby protecting RLEM 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.

Chemical: Low-moderate mite populations, insecticide seed dressings are an effective method. Avoid prophylactic sprays; apply insecticides only if control is warranted and if you are sure of the mite identity.

Late Autumn - one accurately timed spring spray of an appropriate insecticide can significantly reduce populations of RLEM the following autumn. This approach works by killing mites before they start producing diapause eggs in mid-late spring. The optimum date can be predicted using climatic variables, and tools such as TIMERITE® can help farmers identify the optimum date for spraying.

Ongoing- to minimise the risk of further resistance evolution in RLEM, the selective rotation of insecticides with different Modes of Action is advised.

Chemical control should be used in conjunction with other IPM strategies.