Egg Industry Range Regeneration Guidelines

May 2023

A report for Australian Eggs Limited
by M. Copley, C. de Koning, E. McGahan, S. Clarke & S. Wiedemann

ISBN 978-1-920835-77-4

Project Title: Cost-effective and practical ways to generate layer hen ranges

Australian Eggs Limited Project Number: 31RS101

Researcher/Author Contact Details
Name: Mary-Frances Copley
Address: Integrity Ag & Environment,
10 Neil Street, Toowoomba City, QLD 4350
Phone: (07) 4615 4690
Email: maryfrances.copley@integrityag.net.au

In submitting this report, the researcher has agreed to Australian Eggs Limited publishing this material in its edited form.

Australian Eggs Limited Contact Details:

Australian Eggs Limited
A.B.N: 6610 2859 585
Suite 6.02, Level 6, 132 Arthur St
North Sydney NSW 2060

Phone: 02 9409 6999
Fax: 02 9954 3133
Email: research@australianeggs.org
Website: www.australianeggs.org.au

Published in May 2023

Foreword

This project was conducted to integrate recent and ongoing work on range enrichment with knowledge of range management from the Egg Industry Environmental Guidelines and the Practical Guide to Range Management with new information on practical experiences obtained from industry surveys, consultation, and case studies, and package these findings in a guideline designed to promote practice change.

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to Australian Eggs Limited's range of peer-reviewed research publications and an output of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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Acknowledgements

The first edition was prepared by Mary-Frances Copley, Carolyn de Koning, Eugene McGahan, Simon Clarke, and Stephen Wiedemann. The guideline development team warmly acknowledges the following people who have contributed to the development of the guideline.

Free range egg producers
We thank those producers and range managers in Queensland, New South Wales, Victoria, South Australia, Western Australia, Tasmania and the Australian Capital Territory with free range systems who have so generously shared their experiences, insights, views, and expertise to inform the development of the guideline and allowed photographs from their facilities to be used in the manual.

Australian Eggs Limited
Australian Eggs Limited (AEL) provided the funds which supported this project. In addition, we thank AEL for facilitating introductions to several free range egg producers.

About the Authors

Mary-Frances Copley: Mary-Frances is an agricultural consultant with a background in economics and a primary focus on agri-environmental performance and life cycle assessment of egg, chicken meat, and pork production.

Carolyn de Koning: Carolyn has over 25 years of experience in pasture variety development, ecology, and agronomy. In the last decade, Carolyn has redirected her skills and experience into free range poultry research with an emphasis on the outdoor range environment. The focus has been on using plants and other enrichments to encourage ranging behaviour by layer hens and meat chickens.

Eugene McGahan: Eugene works as an agricultural/environmental engineering consultant. He has spent the last 30 years working predominantly on environmental and resource management issues related to agricultural and agro-industrial industries, with a particular focus on the intensive animal industries. Primary work areas include: development of environmental and planning guidelines, extension guidelines, Life Cycle Assessment, including carbon and water footprinting, development and planning applications for industry, environmental management systems, nutrient and manure management, odour, anaerobic digestion, including biogas capture and use, and supplying expert advice. Eugene and Steve are the authors of the egg and chicken meat Environmental Guidelines.

Simon Clarke: Dr Simon is an agricultural scientist with a research background in the applied plant sciences and the tracing of elemental flows through ecosystems.

Stephen Wiedemann: Dr Stephen Wiedemann is the chief scientist and managing director of Integrity Ag & Environment. Steve has spent his professional career working in agri-environmental consulting, research and extension in nutrient management, water, greenhouse gas emissions and life cycle assessment (LCA) across agriculture. Steve and Eugene are the authors of the egg and chicken meat Environmental Guidelines.

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Overview

1.1 Purpose of the Document

These guidelines are designed to assist in regenerating existing ranges, encouraging optimal management, and providing insight into common range management issues and how these can be mitigated when establishing new farms or ranges.

Industry can use these guidelines to ensure free range egg farms are developed, designed, and managed to minimise the risk and severity of range degradation. The guidelines also provide information that range managers can use to identify strategies to regenerate ranges when unavoidable degradation occurs. It is further envisaged that the guidelines and accompanying case studies will assist individual producers in identifying new or novel and cost-effective range management and regeneration strategies by sharing practices and learnings.

1.2 Scope of the Document

1.2.1 Facilities to which this Guideline Applies

The guidelines detail design, management, and regeneration strategies to assist free range egg producers with range management.

While the document focuses on layer farms, the principles outlined equally apply to free range breeder farms.

The principles outlined in this document are equally applicable to small and large enterprises.

1.2.2 Content is Not Legal Advice

While the guidance in this document was developed with reference to state (all references to 'state government' contained in these guidelines include 'territory government') regulatory frameworks, it is not a guide to regulatory compliance. These guidelines do not claim that their recommendations meet regulatory requirements. They only advise on important issues to address when establishing ranges and for their ongoing management.

1.2.3 Guidance Does Not Preclude Alternative Practices

The information in these guidelines is based on current information, knowledge and practices that can be used as a reference standard. Future research and innovation may identify new strategies and best practices for range management. The guidelines aim to provide industry with the necessary information to take a risk-based approach to range management. Where potential solutions and strategies have been identified, there may be alternatives not covered here which also achieve the desired outcome.

1.2.4 Guidance is Subject to Other Requirements

Egg industry facilities, including ranges, are subject to other requirements such as biosecurity, animal welfare and labelling standards. Any changes to these standards can have flow-on effects with respect to range design and management and must be considered.

1.3 Guideline Contents

Chapter 1 – "Introduction" summarises producer motivations for range management and regeneration, outlines the major challenges associated with range areas, and draws attention to biosecurity considerations.

Chapter 2 – "Groundcover" focuses on strategies to establish and maintain appropriate groundcover in the areas immediately outside fixed sheds and inner and outer range areas. The chapter also discusses appropriate groundcover types, e.g., living and artificial.

Chapter 3 – "Trees and Shrubs" covers where to plant trees and shrubs on ranges, appropriate plant choices, and how best to establish them to ensure survival. The chapter discusses how species selection should reflect geographic/climatic conditions.

Chapter 4 – "Enrichment to Encourage Dispersion" outlines how artificial shade structures and straw bales may be used to encourage dispersion in range areas. The chapter also considers the cost of selected structures.

Chapter 5 – "Rotation of Range Areas" outlines key considerations and potential benefits arising from the rotation of range areas for both fixed and mobile sheds.

Chapter 6 – "Modifying Hen Behaviour" covers how changes in management or routines might be used to benefit range conditions and avoid selected productivity losses that may arise because of ranging.

Chapter 7 – "Shed Design" outlines key considerations in shed design (fixed and mobile) to optimise bird behaviour on ranges and conditions of range areas.

Chapter 7 – "Range Design" provides diagrammatic examples of how these guidelines may be utilised to implement design and management changes to range areas.

1.4 Free Range Egg Production

Modern Australian free range layer farms vary from small-scale mobile sheds to large, fixed, environmentally-controlled sheds which can house tens of thousands of birds. Several sheds may be located on the same farm. Layer hens typically remain on-farm for about 60 weeks, after which the birds are removed, and the sheds cleaned before a new batch of hens are placed there.

Shedding used for free range egg production is typically fixed (i.e., immobile), where the hens have access to an outside range area. The range allows hens access to vegetation and open space whilst the sheds provide shelter and protection from weather and predators. Some smaller free range (or pasture) operations use mobile sheds/caravans that are moved regularly around a paddock/range. In some systems, larger sheds may be moved on skids between locations.

1 Introduction

1.1 Why Regenerate Ranges?

Many motivations and justifications exist for investment in range regeneration, varying from purely aesthetic to cost-prevention to welfare and market requirements. As part of the development process for these guidelines, interviews were conducted with producers and range managers of free range egg farms across Australia. The points below on the needs for regeneration have been taken from those interviews.

1. Effectively managed ranges minimise hen stress. Producers noted that, *"Range areas can be the source of numerous stresses, including bright light, high winds, predators, and disease, as well as the behaviour of other hens."*
2. Denuded ranges have negative impacts on production and the credentials of the farm. Produced notes that, *"denuded ranges are an aesthetic problem and are a poor image to present to employees or the public as they are not reflective of the high workplace standards, nor the sustainability goals of the farm. Unsightly at the best of times, denuded ranges become a quagmire of mud and manure after heavy rains. Denuded ranges also directly conflict with the idea of leaving a farm in a better condition than how it was received."*
3. *"Experience has shown that auditors are particularly responsive to positive actions taken to regenerate range areas. Tangible actions may also be important for future development applications."*
4. Well-managed range areas should comply with and align with the principles of welfare standards.
5. Good range design and regular maintenance to range areas are key to avoiding or limiting degradation which must then be repaired at a significant cost to the farm. Produces noted that *"range degradation can be both avoidable and unavoidable. Upfront investment on the avoidable elements maintains the range from the outset and prevents excess cost and time spent on maintenance and production loss"* and that, *""for smaller, family-run businesses, it is a cost and staffing priority to design a system which doesn't require fixing or minimises recurring problems."*
6. Innovation and ongoing improvement in production and land management should support range regeneration. Producers noted that, *"evolving range management strategies are consistent with the constant learning and thinking of new ways of operating farms."*

1.2 The Challenges of Range Management

The interviewees identified the following as key range-related issues of free range egg production:

1. Mortalities – *"higher mortalities in free range egg production compared with cage or cage-free (barn). There is an economic incentive to produce free range eggs (higher selling price), however, for some batches, the returns from cage-free production would be greater due to high mortality rates and issues on the range."*
2. Digging – *"hens have a strong tendency to dig which leads to craters and puddles on the range from which hens may drink contaminated water. The presence of surface water may also reduce egg production as hens stay outside and drink, and the intake of their speciality formulated diet is reduced."*
3. Selective foraging and maintaining groundcover – *"hens prefer grass to weeds and due to a lack of competition from grass, and because options for weed management during a production cycle are limited, weeds can take over the range. As a result, ranges often oscillate between too little and too much biomass."*

4. Budget considerations – *"due to the low profit margins of selling eggs to the major retailers, budget pressure may conflict with range management and regeneration. This keeps downward pressure on wages, potentially resulting in high staff turnover and the hiring of inexperienced staff."*
5. Regulatory requirements – *"regulation which has range management implications, particularly in relation to biosecurity, may be challenging to apply in certain operations or at certain scales."*
6. Runoff management – *"Catchment management authorities may require runoff to be captured in a dam, but these same dams may be a disease risk as they attract wild birds."*
7. Vegetation – *"this can be aesthetically pleasing and may act as a source of shelter and shade; however, vegetation may also attract wild birds, increasing the risk of avian influenza."*

Proactive management and a well-designed range are key to addressing these challenges and reducing the need for major and regular regeneration activities. In short, a poorly designed and managed range will require a lot of time and money to repair. Good design and management may also reduce hen stress and mortality. Solutions must be practical and cost-effective to ensure they are applicable across different regions, farm sizes, and production systems.

1.3 Biosecurity Considerations for Range Management and Regeneration

It is important to consider all factors that may affect the biosecurity of the production area, including range design and management. The *National Farm Biosecurity Technical Manual for Egg Production* (Animal Health Australia & AEL, 2020) notes that while hygiene practices are more difficult to apply to range areas, the fundamental biosecurity principles of preventing disease by controlling livestock movements, equipment, and personnel still apply.

The following objectives and requirements are quoted directly from the *National Farm Biosecurity Technical Manual for Egg Production*. They should be considered in any range management and regeneration strategy:

***Objective**: "To limit and control access to poultry production areas by vehicles and people, and prevent access by livestock, wild birds and other animals (including rodents) as much as possible."*

Requirements of the objective:

1. *"If livestock graze the property, then the production area must have a stock-proof fence."*
2. *"Drainage from livestock pastures or holding areas must not enter poultry enclosures or ranges."*
3. *"If dogs or alpacas are used to protect poultry in the range area, the guard animals should be tested for freedom from Salmonella prior to introduction and ideally retested annually."*
4. *"Free range landscape – trees (e.g., no fruit trees), shrubs and other range amenities should be selected to minimise the risk of attracting the types of wild birds that are a high biosecurity risk."*
5. *"The area around the shed must be kept free from debris and vegetation, and be mown regularly to discourage wild birds, insects and rodents which are potential disease vectors."*
6. *"A range management plan should be implemented to manage potholes or water pooling after heavy rainfall."*

***Objective:** "To reduce the likelihood and introduction of disease agents and contaminants into poultry sheds and enclosures and reduce the attraction of rodents and wild birds to production areas."*

Requirements of the objective:

1. *"Grass on and around the production area must be kept cut – long grass attracts rodents and favours the survival of viruses and bacteria."*
2. *"The free range area must be adequately drained to prevent accumulation and stagnation of water. The area must also be contoured to limit the ingress of runoff water from other parts of the property."*
3. *"The use of manure or poultry litter on adjoining land to the free range areas from other parts of the poultry operation or from other poultry farms should take into account the spread of potential endemic disease agents. The use of windrow composting or off-site disposal is preferable, to remove these risks. Alternatively, manure or litter should be deposited at least 1 kilometre away from the production area."*

2 Groundcover

The following sections describe strategies for maintaining or restoring groundcover on range areas, broken down between areas immediately outside the shed, inner, and outer range areas.

Maintaining groundcover on range areas year-round is difficult, and success or failure may depend on stocking density, region, soil type, and groundcover type.

2.1 Immediately Outside Fixed Sheds

Maintaining any vegetative groundcover in the area immediately (e.g., <10m) outside the shed is incredibly challenging because of the high traffic and may require the use of non-vegetative groundcovers to reduce the loss of nutrients and soil from this area.

Rock aggregate outside sheds reduces soil loss and assists in cleaning hens' feet before re-entering the shed

To prevent holes from being dug immediately outside the shed, mesh (metal or thick gauge plastic, ≤50mm) or rock (aggregate) may be used. Metal mesh is likely the most expensive (costs may range from \$15 - \$50/m^2 depending on quality, quantity, and source) but requires the lowest maintenance and is likely the longest-lasting (up to 10 years). Though cheaper than metal, plastic mesh (costs may

range from \$2 - \$5/m^2) will not last as long and may be more prone to damage by vehicles and machinery. Hens may then dig and create craters in the damaged areas.

Rock or aggregate may be relatively more expensive, in the order of \$7-\$20/m^2 based on a cost of \$35 - \$100/t plus freight for materials and about 100mm depth, if not cheaply available from local quarries. This base is long-lasting, and may also have the added benefit of helping clean birds' feet before they re-enter the shed.

Rock aggregate – fist-sized rocks considered to be the 'ideal' size

Key considerations when using rock include:

1. **Size of the rock**: should be small enough that they don't provide habitat for vermin, but not so small that hens can easily move them onto the inner range area. Fist-sized rocks are considered the 'ideal' size,
2. **End-use of recovered manure**: manure recovered from the area immediately outside the shed may be of very little value if it contains rock, and
3. **Replacement frequency (cost and availability):** additional rock may be required as frequently as every second batch.

Alternatives to mesh or rock aggregate in the area immediately outside the shed include a compacted or concrete pad/apron (Wiedemann & Zadow, 2010). These options may make collection of manure easier (e.g., by scraping) if the producer intends to stockpile manure for on-farm composting or sale off-site, however, manure removal will be required more frequently than on rock. Strategies to contain runoff should also be used if this area is compacted or concreted. Whilst a concrete pad will be long-lasting, the cost of labour and materials will be very high. For an apron along a 2mx50m shed, the cost of reinforced concrete may range from \$75 - \$100/m^2. Producers should source a number of local quotes.

In some cases, carbon-rich materials (such as bark chips) may be used, but many insurers may consider these a fire risk. Bark chips, for example:

- are relatively cheap (costs may range from \$17 - \$22/m^2 based on 100mm depth),
- are widely available,
- are easily moved by farm machinery (but also by hens),
- can be driven over without being damaged, and
- may provide a cooler surface than rock or mesh during summer or in warm climates.

Mulching the inner range area may be another option. However, in high-rainfall regions or episodes, the material may become sodden and break down too quickly, meaning it must be removed and replaced mid-batch. Any mulching system must be monitored and managed to prevent the build-up of contaminants or pathogens (e.g., fungal rot). Mesh may be used to contain the chips or mulch within a certain area. Potential benefits of mulching the area immediately outside the shed include:

- all those listed for bark chips,
- the possibility of selling the mulch, if collected and replaced at the end of each batch, as a compost starter,
- the possibility of selling the mulch as a nutrient-rich compost after composting on-farm,
- limiting stagnant water or manual pools outside sheds as the mulch should allow water to soak through rather than pool,
- it makes it relatively easy to repair any holes dug, and
- reducing nutrient loss.

Pop holes present a high traffic area, meaning artificial groundcover such as rock aggregate is important

For biosecurity reasons and to maintain access to range areas during the production period, earthworks in the area immediately outside the shed should be timed to occur between batches. If there is an excessive build-up of manure, water-logged holes, or weeds, however, repair activities may need to be undertaken during periods when birds are confined to the shed (e.g., early morning, evening). If weeds are a problem that must be addressed during a batch, slashing or chemical-free strategies should be used, as herbicides would likely require a withholding period.

2.2 Inner Range Area

Although artificial groundcover is the best choice for the first 8 – 10m outside the shed, vegetative groundcover should be maintained on the inner range area (10 - 50m from the shed). This is difficult, however, as even where groundcover is well-established before the start of the batch, it may not last

the length of the production cycle if there is a lot of pressure from hens or a lot of bad weather during a batch. Costs to resow groundcover can be significant, ranging from less than $50/ha to $200/ha, depending on whether contractors are used, ease of access to range areas, and seed selection.

Areas under shade are particularly vulnerable to being denuded

Dustbowls or holes in inner range areas are a common issue. Repairs to the inner range areas between batches should be undertaken regularly. Routine maintenance may include re-levelling (e.g., scarifying and towing a heavy object across the inner range) to repair holes. The need for re-levelling and repair to groundcover may be greater during the hot, dry summer months and/or on sandy soils, where wind erosion may also be a greater risk. Where there is no way of preventing dust bowls during a batch, the uneven ground should be ploughed and reseeded as soon as possible after the end of the batch.

Dust bathing can create holes and craters where water can pool

As hens often find pasture palatable and there may not be enough time between batches to engage contractors (if relevant) to re-seed and for pastures to re-establish, reseeding should be done whenever possible and necessary. To avoid delays waiting for contractors, producers should (if relevant) prioritise the purchase of their own cultivator/seeder so the farm can sow when conditions are right. Producers can then quickly re-sow if establishment is poor.

Hens restricted by fencing from accessing part of the range area to allow groundcover to become re-established

Surface netting may be one strategy to prevent hens from digging up established grass, as it restricts access to the roots. Where groundcover on inner range areas dies off due to bird activity or bad weather, alternative, additional groundcover (e.g., hay) should be used (see Section 4.2).

In some cases, most commonly in spring, excessive groundcover can be an issue as hens may eat too much pasture/grass and not enough of their formulated feed, which may lead to a drop in production. Strategies to address this include mowing before the hens move into the paddock or onto the range and changing feeding and pop-hole opening times (see Section 6.2).

Hens may also be reluctant to enter inner range areas if the pasture or crop is too dense or too tall. They may be encouraged to range if corridors are mown out from the shed.

In mobile systems, particularly for small-scale production, it may be feasible to use sacrificial paddocks when groundcover is vulnerable, e.g., when groundcover is dormant in winter or during particularly wet periods.

2.3 Outer Range Area

Compared with inner range areas, it may be easier to maintain groundcover in the outer range, particularly on farms with low stocking densities. It is also easier to fence off parts of the outer range for short periods to allow mowing, etc. Digging and holes should be less of an issue as the outer range can be re-levelled if necessary or ploughed using an offset disc before sowing.

Good groundcover for the outer range areas includes grasses or cereal crops. If the outer range is cropped, temporary exclusion fencing (costs may range from $6 - $10/m - source local quotes, plus $500 - $1000 for an energiser) may be needed as some activities can't be performed when hens are in the immediate area (e.g., some sprays may require a withholding period of several days). If these activities can take place before or after shed doors are closed, this may avoid the need for exclusion fencing. Planting seasonal cover crops (e.g., sunflowers and maize) in strips on the outer range may also encourage hens to range further as these crops are attractive, provide cover, and will be less dense than many cereals. These crops should be sown within a predator proof fence, however, as they can provide cover for predators.

If grasses are used as groundcover on the outer range area, slashing may be required as tall grass can provide cover for foxes. One advantage of grasses over crops as a groundcover is that the former can be maintained with little intervention.

2.4 Groundcover Choice

Choice of groundcover is key to maintaining or prolonging vegetative cover on ranges. As seed is often the most expensive input to range management, groundcover should be appropriate for:

- the stocking density,
- the site specifics (soil, slope),
- region (rainfall, temperature, e.g., drought or frost prone),
- need for and availability of water for irrigation, and
- capacity to undertake maintenance during a production cycle (e.g., mowing, slashing, reseeding).

Key considerations for common vegetative groundcover are outlined in Table 1.

A mix of ryegrass, cocksfoot, and subterranean clover provides a good groundcover.

Table 1. Summary of key characteristics of selected vegetative groundcover types that can be used on fixed shed and mobile shed farms

	Variety	Drought tolerance	Frost tolerance	Range area best suited	*Cost ($/kg seed)	Attractiveness to hens (pecking, eating)	Resilience	Other considerations
Grasses	Ryegrass (*Lolium* species)	L	M	Inner or outer	$4.50 - $15.20+	H	Grasses tend to be more resilient to hen activity than legumes (Breitsameter et al., 2014).	Too much grass can reduce hen productivity. Grass may need mowing.
	Rhodes grass (*Chloris gayana*)	M	L		$20.90 - $28.80	L (when mature)		Can be killed by hens if allowed onto new growth too soon after mowing.
	Couch grass/Bluegrass (Various species)	H	M (goes dormant)		Kentucky bluegrass = $25.00 Bermuda couch = $31.70 QLD bluegrass (*Dichanthium sericeum)* (native), = $107.00 Bisset creeping bluegrass (Bothriochloa insculpta) = $42.50	M		
	Kikuyu (*Pennisetum clandestinum*)	H	M (goes dormant)		$65.00 - $110.00	H		Nitrate poisoning and fungal disease in Kikuyu cause toxicity in cattle. Hens may eventually dig up Kikuyu runners.
Legumes	Clover (red or white)	L	M		Red clover $17.00 - $29.40	H		In a mixture of grasses, hens will

	(*Trifoilum pratense & T. repens*)				White clover $12.30 - $13.00			target red and white clover first.
	Subterranean clover (*Trifolium subterraneum,* many varieties available suited to low to high rainfall areas)	M	M		$8.00 - $10.00	M - H	Annual plant grows through autumn, winter & spring. Self-seeding is best on the outer range.	Suitable in mixtures with grasses. Mostly suited to slightly acidic to moderately acidic soils.
	Annual Medic *(*Various *Medicago* species)	M	M		From $5.50	M - H	Annual plant grows through autumn, winter & spring. Self-seeding is best on the outer range.	Suited to slightly acidic to alkaline soils.
	Lucerne (*Medicago sativa*)	H	M - H		From $12.10	M - H		Lucerne needs at least 12 weeks to establish before hens can be allowed to forage on it.
Cereal crops	Oats (*Avena sativa*)	L	H	Outer	$0.60 to $1.50/kg	M - H		Hens may scratch up cereal seeds if allowed onto crop too soon.
Helianthus species	Sunflowers	M	L	Outer	From $6.00	H	Plants need to be above hen height before hens are allowed to forage.	Seeds can attract wild birds, but hens will also seek out the seeds.

H= High, M = Medium, L = Low

**Cost of seed can depend on the source, variety, and the bag's weight. The heavier the bag, the cheaper per kg. Most costs shown are based on 20 kg or 25 kg bags. Cost per kg is only indicative at the time. +Cost of ryegrass seed also depends on the type of ryegrass (e.g., annual, perennial, Italian). #Consult your local agronomist for species and choices of variety for your area and the sowing rate.*

Regardless of groundcover type, it should be given the longest possible time to get established before exposure to hens, particularly as new shoots may be highly palatable to the birds. On farms with fixed sheds and fixed range areas, there may not be enough time between batches to re-seed and re-establish cover, but temporary fencing is one strategy to give some areas longer to establish. If possible, temporary fencing could be set up outside the shed, e.g., at the edge of the rock area immediately outside the shed, so hens still have outdoor access whilst they are young and less likely to range far from the shed.

Care should be taken to ensure that groundcover doesn't become too long as long leaves can result in mass indigestion (crop impaction), which may result in poor hen health and reduced production. Note, however, that this may conflict with other objectives if the groundcover doubles as a crop for farm use (e.g., hay-making lucerne). However, long blades of grass pose the greatest risk (compared with lucerne) as hens can ingest them whole, causing digestion issues.

In mobile systems, movement frequency (see Section 5.2.1) is key to evenly spreading manure and nutrients and avoiding nitrogen burn.

Subterranean clover provides good groundcover on the outer range of a fixed shed farm (pictured 60 - 80m from the shed).

3 Trees and Shrubs

Although trees and shrubs on ranges may be a good source of shade, amenity, and support range regeneration, biosecurity and fire policies should be consulted before planting.

Trees planted at least 20m from the shed

Where planting on range areas (particularly inner ranges) is prohibited, the sheds can provide good shade and protection from bad weather. Tree lines should be planted at the edges of ranges or paddocks as windbreaks, providing further protection. Tree lines can, however, provide habitat for foxes and vermin, so depth, density, and distance from sheds should be considered.

The following sections detail the potential placement of trees and shrubs on range areas, plant selection, and key issues during establishment. How region/climate should be factored into planting and plant choice is also considered.

3.1 Where to Plant

The planting of trees and shrubs should align with biosecurity and fire management requirements, including those of insurers. Producers should review all requirements and policies before planting.

Although planting trees close to (<20m) to sheds may encourage hens to enter the range and provide a source of shelter and shade, avoiding planting in that location may reduce the number of wild birds near the shed and the majority of the flock.

Example planting configuration

Any planting configuration has advantages and disadvantages, meaning producers/range managers should evaluate the most suitable based on farm specifics and regional climate. Where possible, small-scale (e.g., one paddock or range) trials may be worth undertaking before commencing widespread plantings.

Shelterbelts or tree lines should consist of shrubs, short trees, and tall trees to act as windbreaks at multiple levels. If it is possible to plant on the range, trees and shrubs should be positioned to provide a windbreak around pop holes.

Tree lines at paddock edges on a mobile caravan farm

Although often planted in rows along fence lines or scattered individually across the range, trees planted in groves (see *Figure* 6) may be more likely to withstand strong winds and easier to fence and irrigate whilst still being attractive shelter and foraging spots for hens. Hens have been observed to run from one grove to another, seeking cover and forage as the groves attract insects, adding to their appeal. Dust bathing within groves and any associated damage to roots may be less of an issue than around single trees, as hens have been observed to prefer dust bathing at the edges of the groves, where they can also sunbathe.

Inside a circular grove planted with wattles (3 years old) and slower growing eucalypt.

Hens ranging towards tree plantings

For fixed sheds in particular, planting trees in corridors (e.g., 3 trees wide, 2.5m between trees, leaving gaps for machinery to pass through) radiating out from a shed (e.g., starting 8 - 10m from the shed) to the range boundary may encourage hens to leave the vicinity of the shed and range out along these corridors. Radial planting (see *Figure* 2) and consistent shelter such as this may also encourage more even distribution across the range, reducing the intensity of destructive behaviour beneath trees.

For shrubs, scattered plantings or rows may be appropriate. In the former case, scattered plantings may allow for greater movement (i.e., lateral and vertical) of mobile sheds than if planting is done in rows, ensuring wider distribution of nutrients across the range. For fixed sheds, shrubs (e.g., saltbush) may be planted in rows (starting 10 m from the shed), i.e., at edge of rock aggregate, running parallel to the shed to form hedgerows (see Figure 4). An additional benefit to this planting configuration may be a reduction in wind entering pop holes. Consistent planting in rows may encourage hens to range from row to row, moving further away from the shed and more evenly distributing nutrients and digging, reducing build-up in high-traffic areas.

3.2 Plant Choice

It is highly recommended that a horticulturist or specialised landscape or nursery consultant is engaged to assist in a site-specific selection of appropriate plant species. A list (non-exhaustive, non-site specific) of potential plant choices is outlined in Appendix 1.

When considering plant choices, producers/range managers should:

- select several species of grasses, shrubs, or trees to reduce the risk of damage or loss if pests or diseases appear in certain species. Diversity reduces the chances of a mass dying off during

different weather conditions (e.g., drought, wet soil conditions, heatwaves, frost), and

- select plants with different growth rates. Although fast-growing plants will provide quick shade, shelter and visual screening, these species are generally short-lived and need replacing sooner than slower-growing species.
- Select nutrient tolerant varieties because tree areas receive more manure deposition than other parts of the range.

Combination planting of saltbush and wattle provides a good variety of species

3.2.1 Trees

Ideal characteristics of trees on range areas are:

- low maintenance/care and not sensitive or prone to disease and pests,
- low leaf and twig litter to reduce the risk of fire and rodents. Trees should not be prone to breaking in strong winds,
- complex leaf shapes and waxy leaves filter dust,
- stable root systems to withstand strong winds and drought stress,
- nutrient tolerance, because depending on placement, hens may congregate under trees, meaning the species must have high nutrient tolerance, and
- avoid trees that have seeds or produce fruit to minimise the attraction of wild birds.

Olive trees (pictured approx. 40m from the shed) provide a resilient tree option

A variety of tree species should be selected to ensure that tree cover on ranges remains constant (i.e., to avoid a mass dying off). Selection should also include fast-growing trees (e.g., wattles, blackwoods) with shorter lifespans and slower-growing, longer-lived species (e.g., gums, bottle trees).

3.2.2 Vegetation

Evergreen grass or a mixture of summer- and winter-active species are recommended to provide year-round shelter and vegetation. To stimulate new growth, grasses should be regularly slashed. However,

slashing should be staggered between rows/plantings to ensure that there is always mature growth on the range.

Select a mix of grass species that provides year-round cover

Ideal characteristics of vegetation (grasses and hardy shrubs) are:

- evergreen species, or a mix of summer- and winter-active species, which provide year-round shelter and vegetation,
- tolerance to hot and dry conditions,
- tolerance to wet, dry or compacted soils,
- clump growth, i.e., plants which will not spread and become invasive,
- stable root systems and/or upright forms with stiff stems to withstand high wind speeds (if needed),
- dust filtering capability (if needed), e.g., from waxy leaves or complex leaf structures, and
- nutrient tolerance, because depending on placement, e.g., in high-traffic areas (as a major source of shelter) or at the bottom of sloping areas on ranges, plants may need to be tolerant of high levels of nitrogen, phosphorus and potassium.

Vineyard as a range area where hens range between rows and forage under the plants. No negative effects from nutrient deposition were observed in the vines or grapes at this site.

Saltbush, for example, is highly suitable in a wide range of climate and rainfall zones and is also suited to range areas (minimum 3m x 3m spacing) for the following reasons:

- the naturally high salt content of its foliage may aid in dealing with pecking behaviour,
- it may be planted in inner range areas to provide natural shade, helping cool the

environment immediately around the shed, making it a more pleasant environment for hens and staff,

- it provides cover when wild birds fly overhead, and
- it has a reputation for being tolerant of both drought and high soil nitrogen concentrations, making it an ideal species for inner range areas in hot and dry environments.

On several farms, saltbush plantings have proven a good option due to their drought tolerance and ability to handle high nitrogen concentrations in the soil

3.3 Establishment

For new farms or sheds, trees and shrubs should be planted (if possible) before the completion of new sheds or introducing hens to the range area so that the plants have time to become established.

Ensure trees are well established on the range before the introduction of hens

Construction of new sheds may lead to compaction of soil or gravel and removal of topsoil, meaning that, before planting trees, vegetation or vegetative groundcover, the following may be required:

- application of additional topsoil,
- application of compost to improve soil drainage,
- deep ripping and gypsum application to uncompacted soil, and
- application of lime to correct soil pH.

Where trees and shrubs are to be introduced to an existing range area, consideration should be given to the following:

1. **What plant size of plant is most** suitable (e.g., tube stock vs mature)? Note: Tube stock are cheaper but mature plants have higher survival rates and may be better value in the long term.
2. **Does temporary fencing or other protection for new plants need to be installed?** Fencing may be required to prevent hens damaging young plants and to protect growing plants from rodent defoliation. As options for rodent control during the production cycle may be limited, proactive or preventative measures should be taken at the time of planting. Tree guards or improvised guards (e.g., PVC pipe) may be used to protect young plants from rodents and hens at high stocking densities. In hot weather or climates, temporary fencing may be used to protect young

plants from hens during establishment. It can also be reinstalled to rest the area again if needed.

3. **What irrigation is needed** (and how this might be done, e.g., drip lines, fluted mulch pads to funnel rainwater)**?**
4. **What planting configuration is most suitable** (taking into consideration the fencing and irrigation requirements , e.g., staggered, or groups instead of rows)**?** Staggering planting may reduce the risk of widescale plant loss in bad weather. For plants with short lives, staggered plantings may avoid complete loss of vegetation.

As weeds are a major threat to plant establishment, some management activities (e.g. tilling and chemical application) should be undertaken before planting to eliminate weeds. Mulching around vegetation:

- will suppress weed growth,
- assist in moderating soil temperature and moisture retention, and
- should be performed in areas with low rainfall or scarce water for irrigation, and the chosen plants in such areas should be drought-tolerant.

Adding gypsum or compost can improve drainage when planting in heavy or sodic soils.

Established groundcover, saltbush, and tree lines on the range ensure that vegetation is abundant and that the shrubs and trees provide shade and shelter

4 Enrichment to Encourage Dispersion

The use of enrichment objects may encourage ranging and reduce hen activities in typical high-traffic areas, such as under shelter and in the area immediately outside the shed. Enrichment structures and objects have been found to increase the number of hens using the range (De Koning et al., 2018).

A variety and combination of enrichment structures and objects (see Figure 5) is most effective. Even distribution should be maintained, and placement should not be too close to the shed.

The cost of implementing enrichment strategies may range from less than $50/ha up to $200/ha.

Use of straw bales as enrichment strategies encourages hen dispersion across the range

4.1 Shade Structures

4.1.1 Artificial

Artificial structures may form part of a strategy to encourage hens to range by providing shelter or where trees are not appropriate or permitted, e.g., in the inner range area where trees might pose a fire hazard, encouraging hens to range further, limiting congregation and destructive behaviours on the inner range.

Before artificial structures are implemented at a wide scale, they should be trialled at a small scale to determine whether hens respond positively to them and whether the cost is warranted. Shade huts with scratching pens, for example, might be most successful at providing permanent shade and encouraging positive behaviour. Still, there are far cheaper alternatives (e.g., pallets wired together to provide shade and a climbing structure).

Makeshift structure on the range to provide enrichment and a source of shelter

The longevity of materials should also be considered, as many materials and designs do not last when exposed to the environment or bird behaviour. Metal shade huts are the most robust; however, there should be confidence in a return on investment before installing these widely across an enterprise. It is estimated that for a 3x2m metal-framed welded structure on wheels with shade cloth, costs could range from $500 - $1000 where the lower estimate is based on an on-farm workshop. Near blackout (up to 90% UV block out), shade cloth has been observed to be the most durable and attractive option for hens. Depending on source and quality of shade cloth, prices may range from $5 - $12/$m^2$.

The benefits of fixed versus portable structures should also be considered. Portable structures, such as moveable shade sails, can be regularly relocated, encouraging birds to use different areas of the range and limiting destructive digging in particular areas.

Types of artificial shade structures (in increasing cost order) which could be trialled include:

- makeshift structures constructed from on-hand or cheaply available materials, e.g., old planks or offcuts, single-use pallets,
- portable shade sails,
- fixed shade sails, and
- fixed metal sheds (prices will vary depending on size, number, source)

A combination of trees and artificial shade structures (portable and fixed) encourages hens to range away from the shed.

A portable self-made shade structure can be moved incrementally to encourage hens to range further over time

Portable commercial-made shade structures offer a long-lasting, moveable, and low-maintenance option. Consider trialling before widespread adoption and investment.

4.1.2 Living

Living shade structures may be comprised of readily available or relatively inexpensive materials, e.g., 44-gallon drums (plastic drums may range in cost from $25 - $130, used to new) filled with organic waste materials and soil, placed on top of a wooden pallet (may be available for as little as $5/pallet from scrap or council waste depots), tall grasses (e.g., Bana grass) planted in the drums and mulched, and mulch covered with chicken mesh.

Living shade (Bana grass in full-height drums and halved drums on a wooden pallet) provides a novel and portable source of enrichment and shade.

Placing the drum and grass on pallets will make it easier to move. These living shade structures may also provide some protection from wind and act as a preferable alternative to artificial structures, particularly if adding vegetation to the range is a priority.

Potential benefits of living shade structures include:

- improved range aesthetic, e.g., particularly where vegetative groundcover or shrubs struggle, and trees are not permitted,
- Portable shade and portable windbreaks as the structures can be moved seasonally to protect from dominant winds,
- inexpensive, sustainable,
- low maintenance (e.g., occasional watering may be needed) compared to artificial shade structures, which may be vulnerable to strong winds, storms, and UV degradation,
- may reduce pressure on high-traffic areas by encouraging hens to move out towards the shade, particularly if trees are not permitted near the shed,
- unlike trees, grasses in drums are unlikely to attract wild birds or provide cover for predators, and
- unlike fixed trees or shrubs, living shade structures can be moved if the plants require resting or maintenance.

4.2 Straw Bales

Straw bales (~$35/ round bale) can be placed on range areas to encourage dispersion. Hens may spread the straw (from intact bales) across the range, or the bales can be spread at placement. The straw may contain or attract insects for hens to find. '

Straw bale to encourage ranging from the shed and to provide additional groundcover where vegetative groundcover is depleted.

Additional benefits are that straw:

- bales may provide supplementary groundcover when cover in range areas is depleted (particularly due to seasonal conditions),
- it may absorb excess water, reducing mud on ranges during wet weather periods, and
- it supplies extra carbon, supporting soil biota and diversifying the microorganisms (beyond bacteria from manure) that hens encounter on the range.

4.3 Pecking Objects, Dust Baths

Other objects and structures should be included on range areas to provide enrichment and encourage birds to leave high-traffic areas. Objects which encourage natural behaviours, such as pecking and dust bathing, should be selected to limit damage to the range itself from these behaviours.


Use brightly coloured, inexpensive objects to encourage pecking

Producers should consider using the following:

- peck stones (may range in cost from $10 - $40/stone depending on source, brand),
- other brightly coloured available objects (such as traffic cones), and
- dust bathing boxes (e.g., roofed boxes filled with sand, old tyres filled with sand, or other homemade alternatives).

Past studies suggest that a larger variety of enrichment objects, rather than a larger quantity, encourages hens to range more.

Peck stone provides a source of interest on the range and a different option to exhibit natural behaviours than establishing vegetation

5 Rotation of Range Areas

5.1 Fixed Sheds

Rotating range areas on farms with fixed sheds is not a common practice. Where range areas are rotated, it must be ensured that the practice does not conflict with requirements for the frequency of doors/pop-holes. Where stocking density requirements allow, restricting access to part of a range (e.g., a third) may be useful for establishing or resting groundcover (see *Figure* 3). Additional welfare checks may also be required, i.e., if hens are prone to jumping interior fencing.

5.2 Mobile Sheds

Fencing (permanent or temporary) may be used to facilitate range rotation. Permanent fencing around the total production area may be sufficient, and sheds can be moved within this larger area. Where only one perimeter fence is used, other strategies (e.g., Maremma dogs) may be needed to deter predators. In other cases, temporary fencing may be preferred to create a smaller range area around one or more mobile sheds, particularly where there are features (e.g., dams) from which hens should be restricted access. The temporary fencing and sheds can then be moved on a rotational basis.

Temporary fencing (electrified poultry netting) on a farm with mobile sheds

Range rotation may be a key strategy in a broader plan for range regeneration or circular production. Circular economy refers to a model of production and consumption which involves reusing existing materials and products for as long as possible, e.g., using chicken manure as organic fertiliser for pasture or cash crops. Where manure is deposited on the ground under the shed, the mobile shed should be moved to fresh groundcover once the manure begins to accrue. After the shed is moved or the range area rotated, the manure may be ploughed into the ground, reducing the need for soil additives (e.g., lime, nitrogen), pasture re-sown and then rested until established.

Range rotation may be planned such that hens are brought onto a paddock before planting a cash crop to provide nutrients to the soil (see Figure 7). Once the crop is established, hens may be let back on to

forage and deliver more nutrients to the crop. Where limited range areas are available on a property, positioning sheds so that hens may range onto cropland at appropriate times may allow longer resting periods for ranges or facilitate regeneration activities which require manual intervention (e.g., re-sowing, re-levelling).

5.2.1 Frequency of Shed Movement

To avoid excessive nutrient build-up, sheds should be moved at a high frequency (every 2-3 days). If sheds are moved less frequently, manure should be collected from under them. If not, nutrient levels below mobile sheds will quickly exceed annual plant uptake capacity, resulting in an increased risk of environmental loss. The frequency and distance of shed movement should reflect nutrient deposition patterns.

For high-frequency shed movement (see Figure 1), manure deposition will be highest under the sheds; however, the frequent movement means that total deposition in one area is limited. This will result in nutrients being spread across the whole range area and will protect pasture cover. Birds will also range over the areas where the shed was previously, breaking up and distributing the manure.

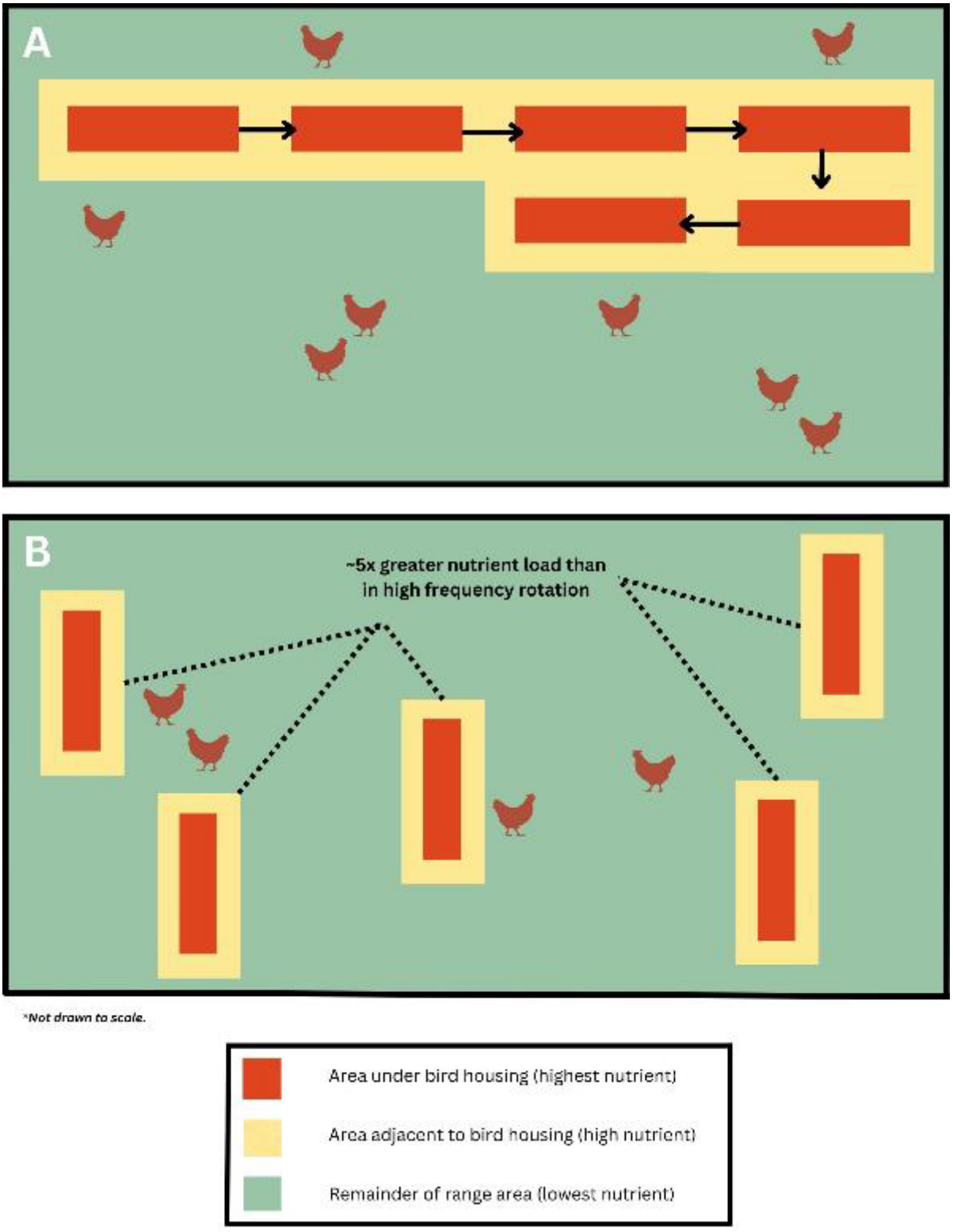


Figure 1. High (A) and low (B) frequency mobile shed movement and resulting nutrient distribution on range areas

For low-frequency (fortnightly) shed movement (Figure 1, B), manure will not be spread evenly across the range, requiring additional management to reduce the risk of nutrient loss or damage to the pasture.

At either frequency, producers should avoid returning the shed to the same location within 12 months to avoid excessive nutrient build-up.

On farms with short return periods (<12 months) or increased risk of nutrient runoff (high slope, low groundcover, high rainfall etc.), additional management may be required, such as:

- collecting manure with scrapers once the shed has been moved and either selling off-farm or spreading the manure across other areas of the range (where the shed will not or has not been moved to recently),
- using metal sheets or tarpaulins under the shed to collect manure and then either selling off-farm or spreading evenly across the range, or
- using litter in sheds to limit deposition beneath sheds, then removing and spreading or selling the spent litter.

More frequent movement may be required at higher stocking densities to avoid nutrient build-up, range denudation or dust bowls developing. Other issues which may affect the frequency of shed movement include:

- condition of pasture around the shed,
- availability of new pasture,
- proximity to other sheds, and
- state of the ground (e.g., soft/wet from rain).

6 Optimising Hen Behaviour

6.1 Training Young Hens To Range

Pullets are generally reared in cage or barn systems, and the lack of exposure to the outdoors may impede ranging, particularly early in the batch. Training young hens to range, however, may also be problematic. For example, if young hens are cold because the shed doors are open, there is a risk that they will pile up for warmth. There is also the risk that hens will not train successfully to use their nest boxes. Allowing access to the range early in the production cycle and closing pop holes when hens begin to lay should be avoided, as doing so may cause stress, disrupt production, and cause manure to pile up around pop holes.

The degree to which the hens' range (particularly to outer range areas) may differ between:

- breeds,
- density of the crop or pasture,
- width of the inner range area, and
- season hens were trained on the range, e.g., hens may range further if introduced to the range in cooler months where shade-seeking behaviour or the attractiveness of a climate-controlled shed is reduced. Birds may require additional incentives (e.g., enrichment) to encourage ranging in warmer climates.

Ultimately, the behaviour of one batch will not necessarily be the same as another, and range management should be adjusted as needed.

6.2 Feeding and Pop-Hole Opening Times

Feeding times and pop-hole opening times may be useful for reducing negative impacts from hen behaviour on ranges.

Turning on shed lights at dawn (particularly in winter) while pop-holes remain closed may discourage over-indulgence on pasture, as the hens are woken with time to drink and eat the specially formulated layer mix in the shed before venturing outside. This strategy, in addition to providing consistent light hours over the year, may also reduce the drop in productivity over the cooler months.

In sheds without automatic feeders, feeding 15 minutes before opening the pop-holes may lead to less aggressive birds entering the range and less destruction. Opening pop holes later in the day (particularly in summer when days are longer) may also ensure that hens enter the range after feeding and drinking in the shed, improving control over the quality of feed and water consumed by the hens. Later pop-hole opening times may be prudent at other times of the year, e.g., when there is excessive groundcover from spring growth, and hens may consume too much pasture and too little formulated feed, resulting in a drop in production.

7 Shed Design

Certain shed design elements may sometimes mitigate range degradation and/or encourage ranging. These include:

1. Eaves and gutters on sheds (to reduce mud and water immediately outside shed doors).
2. Rainwater (from gutters) is collected and stored in covered tanks to control the movement of water and nutrients on the range (e.g., runoff, pooling) and to reduce mortality.
3. Allowing access to the range on one side of the shed only and using the other side to service the shed (e.g., pop holes on one side only). This minimises the need for vehicles to enter the range area, that has both practical (avoided compacting, tyre damage) and biosecurity advantages. In some studies, however, this has been found to limit the number of hens using the range to those that typically remain in the area of the shed close to these pop holes (Pettersson et al., 2016).
4. The number of pop holes per shed. Some studies have found that percentage range use increases with the number of pop holes available per bird.
5. Height of pop holes. Elevated (>50cm high) pop holes may be difficult for hens to negotiate, and hens have been found to show aversion to spaces of certain heights (<46cm).
6. Verandas/winter gardens with awnings that run the length of the shed may encourage birds to exit the shed and provide a permanent source of shade on the range area (particularly where trees are prohibited).
7. Litter use. As pop holes are often accessed from shed floors, poor litter quality may discourage litter use and, by extension, range use (Pettersson et al., 2016).
8. For mobile sheds,
    - Narrow sheds (e.g., to fit through gates) allow for easier transportation between paddocks/ranges with permanent fencing, i.e., easier/faster rotation.
    - In high-wind areas, it may be prudent to avoid sheds with sides that open, as the large surface area (and a lightweight shed) may be a hazard.
    - Where trees are prohibited on inner range areas, and shade is a priority (particularly in warm climates), setting sheds above the ground (e.g., 50cm) may provide a source of shade outside the shed itself.
    - Floorless (no mesh) sheds allow almost all manure deposited in the shed to fall onto the range area, which, if ploughed into the soil after the shed/range area is moved, may improve soil nutrients for uptake by the range pasture/groundcover. This system will, however, require regular moving to avoid nutrient built-up.

8 Range Design

8.1 Fixed

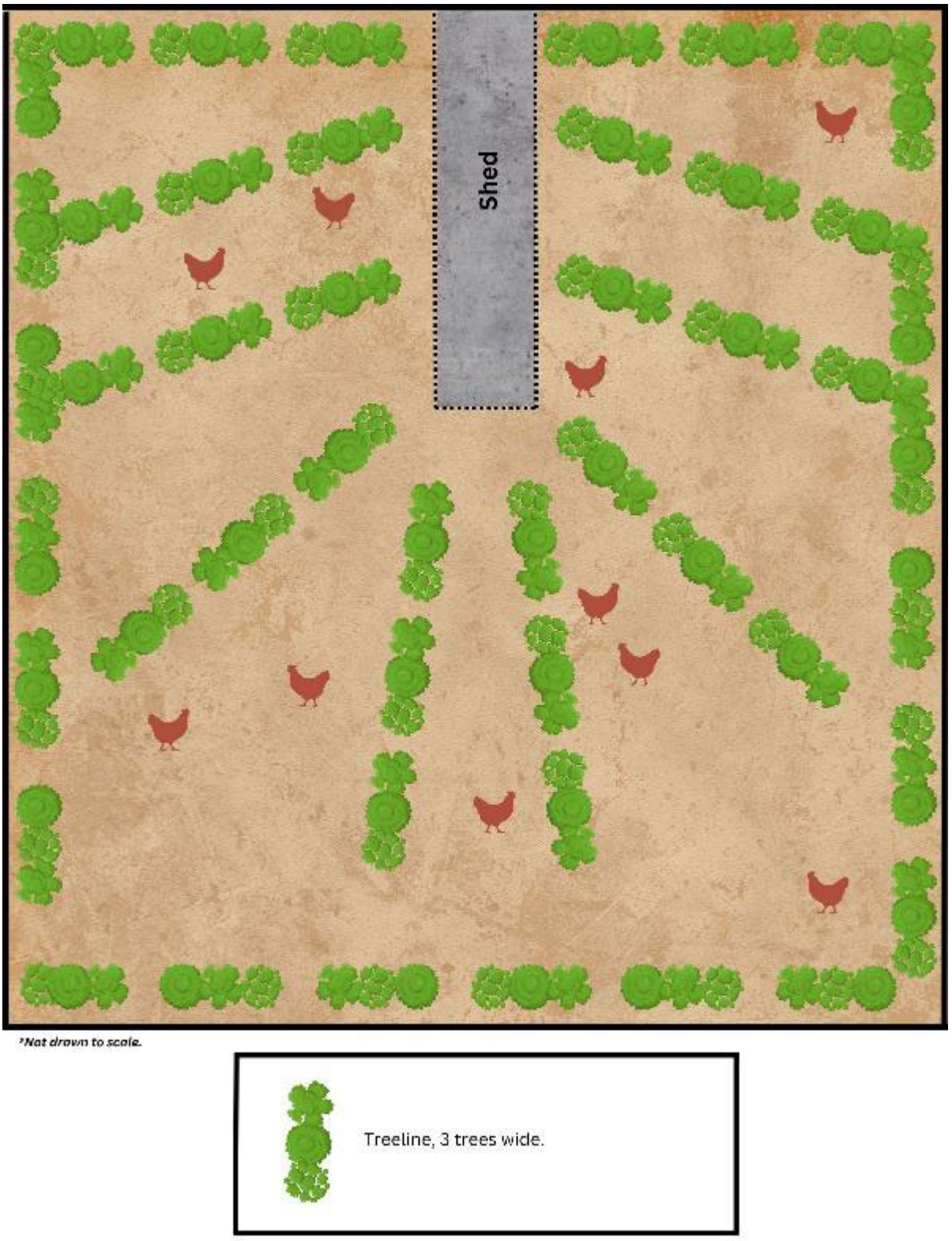


Figure 2. Diagram of radial tree plantings on a fixed shed farm

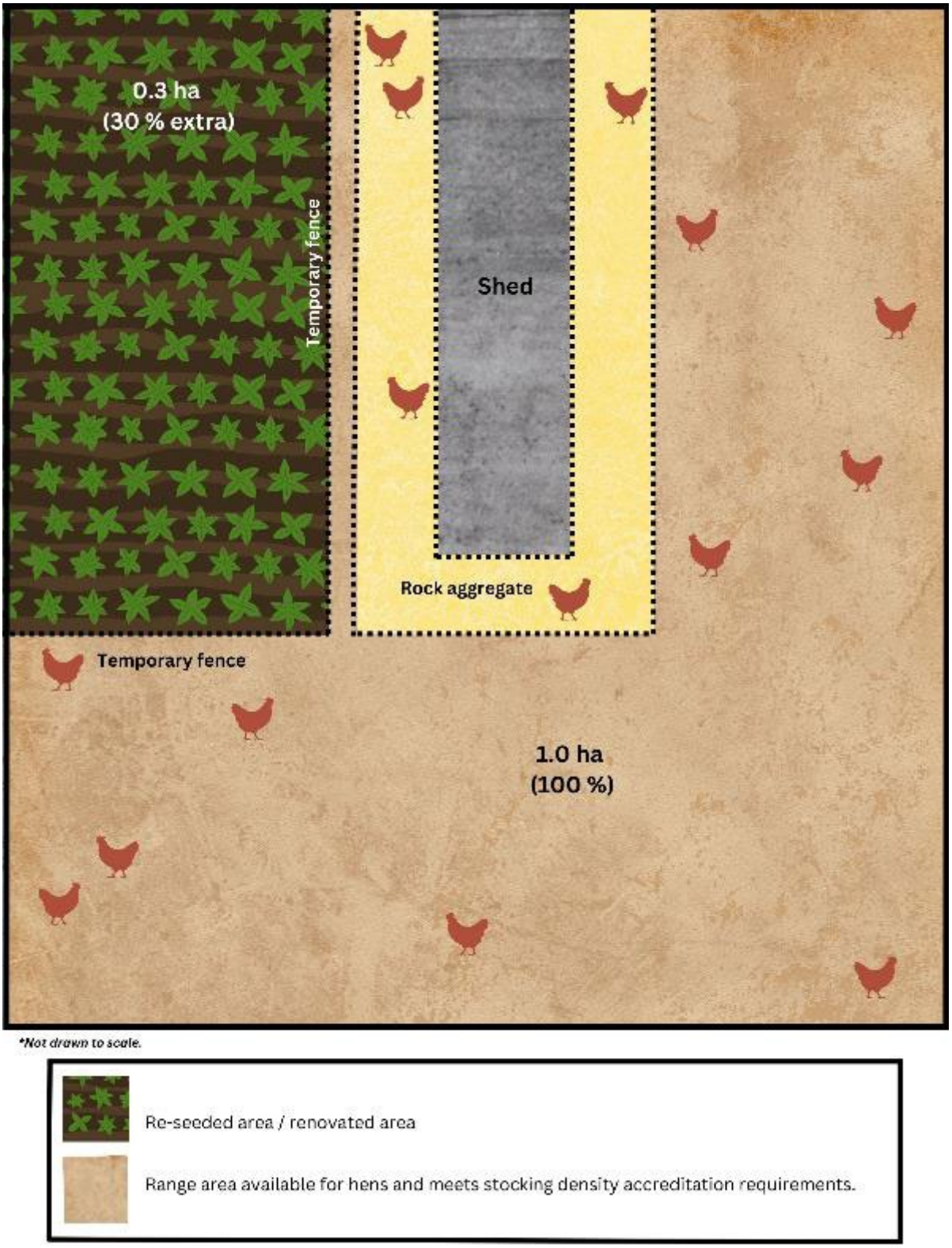
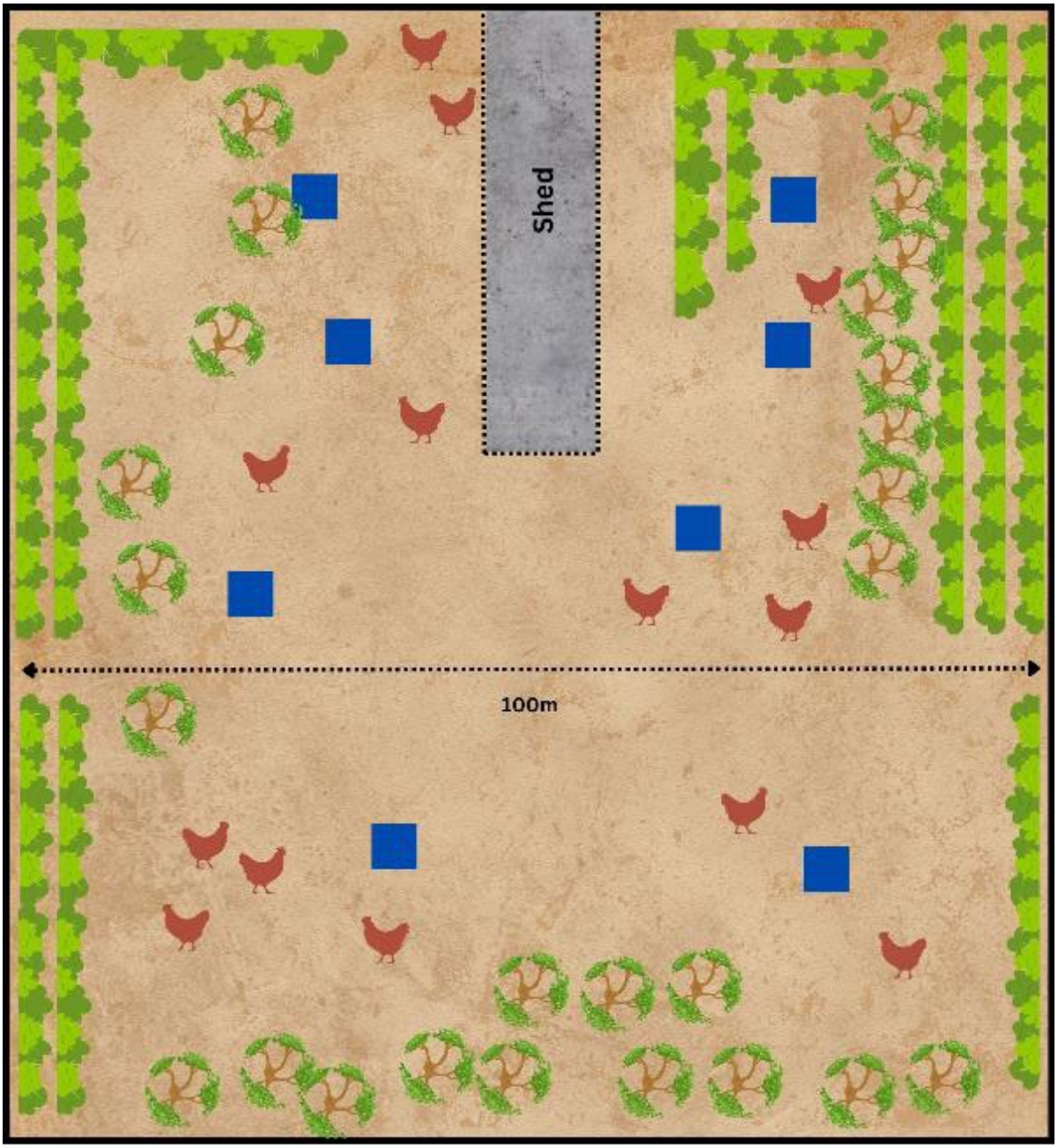


Figure 3. Diagram of temporary fencing on a range with fixed sheds to allow re-seeding and re-establishment of groundcover on part of the range



*Not drawn to scale.

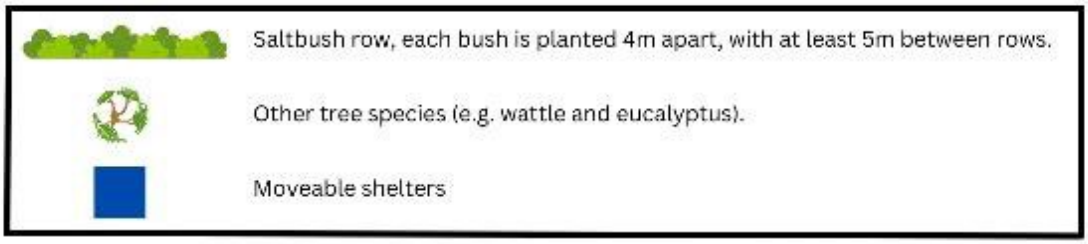


Figure 4. Diagram of saltbush and tree plantings, and placement of moveable shelters, on range areas on a fixed shed farm

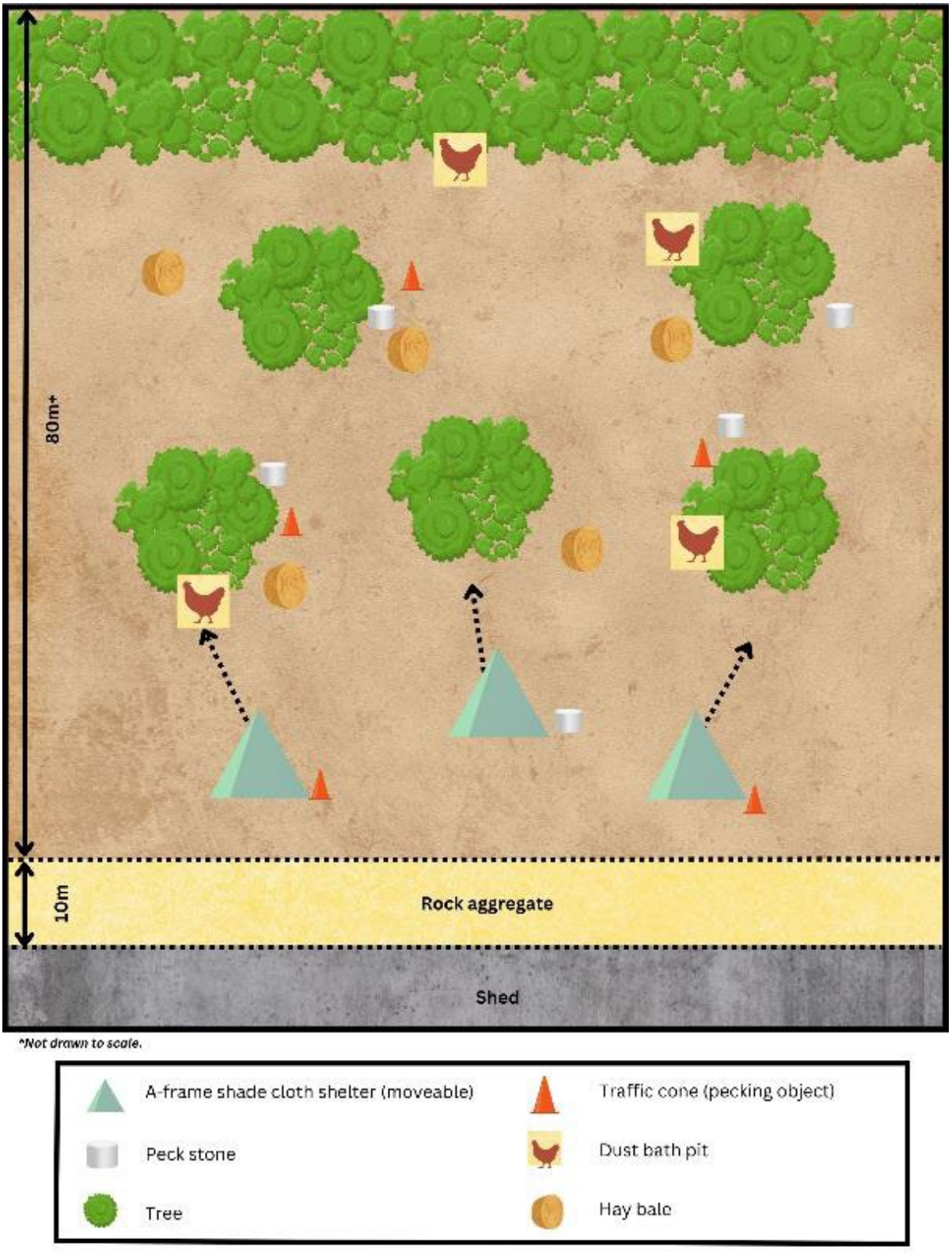


Figure 5. Diagram of placement of enrichment objects (hay bales, dust baths, pecking objects) and tree plantings on a range with fixed sheds

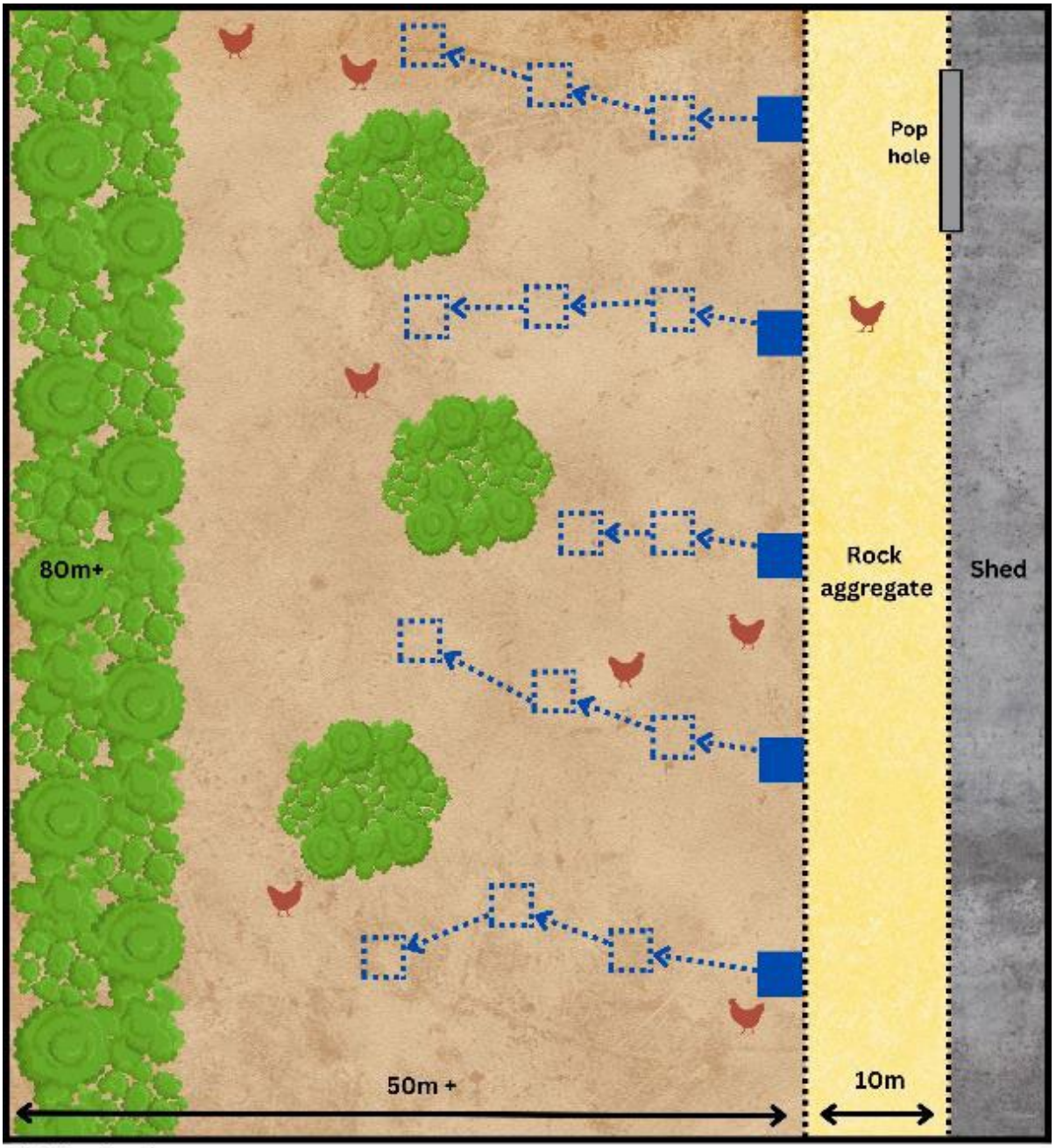
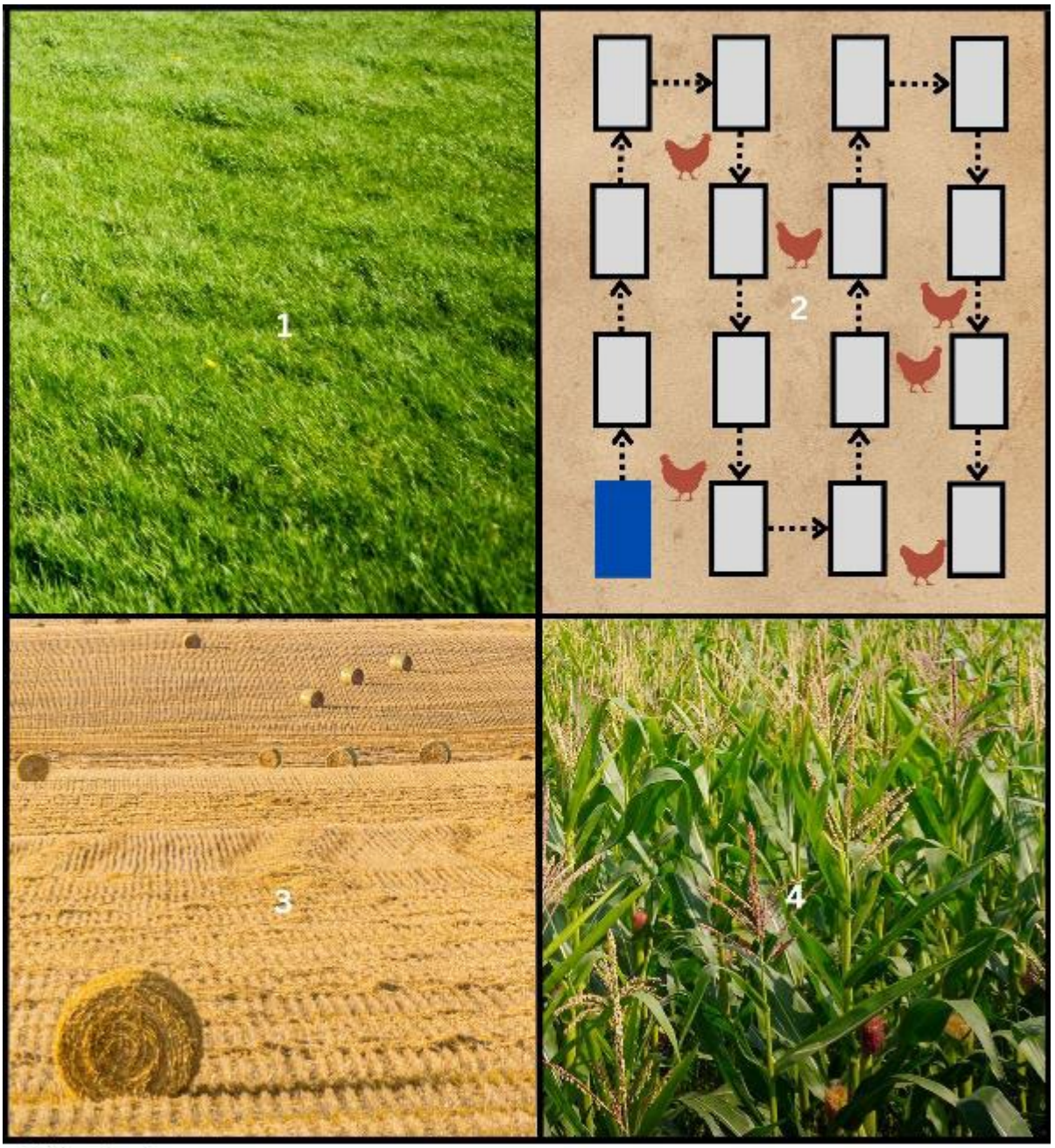


Figure 6. Diagram of tree plantings in groves and incremental movement of portable shelters on range areas to encourage dispersion

8.2 Mobile



¹Not drawn to scale.

Paddock #1: Pasture, ready for the hens next move.

Paddock #2: Mobile shed and hens.

Paddock # 3: Hay crop, meadow or Lucerne.

Paddock #4: Corn crop - following hens.

Figure 7. Diagram of optimal mobile rotation of mobile sheds with a rotational production system

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Appendix 1

The following table provides a sample list of plant species suitable for range areas. Note that the list is not exhaustive, and an appropriate specialist should be engaged to assist with selecting site-appropriate species.

Table 2. Selected plant species (and their key characteristics) suitable for range areas.

Species	Description	Growth rate	Suitable climate zones	Drought tolerance	Frost tolerance	Salt tolerant	Suitable soil type	Fire resistant	Sun	Care level
Bana grass (*Pennisetum purpureum x P. americanum*)	Tall clumps (~4m tall)	Fast	Subtropical, Warm temperate	High	Low	Unknown – no literature on tolerance to high salinity	Well-drained, infertile sandy soils through to nutrient-rich loams	No	Full sun to part shade	Low
Old Man Saltbush (*Atriplex nummularia*)	Evergreen shrub (2m x 2m)	Medium	Temperate, Warm temperate, Subtropical	High	High	Yes	Well-drained clay loams through to low nutrient and low fertility soils	Yes	Full sun	Medium
Tree lucerne (tagasaste) (*Cytisus proliferus*)	Evergreen shrub (4m x 2m)	Fast	Cool temperate, Temperate, Warm Temperate, Subtropical	High	Moderate (Seedlings have low tolerance)	No	Well drained, moderate acidity	Yes	Full sun	Low
Green Pillar Pittosporum (*Pittosporum tenuifolium*)	Evergreen shrub (3m x 2m)	Fast	Temperate, Warm temperate	Moderate	Moderate	Yes	Well-drained, humus-rich, most soil types	No	Full sun, part shade	Low

Sally Wattle (*Acacia salicina*)	Evergreen tree (8m x 3m)	Medium	Temperate, Warm temperate, Subtropical	High	High	Yes	Well-drained, sandy through to clay loams and poor soils	Yes	Full sun, part shade	Medium
Wilga (*Geijera parviflora*)	Evergreen tree (8m x 5m)	Slow	Warm temperate, sub-tropical	High	High	No	Red clays or sandy soils	No	Full shade to full sun	Low
Bottle tree (*Brachychiton rupestris*)	Semi-evergreen	Slow	Sub-tropical, Warm Temperate, Mediterranean	High	Moderate	Yes	Well drained, slightly acid, clay, shale basalt	To some degree	Full sun/part shade	Low
Olive (*Olea europaea*)	Evergreen tree (8m x 5m)	Slow	Sub-tropical, Warm temperate, Semi-arid	High	High	Yes	Most soil types but intolerant of wet, cold soil. Best in poor-quality sandy or gravel soil.	No	Full sun	Low