

Managing feed supply
and groundcover in
rangelands through
nutritional
shepherding:
'Rangelands Self
Herding'



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Lead organisation: Rangelands NRM Coordinating Group (WA)

Partner organisations: Revell Science, Stress Free Stockmanship and CSIRO

Rangelands NRM <http://www.rangelandswa.com.au>

Dr Dean Revell (Revell Science): dean@revellscience.com.au

Bruce Maynard (Stress Free Stockmanship): bruce.maynard@bigpond.com

Dr Dean Thomas (CSIRO): dean.thomas@csiro.au

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EXECUTIVE SUMMARY

Rangelands Self Herding and Rangelands Self Shepherding approaches and procedures developed in this project have created a new opportunity for profitable natural resource management and improved livestock productivity. The rapid evolution of the practices was due to an effective combination of government and institutional support with immediate application and testing by collaborating pastoralists, which allowed flourishing of new techniques that were locally relevant, adaptable, and broadly applicable. The responses from landholders and other industry and NRM personnel have been enthusiastic, as the possibilities of Rangeland Self Herding have been explored and tested.

Collaborating pastoralists successfully modified the grazing distribution of livestock by deploying the approaches and procedures developed in this project. Highlights included: demonstrations that livestock could be retained in targeted areas without relying on fencing; increasing the total area grazed by livestock, thus providing a means to reduce the grazing pressure on heavily utilised areas; positively changing livestock behaviour and the interactions between people and their livestock, with considerable benefits to the ease and efficiency of mustering or trapping; development of new ways to adjust stocking rates within a production year; demonstration that grazing patterns can be positively influenced even in the presence of other major factors such as fire and water availability; and accelerating the adaptation of livestock following relocation across regions.

The significance to the wider livestock industries is that there are now methods that can address issues that formerly were considered too difficult or intractable, such as redistributing livestock grazing pressure, adjusting stocking rates during a production year, and relocating livestock across regions with minimal penalties in animal productivity.

Ongoing development and adoption of Rangelands Self Herding will require a structured outreach program with training of and support for people who are regionally based and able to adapt to local circumstances. We also recommend continued evaluation and refinement of Rangelands Self Herding practices so that new learnings are captured and communicated. The principles of Rangelands Self Herding and Self Shepherding are applicable across the rangelands and across animal species, and the procedures can be locally adapted to address specific issues and opportunities.



Contents

EXECUTIVE SUMMARY	3
BACKGROUND	6
Rangeland characteristics	6
Protecting the resource base	6
Improving planning and capacity for flexible resource management	7
METHODOLOGY	7
1. Development of key principles	7
2. Information transfer	7
3. Development of approaches and methods	8
4. On-ground activities	8
Table 1. Pastoral stations Interactions.	9
5. Animal monitoring	11
RESULTS	12
1. Rangelands Self Herding Principles	12
2. Rangelands Self Herding Approaches – Planning at a landscape scale	12
Figure 1. Grazing Lattice	13
Figure 2. Mapping sectors on a property.	14
3. Rangeland Self Herding Procedures	17
Figure 3. Cattle concentrated around a Jackpot reward provided at a station in the Murchison region of WA.	18
Figure 4. Water Wheeling Diagram.	19
Figure 5. GPS tracks of a cow over a period of four months at Carey Downs	20
Figure 6. Examples of how Guidances Fences or Guidance Tracks, used in conjunction with Attractants, can be used to influence livestock movement.	22
Figure 7. A representation of the design and use of a Skimmer Box.	24
4. Nutritional Attractants	25
5. Signals	25
Figure 8. Examples of signals used	26
6. Main trials	26
Figure 9. Cattle Movement Post Fire.	27
Figure 10. Grazing density distributions and minimum boundary polygons over three successive months with Rangelands Self Herding (Attractant Hopping)	29



Figure 11. A trap yard and water point at Carey Downs Station	29
Figure 12. Images of ‘cleanskin’ bulls that showed marked changes in behaviour	30
7. Supporting Sites	30
Figure 13. Contrasting grazing patterns over one-month periods	30
Figure 14. GPS tracking of two animals on Carey Downs	31
8. Detailed behavioural analyses	31
Figure 15. Diurnal pattern of the distance from daily camping areas for a single cow at DeGrey station	32
Figure 16. Minimum convex polygon of the home range of individual experimental cattle.	33
Figure 17. The proportion of days each month that cows returned to a water point	34
DISCUSSION	34
Significance of findings	34
Implications of behavioural analyses	34
How the research can increase productivity	35
How Rangelands Self Herding can benefit profitability of enterprises and landscape health	36
Table 2: Benefits to Landholders versus Landscapes	37
Future Needs for Innovation Uptake	37
COMMUNICATIONS	38
REFERENCES	39



BACKGROUND

Rangeland characteristics

Rangeland livestock production is typically characterised by habitual grazing patterns and nutritional deficiencies. These recurring patterns profoundly affect ecosystems and are key threatening processes in pastoral areas. The innovations in this project are to use nutrients as 'attractants' that, in turn, increase the capacity of livestock to obtain the nutrient balance they require from the broader landscape. The use of behavioural science insights, such as combining nutritional attractants with clear signals (i.e. behavioural cues), allows a large range of new opportunities to be created to influence and manage grazing distribution and patterns. This then helps to minimise damage to vegetation and reduce risk of erosion, whilst improving livestock productivity and adaptability, and increasing the efficiency of gathering livestock by mustering or by trapping.

Currently, supplements in the rangelands are usually deployed in areas frequented by livestock to ensure easy access, with the consequence that livestock continue to congregate and heavily graze areas around nutrient and water supplies, even when abundant forage is available in other areas. With the more strategic application of principles developed and refined in this project, involving timing and variable placement of nutritional rewards, stockmanship skills, and the use of audible, olfactory and visual signals, beneficial behavioural changes in livestock have occurred quickly and appear to be long-lasting. Additional tools and tactics such as Guidance Fences or Guidance Tracks have been developed as follow-on activities to 'nutritional herding'. Collectively, the full suite of tactics is described as 'Rangelands Self Herding'.

Nutrient deficiencies are well known in the pastoral Australian cattle industry and supplements are used widely to improve production (Gartner et al., 1980), although often with variable or unknown success. Importantly, ruminants deficient in nutrients can display a strong desire to find and consume these elements (Ginane et al., 2015), which provides an opportunity for livestock managers to strategically provide and place nutritional attractants in the landscape. This behaviour has been exploited in other environments to manage livestock movement. The best example is in the rangelands in the USA where nutrient placement has been used to lure livestock to areas that typically receive little grazing and to rest overgrazed patches (Bailey, 2004). The presence of nutrient deficiencies and the use of nutritional attractants, however, is only part of this innovation. The research in the USA and elsewhere has also demonstrated that large herbivores have spatial memories and use these in the on-going selection of grazing locations to improve foraging efficiency. Combined with this, grazing ruminants benefit when introduced to new and diverse feed sources, and this reduces the risk of eating out preferred species (Provenza et al., 2003).

Importantly, livestock productivity and landscape health are both better, especially in dry periods, when there is a diverse mix of vegetation and when the animals have learnt how to use the diverse vegetation (Fynn, 2012). The last step - animals knowing how to use a diverse mix of plant that change over time and space - has been largely overlooked and, until now, has not been routinely built into management decisions in Australian pastoral businesses. With Rangelands Self Herding utilising audible, olfactory, tactile and visual signals for animals to use as a cue for the location of the nutritional attractants, livestock can be encouraged to use areas that are currently less grazed but often nutritionally more dense and diverse. Changes in livestock behaviour form new grazing patterns that can be long lasting (years), including being transferable to new generations, and, consequently, overgrazing of patches can be reduced.

Protecting the resource base

The strategies developed in this project have broad implications because landscape function in the rangelands is affected by the behaviours of livestock and other animals, with flow-on effects to plant-soil interactions. Livestock are the key variable that managers can manipulate to enhance these interactions. To obtain adequate rest and recovery, grazing distribution needs to be guided (Williams, 1954; Hunt et al., 2014), and using behavioural approaches is a cost-effective way to achieve this. Grazing patterns, although complex, are not random and neither



are they fixed. Foraging patterns are formed by associations between cues and consequences, individual and social learning, animal responses to familiarity and novelty, and spatial memory (Launchbaugh and Howery, 2005). All of these elements are taken into account in the suite of procedures developed in Rangelands Self Herding.

Improving planning and capacity for flexible resource management

Conventional methods to manage grazing distribution include the location of water and positioning of fences, which are effectively forms of forced control. The innovation of this project provides a new and exciting third approach that deviates from convention by guiding animals via choice rather than exclusion or restriction. The approaches and methods are developed for pastoralists and livestock managers, and are based on behavioural science, animal nutrition and ecology. The immediate payoffs for pastoral enterprises include gaining the benefits of more controlled and intensive grazing without increasing management intensity or infrastructure. Other benefits gained have been improved monitoring and flexibility, improved efficiency of mustering, gathering or trapping livestock, and having livestock that initiate more exploratory grazing behaviours. The innovation provides practical, low-cost options for pastoralists that are suited to individual needs and local conditions. The range of approaches developed in the project enable flexible responses to changes in weather, ecosystems, markets, animal welfare and business factors.

METHODOLOGY

1. Development of key principles

A set of overarching principles were developed and refined to (i) summarise the scientific basis of Rangelands Self Herding, (ii) aid the transfer of information to pastoralists by providing a succinct set of statements to explain how combinations of management tools will affect animal behaviour and grazing patterns, and (iii) assist in developing and revising on-ground action plans. The seven foundation principles formed the basis of the approaches and procedures that were devised.

2. Information transfer

2.1 Workshops

A series of workshops were presented during the life of the project, with those held at the beginning being introductory in nature to outline the potential of Rangelands Self Herding. As the project progressed, workshops became more targeted to on-ground practices, and were supported by evidence and experience as pastoralists began testing and implementing new practices. The main workshops were:

- (i) Kimberley region, Broome, April 2014 (with internationally-renowned researcher, Professor Fred Provenza, Emeritus Professor Utah State University, USA)
- (ii) Pilbara region, hosted by De Grey LCDC and Yarrie Station, September 2014
- (iii) Gascoyne region, hosted by the Upper Gascoyne Catchment Group and Lyndon Station, July 2014
- (iv) Murchison region, hosted by Southern Rangelands/Mt Augustus LCDC and Carey Downs Station, June 2014.

2.2 Industry forums

Information on, and from, this project were presented at numerous industry forums around the WA rangelands, including:

- (i) West Kimberley LCDC meeting, December 2014 (Country Downs Station)
- (ii) Mt Augustus LCDC meeting, July 2014 (Mt Augustus Station)
- (iii) De Grey LCDC AGM, July 2014 (De Grey Station) and follow-up planning meeting, September 2014 (Yarrie Station)
- (iv) Goldfields Nullarbor Regional Biosecurity Group AGM, February 2015 (Kalgoorlie)
- (v) Pilbara District Consultative Meeting, November 2014 (Port Hedland)
- (vi) Pastoral Profit Innovation Expos:



- a. Goldfields/Nullarbor (Hampton Hill, September 2015)
 - b. Mt Magnet (Wogarno Station, October 2015)
 - c. Carnarvon (November 2015)
- (vii) BEHAVE (Behavioural Education for Humans, Animals, Vegetation and Ecosystems) Australia consortium - workshop, Dubbo NSW, March 2016.

2.3 Station visits

As the project progressed, the need for targeted on-station visits was identified. The project team of Dean Revell and Bruce Maynard visited 24 properties and met with 33 pastoral managers or owners either one-on-one or in small groups (e.g. with 2-5 properties represented). Specific follow-up information was provided to seventeen properties in response to the interest to address local issues, with the feedback including telephone conversations, emails, personalised video messages (via YouTube) and detailed written plans for on-ground implementation of Rangelands Self Herding.

3. Development of approaches and methods

In designing and testing the innovation, we identified the need to define different 'approaches' as well as specific procedures. The 'approaches' outlined different management intents that could be addressed with Rangelands Self Herding and include both planning and monitoring, whilst the procedures were the actual tools and tactics available for on-ground activities.

4. On-ground activities

At the commencement of the project, the concepts and opportunities of Rangelands Self Herding were presented to groups. Sites and collaborating landholders self-selected from these initial meetings (Table 1). Three main sites were used, one in each of the following regions: Kimberley, Pilbara and Gascoyne. In addition, the project had direct engagement with another 21 properties, some of which included monitoring activities (in the form of observations, diary notes, images with trap cameras, or GPS tracking of livestock).

4.1 Kimberley – Country Downs (Kimberley region)

The focus of the trial at Country Downs was to 'Reliably Relocate' cattle after a devastating fire that burnt 80-90% of the property. The urgent need was to retain a mixed selection of animals on a small area of unburnt country, and avoid the cattle dispersing to other water points or across damaged fences to their previous home ranges where the vegetation needed rest after the fire to rebuild the forage base.

One of the first tasks in the rebuilding phase was to collect cattle from various locations within the property and relocate this mixed group to an unburnt area, with a new water point recently installed that had not previously been used by any animals. About 100 cattle were selected across a wide range of ages and weights, including bulls, cows, steers, heifers and calves. For a one-week period whilst in yards, the cattle were trained to associate specific visual and audio cues with nutritional rewards (Attractants) together with positive human-animal interactions. Attractants offered in cut-off drums included mineral lick and salt, and an Attractant Coathanger was paired with the Attractants. The cattle also received regular Jackpots during this week, with chaff and molasses used as the nutritional reward, paired with the sound of a whistle.



Table 1. Pastoral stations Interactions. This table displays the stations that the project team interacted with in varying ways during the project. Additional stations interacted with the project via group workshops or seminars.

<i>Region</i>	<i>Main sites</i>	<i>Additional sites with some monitoring</i>	<i>Discussions or follow-ups, but no monitored trial work</i>
<i>Kimberley</i>	<i>Country Downs</i>		Anna Plains
			Wallal
			Larrawa
<i>Pilbara Gascoyne</i>	<i>De Grey</i>	Yarrie	Peedamulla
	<i>Carey Downs</i>	Lyndon	Mia Mia
		Bullara	Yanrey
			Koodarrie
			Williamburry
			Pingandy
<i>Murchison</i>			Meedo
		Challa	Wondinong
		Austin Downs	Byro
		Nallan	
<i>Goldfields</i>			Yerilla
			Sturt Meadows
			Gindalbie Station

The cattle were taken by truck to their new location, and held in a temporary paddock yard for 4 days whilst the Attractants and Jackpots continued to be offered, further reinforcing the relationships between the signals and the rewards. On the day that the cattle were released from the temporary yard, the Attractant stations and Jackpot were offered nearby. On each subsequent visit over the next 3 weeks – which began at a daily rate, but was reduced to a visit every 3-4 days as time progressed – the Attractant stations and Jackpot location were moved a small distance in the direction of the unburnt area. The repositioning of the Attractants was to maintain the interest of the animals in the rewards, and to entice the cattle towards the intended area.

Two animals were fitted with GPS collars to quantify grazing patterns over the first 4 weeks after the relocation. Motion detector cameras were positioned near the Attractant stations to record animal visits and utilisation.

Subsequent on-ground activities at Country Downs continued the use of Attractant station and Jackpots to modify grazing location of cattle.

4.2 Pilbara – De Grey (Pilbara region)

The focus of the De Grey site in the Pilbara was to test a ‘Managed Movement’. A large (45,000 ha) paddock spanning multiple land systems and vegetation patterns was used. The intention of the land managers was to encourage cattle to move over a series of months from a well-utilised area into a poorly-utilised area (spinifex Pindan country) within the same paddock. This intended movement would require animals to extend their grazing range into areas not previously used by them to any great extent. The trial ran in October-December 2014, and recommenced in September 2015 through to December 2015.

Attractant Leapfrogging and Jackpots were the main methods used to encourage cattle movement from their original location into new areas. A Taggle® system was used to monitor animal locations and movement, with 50 cows and 50 heifers fitted with radio transmitter ear tags. Three receiver towers were positioned in the paddock. In addition, four animals were fitted with GPS tracking collars.



4.3 Gascoyne - Carey Downs (Gascoyne region)

The focus of on-ground activities at Carey Downs was to influence the utilisation patterns of cattle, and improve the efficiency of trapping through behavioural change of the livestock. Attractant Stations and lick feeders, with visual and audible signals, were placed in various locations to encourage broader utilisation of the landscape (and thereby avoiding over-use of sensitive areas). Mobile lick feeders with cracked lupins were fitted with visual and audible signals. Attractant drums with mineral lick and occasional use of molasses were provided in various locations, sometimes in the vicinity of the lick feeders and sometimes on their own. The positioning of the Attractant stations was varied over time to encourage the cattle to continue interacting with them, and 'Jackpots' were also used to strengthen behavioural responses.

Observations by the station managers and trap cameras were used to monitor the interactions between livestock, Attractant stations, and trap yards. Four cows in one mob were fitted with GPS tracking collars.

4.4 Supporting sites

Various on-ground activities were conducted at six properties.

Yarrie (Pilbara region)

- Reliable relocation of cattle from a river with permanent water to a new water point.

The managers actively manage their river country as the 'backbone' of the property. Much of the river is fenced, but even within this paddock (with fences about 3-4 km from the river on either side) there is uneven grazing. The cattle tend to spend time along the river where there is permanent water.

Reducing the grazing pressure along the river and making use of good feed just a short distance away has been a goal, but previously when cattle had been taken to a water point away from the river, they'd returned to their previous range within days.

In October 2014, some relatively simple Rangelands Self Herding tactics were employed. These included making cattle familiar with a mineral lick and troughs (a nutritional attractant). The cattle were then taken to the 'new' water point and placed there with good stockmanship. They were not held at the new water point (which could be perceived by the cattle as a negative experience) but encouraged to stay through the provision of the attractant stations and good stockmanship. The nutritional attractant around the water point was re-stocked daily for about 3 weeks.

Lyndon (Gascoyne region)

- Accelerated Adaptation with rangeland cattle being relocated to a farm in the WA agricultural region for backgrounding or finishing
- Attractant Hopping – increasing utilisation in specific areas and improving mustering efficiency through behavioural changes
- Two animals were fitted with GPS collars to provide preliminary information on grazing patterns

Bullara (Upper Gascoyne region)

- Adaptation of cattle purchased from other stations during a re-building phase with part of the business changing from sheep to cattle production
- Two animals were fitted with GPS collars to record patterns of habitat selection in animals that were new to the landscape but had received 'training' to become familiar to attractants, rewards and visual cues.

Challa (Murchison region)

- Adaptation and retention of animals on a newly acquired, neighbouring property

Nallan (Murchison region)



- Use of Attractant Hopping and Jackpots to influence grazing distribution.

Austin Downs (Murchison region)

- Use of a Grazing Jigsaw, and Attractant Hopping and Jackpots to influence grazing distribution
- Testing of an electric Skimmer Box

Gindalbie/Yerilla/Sturt Meadows (Goldfields region)

- Discussion to encourage the movement of cattle from overused areas to less grazed areas, or to increase the effectiveness of mineral supplementation

5. *Animal monitoring*

Location monitoring devices were installed on cattle at a number of the Rangelands Self Herding research sites (Table 1), with animal ethics approval granted (CSIRO Organisational Reference: Project 1410). The monitoring devices allowed measurement of a number of important behaviours of cattle, such as their use of the rangelands, daily travel distance, water point use (site and frequency), and daily patterns of activity. These observations would not otherwise have been possible without intensive and expensive observational studies with the risk of disturbing normal patterns of behaviour.

Two types of monitoring devices were used. At De Grey station, a Taggle® radiolocation system was installed. At a number of other sites, GPS tracking collars were secured around the neck of adult cattle and locations were estimated through the units GPS chip.

5.1 *Taggle® radio transmission*

The Taggle® ear tag tracking system tested as part of this project enabled higher frequency and duration data to be collected than has been previously possible. Taggle® tracking is a pre-commercial livestock monitoring system where cattle ear tags transmit a radio signal that is received by several ground-based towers. Through radio beacon triangulation of this information, the animal's location is estimated similarly to the GPS system (<http://taggle.com.au/applications/agriculture/livestock>). The Taggle® ear tags were manufactured by Taggle Systems Pty Ltd, NSW, Australia. The Taggle® monitoring system has potential advantages in timing, cost and accuracy for monitoring cattle behaviour in the rangelands compared with aerial photography and radio interferometry. Advantages in monitoring frequency and duration, and cost per unit deployed are also possible compared with commercial GPS tracking systems.

The first deployment of Taggle® tags were attached to 80 mature cows on 18 August 2014 at De Grey station, where three Taggle® receiver antennas had been installed. The performance of the trackers decreased during the subsequent months, so a second deployment of 20 Taggle® tags were released on new cows from the same paddock on 4 June 2015. Taggle® data was transmitted at a maximum frequency of 12-minute intervals, setting a maximum value of 120 tracking points per cow per day. Due to the technical limitations of the Taggle® system deployed in the rangelands, generally fewer than 60 tracking points per cow per day were recorded. A Linux-based script was used to transfer tracking data from the host Taggle® server to a local CSIRO server on a daily basis.

From the two deployments a relatively small subset of data was selected for analyses. The criteria were that individual animals required data over at least 10 days per month over three months, with eight positions or more per day. Based on this, a total of 7 cattle were selected in 2014 and 4 cattle in 2015. A detailed analysis of these data was carried out, and the behaviours of cattle were compared between individual animals and across seasons.

5.2 *GPS collars*

The main GPS collars used for the project were EcoKnowledge GPS tracking collars, which recorded animal positional data (4 points per day at 0500, 0900, 1400 and 1800 hrs). Four points per day were chosen to optimise the battery life so that the collars would provide data for at least 12 months, and the time of day that waypoints were recorded were selected to be before and immediately after the expected main grazing events; one in the morning around sunrise and the other in the late afternoon/ early evening. Data recorded on the collars was



transmitted via satellite communication to a web database, where the information could be viewed in near-real time. All time periods and months have equal data numbers. Collars were installed on adult cows at Lyndon Station (2), DeGrey Station (5) and Carey Downs Station (5). The performance of the collars was variable, but in general sufficient for acquiring data on animal location and movement. Later in the project, Sitrack Iridium collars (Sirtrack Ltd) were deployed at Carey Downs Station, with good success.

RESULTS

1. *Rangelands Self Herding Principles*

The following seven principles were developed, and published at the Australian Rangelands Society conference (Revell *et al.*, 2015).

- (i) *Human-animal interactions shape outcomes.* In adaptive systems, the relationship between humans and livestock is critical in achieving favourable results in a timely fashion.
- (ii) *Internal feedback sets behaviours.* Animals start an eating behaviour if they expect a reward; sight, sound and smell cues, both natural and contrived, can be used to influence that behaviour. They continue the behaviour if they receive the reward because it provides positive feedback that reinforces the initial behaviour (Ginane *et al.*, 2015).
- (iii) *Experience reinforces behaviour.* Past experience is a major factor in determining current behaviours, including dietary choices and habitat selection. However, unwanted behaviours can be replaced by encouraging new behaviours that establish a new set of experiences.
- (iv) *Animals seek diet diversity.* Different plants bring different nutrients from different soil depths at different times. Livestock perform better when there is diversity, but they must learn how to use this diversity (Masters *et al.*, 2010; Fynn, 2012).
- (v) *Adaptability is required to face change.* A wide range of experiences prepares animals for a range of future circumstances. Exposure to different feeds and forages *in utero* and pre-weaning can have important long-lasting consequences (e.g. Chadwick *et al.*, 2009; Digby *et al.*, 2010). Continued learning from experienced peer animals (e.g. Thomas *et al.*, 2009), with low levels of stress (Villalba *et al.*, 2009), can help animals manage further changes.
- (vi) *Individuals and groups influence each other.* Individuals need to experiment with, and learn about, all the resources where they live. Individuals shape the behaviour of a group, but so too does group behaviour influence individual responses; it's a dynamic relationship that acts continuously in both directions (Smith *et al.*, 2010; Tanner and Jackson, 2012).
- (vii) *Consequences are broad as everything is connected.* Livestock behaviours affect other parts of the system: soil, plant communities, predator behaviour, and other animals in the landscape (Provenza *et al.*, 2003). Being aware and observant to this can create opportunities for multiple benefits.

In planning stages with landholders, any particular intervention could be scored for the level of sophistication against each of the seven principles to semi-quantify the likely scale of impact of the intervention.

2. *Rangelands Self Herding Approaches – Planning at a landscape scale*

A suite of Self Herding Approaches were developed during the project to capture issues identified by pastoralists or project members and assist in planning.

2.1 *Grazing Lattice – a planning tool to link livestock, landscape features and water points*

At any given point in time, animals will normally have a 'grazing centre', where they spend most of their time, and from where they move to graze and explore the surrounding areas. Most often, the grazing centres are around water points, but they may also be around preferred camping areas where there is plenty of shade.



Livestock managers can influence the decisions animals make about their grazing centre, how tightly the individuals and the group as whole are focussed around their centres, and the movement of animals from one location to another.

Visualising the pattern of landscape use over time, with different grazing centres, each with their unique size and shape based on landscape features and the supply of feed and water, and with animal movement between centres, reveals a conceptual 'lattice' (Figure 1). Self Herding can help create the Grazing Lattice by influencing the decisions of animals to either remain in an area or to move from one area to another. Moving between grazing centres can be on a regular basis – such as livestock that have incorporated multiple water points into their grazing home range – or can be triggered by changing the preferred grazing area from one location to another.

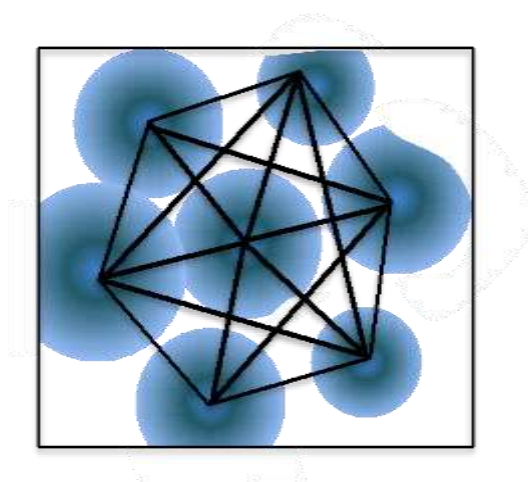


Figure 1. Grazing Lattice In the schematic diagram above, the shapes represent the grazing sectors around water or camping areas, and the linkages between the sectors, which form the 'lattice' represented by the black lines.

2.2 Jigsaw Circuits – a planning and recording tool for managers to show which parts of the landscape received grazing intensity over a 12-month period

The Jigsaw Circuit is a planning and recording tool that ensures management continues to change the 'centres of grazing'. Actually changing utilisation patterns requires decisions on where and when to move Attractants or to place Guidance Tracks or Fences. So the Jigsaw serves as a prompt and a visual reminder of the previous, current, and future locations of the 'centres of grazing' (Figure 2).

- It is based on an aerial photo or satellite image of part of the property.
- The area is assigned into 26 parts, A-Z. The number 26 is chosen to encourage land managers to consider a large number of units within a paddock or part of a property to more closely reflect the scale at which animals make decisions on a daily basis about where to graze and what to eat, but of course the exact number is arbitrary.
- There is no single way to decide on the size or shape of the portions, but should reflect the way animals are likely to use the landscape, influenced by water locations, vegetation patterns, terrain and current animal behaviours. As satellite imagery and spectral imaging become more readily available and calibrated across a wider range of vegetation types, seasonal profiles of NDVI, fractional cover or other vegetation index could inform the manager about the intended path for livestock to optimise landscape use.
- The portions can reflect how the animals are using the areas, or how a land manager would like them to use the areas.
- The idea is to shift the 'grazing centre' through the portions as the manager sees fit during the year.
- The planning tool includes a table to record the location being targeted at any given time as the 'grazing centre'.

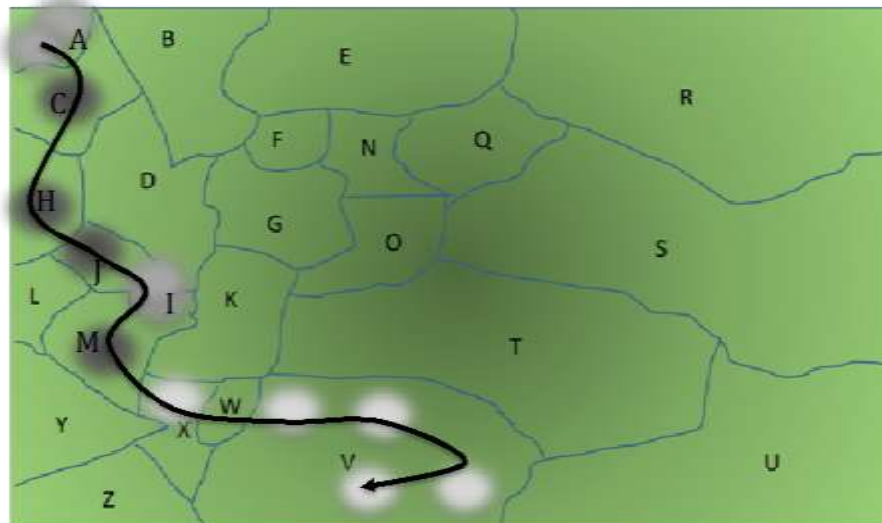


Figure 2. Mapping sectors on a property. A diagram to show different sectors or portions that would be marked onto an aerial photograph or map of a property. The manager can record the location of Attractants and, therefore, records where animals focus their grazing. The darker marks represent a higher level of grazing intensity as a result of more focussed application of Self Herding methods.

2.3 Managed Movements - a plan to influence the movement of livestock in a landscape over time

The intent with a Managed Movement is to coordinate the movement of livestock through a landscape over time. With a behaviour-based approach, we are not talking about 100% of the animals sweeping across the landscape like a herd of wildebeest, but rather it's about shaping the majority of animals to direct their grazing pressure.

Triggering the movement of livestock from one area to the next, using a Grazing Jigsaw to help plan and monitor progress can effectively bring a larger area into production than is normally achieved, and also allow areas that would normally be over-used to have periods of rest and recovery.

The main tactics used in Managed Movement are Attractant Hopping, Attractant Leapfrogging and Water Wheeling (see Results section 3).

2.4 Reliable Retentions – a plan to retain livestock in targeted areas after relocation to a new area (e.g. a new water point) on the existing property or on a new property.

The aim of a Reliable Retention is to have livestock choosing to stay in a particular area for a given period of time. If the area in which the animals are to be retained is not currently being used, then a new set of behaviours must be instigated so the animals are comfortable to use the new area.

For example, a manager may have a new water point commissioned and want to place animals at that water and for them to develop new grazing habits around that position in the landscape. They may be keen to avoid animals voluntarily moving off quickly and returning to their previous grazing range.

Livestock managers may need to move livestock from one part of the property to another area, or they may have purchased animals from another property and want those animals to remain mostly in one mob in their 'new home'.



The main tactics used in Reliable Retentions are Attractants (see below). A key to the success of a Reliable Retention is building familiarity in the animals before they are taken to a new area.

2.5 Pyric Grazing – a plan to manage the interaction between fire and grazing to reduce fire risk or increase the number of landscape mosaics in a given area

Pyric grazing is a term that describes the interaction between fire and grazing, in terms of where the interactions occur (spatial) and when they occur (temporal). The interactions between fire and grazing trigger processes that give a shifting pattern of disturbance across a landscape. These shifting patterns – often called ‘mosaics’ – create different niches for a wide range of plant species. Rangeland animals rely on this wide range by utilising varying amounts of many different forages. This helps build resilience into the biological systems and increases livestock production, by allowing the animals cope with any dietary deficiencies, and capitalise on fluctuations between seasons.

With the use of fire as a management tool, there are three basic landscape conditions: burnt, unburnt and recovering (or transition). But if land and livestock managers are also able to control the grazing impact on each of these mosaic patches using Rangelands Self Herding, they can double the number of landscape patches; i.e. each of the existing conditions (burnt, not burnt, and recovering) can now also be grazed or ungrazed.

Another management option is to target grazing in areas that are at risk of fire to reduce the fuel load, or to create more effective firebreaks with some focussed grazing off tracks or in between tracks.

2.6 ‘Range-lotting’ – the strategic use of supplementary feeding in a targeted area to improve landscape function by increasing livestock performance

Range-lotting is a procedure to rehabilitate degraded soil whilst simultaneously increasing productivity. Landscape regeneration can benefit from intensively managed, short duration grazing, but good management is critically important to avoid risking further degradation. ‘Range-lotting’ involves concentrating the location of animals, precisely placing them within their allocated paddock, moving them from patch to patch at regular intervals using Self Herding tactics.

The animals are to be kept in the allocated area for a discrete period of time (e.g. heifers placed in a paddock for 6 weeks prior to joining with bulls), and can receive strategic supplementation to boost production (e.g. increase fecundity in heifers). The animal impact is a critical part of the procedure with a mobile feeder shifted very frequently (maximum of 2 days in any location). This provides disturbance and manure fertilisation of sites without risking structural damage to the soil. At least three sets of these paddocks are to be used so each area is not grazed every year, as sufficient time for paddock regeneration is required.

The use of supplements, such as grain or pellets, has the added advantage of exposing animals to feed resources that they may encounter again later (e.g. in a formulated ration), which can be very helpful to encourage consumption and increase the efficiency of utilisation when that time comes. If pregnant animals are used in Range-lotting, their offspring will receive nutritional and metabolic feedback that can help them use those feed resources later in life.

2.7 Accelerated Adaptation – improving the capacity of livestock to adapt to change through de-stressing and positive exposure to novel places and feedstuffs

A precise yet simple procedure was developed during the project so that it can realistically be used under commercial conditions where time constraints are often limiting, especially when animals are yarded and preparations for transport are underway.



'Departure Lounge' procedures

These instructions are aimed to initiate behaviours that can be repeated upon arrival to ensure the animals regain their usual eating and exploratory behaviours.

Time suggested: 4 hours total split over 2 days.

Pre-departure tasks:

- Mix strawberry flavour with water in a 1/50 ratio and put mix into spray bottle.
- Put out hay in departure yard (yard 1).
- Put witches hats into yard.
- Put coarse salt into one drum and drizzle molasses through the salt, place in yard 1.
- Put mineral lick into other drum and place in yard 1 (if using lick blocks do not use a drum).
- Spray hay with strawberry flavour and also spray along side of water trough, feed drums and witches hats (do not spray into drums or water trough).

Adaptation tasks:

Day 1.

Task A – De-stressing in Yard 1 (30 minutes)

- Let animals into yard and observe closely to see if all are either eating or drinking. Do not interfere with those that are eating or drinking but, for those that are not, they should be de-stressed using Stress Free Stockmanship methods.

Task B – Novel Feeds introduction in Yard 2 (30 minutes)

- Place troughs into yard and put oats in one and lucerne chaff in the other.
- Place witches hats (the signals) near troughs in yards.
- Spray sides of troughs and witches hats with strawberry flavour.
- Blow whistle with three loud bursts.
- Let animals in to the yard, concentrating on walking them in rather than allowing them to run in.

Task C – De-stressing in Yard 1 (30 minutes)

- Return animals to Yard 1 and observe for excess movement, ill-health or lethargy. De-stress using Stress Free Stockmanship methods.

Task D – Novel Feeds introduction in Yard 3 (30 minutes)

- Repeat Task B.

Day 2. Repeat the above tasks A through D but changing to different yards for Task B and D, and changing from troughs to drums if available.

'Arrival Lounge' procedures

These instructions aim to reinforce behaviours that have been 'imprinted' on the animals so that they more rapidly adapt to completely new surroundings. By easing their anxiety associated with the transition, higher performance can be expected.

Time Suggested: 2 hours total split over 2 days



Pre-arrival tasks:

- As for the 'Departure Lounge' pre-departure tasks, except each of the four tasks is for 15 minutes, rather than the 30 minutes that is used pre-departure.

Adaptation tasks:

Day 1.

- As for the 'Departure Lounge' Adaptation tasks.

Day 2. Repeat the above tasks A through D but changing to different yards for Task B and D.

3. Rangeland Self Herding Procedures

Procedures for implementing Rangelands Self Herding were developed, tested and refined in collaboration with the pastoralists. A description of the procedures was shared with land managers via different mediums, including verbal descriptions at meetings or workshops, emails outlining suggested courses of action, a Self Herding YouTube channel, and website (www.selfherding.com).

3.1 Attractants

Attractants are not supplements. They are a feedstuffs that are nearly constantly available, which provide positive feedback signals to the animal when consumed. They are not eaten in large amounts, and therefore they are not expensive to use.

The purpose is to have animals investigate an Attractant Station on a regular or frequent basis (depending on the circumstances and the aim of the manager). The amount of the Attractants eaten isn't as important as the number of visitations by animals. Any safe feedstuff can be used as an Attractant, but a key principle of Rangelands Self Herding is that it cannot become an expensive exercise. If a livestock manager knows that a particular nutrient is limiting livestock performance, it can be beneficial to provide that nutrient in an Attractant as the livestock will more readily seek it and the positive nutritional feedback will reinforce the positive behaviour of visiting the Attractant station. If offered in larger amounts it could be considered as a supplement, but when offered in smaller amounts, it effectively remains an Attractant.

The three Attractants in a standard Attractant Station are:

- Trough 1 – coarse salt
- Trough 2 – 'Bruce's Brew' – a mix of ash and charcoal
- Trough 3 – A commercial or home-made mineral lick

3.2 Jackpots

A Jackpot is a small amount of a delicious feed reward that is offered occasionally. It is designed to trigger strong movement by animals towards the Jackpot that, in turn, will attract other animals towards the location (Figure 3).

The Jackpot reward is paired with a very clear and consistent sound cue such as a whistle because it can be loud and clear, is easy to carry around, and all people (staff) who might be offering a Jackpot on a property can use the same signal.

The attractant used for a Jackpot can be any palatable food – a biscuit of hay, crushed lupins, oats or other grain, cattle or horse pellets etc. The feed used for the Jackpot can be changed between different offerings; in fact, we recommend that the reward be varied as it will help maintain the keen interest of the animals. The consumption of variety in one set of foods encourages animals to eat a variety of other foods. So this means that building variety into the Jackpot procedure will also help to encourage animals to include a broader range of feeds in their diet.



Figure 3. Cattle concentrated around a Jackpot reward provided at a station in the Murchison region of WA.

3.3 Super Jackpot

A Super Jackpot is the provision of a larger Jackpot so more animals are able to share in the benefits. A roll of good quality hay is ideal and, to increase its attractiveness, lupins (or other grain, or pellets) can be sprinkled all over the teased-out hay, or diluted molasses can be drizzled over the hay.

The same signal (e.g. whistle) can be used for a Super Jackpot as for a regular Jackpot or, if a Super jackpot is used frequently enough, it can be paired with its own unique signal to distinguish it from a conventional Jackpot.

3.4 Attractant Hopping

Attractant Hopping encourages movement of livestock in a planned direction to broaden the area being utilised by livestock, providing rest and recovery of areas, and broadening the diet as animals move through their landscape.

The first step is to allow the animals to become familiar with Attractants and Jackpots in an area that they are comfortable to be in (e.g. near a water point that they are regularly using) or when they are yarded, as this maximised the number of encounters the animals will have with the Attractant Troughs and the Jackpot. Providing Attractants during the familiarisation phase must be coupled with clear and unambiguous cues, or signals, that the animals learn to associate with the rewards.

The most suitable signal/s to be paired with nutritional Attractants depend on the type of country; e.g. in shrublands, audible signals will be more useful than visual signals, whereas in open (grassland) country, visual signals will be effective. Using multiple signals (e.g. audible, visual and olfactory) is recommended to maximise effectiveness.

An attractant station can provide a constant supply of Attractants and also an occasional 'extra reward' via the Jackpot method. By doing both of these, the animals receive a more powerful message and nutritional feedback. Plus, once the animals have learnt about the procedures and the rewards, their use can help if a manager wants to trigger some movement (or retention) of these cattle at some other time or in another location in the future.

Once a high level of activity and investigation of the troughs has commenced, the Attractant station can begin to be moved in the desired direction to trigger new exploratory behaviour. Initially smaller, less frequent moves may be



required, before longer moves are incorporated. The frequency and distance of each move depends on the responses of the animals.

3.5 Attractant Leapfrogging

This is similar to Attractant Hopping, but with Leapfrogging, there is the use of a larger reward in addition to the use of Attractants in troughs. An example of a larger reward that has been successfully at a number of pastoral properties in WA is a mobile lick feeder containing grain, pellets or a mixed ration. A lick feeder is particularly suitable because the amount of feed consumed can be controlled by adjusting the feeder settings; thus avoiding high costs associated with supplementary feeding as distinct from the lower cost of providing nutritional Attractants.

The Attractants are moved towards the lick feeder that is placed some distance away. When the Attractant Station reaches the lick feeder, they are moved beyond it (i.e. leapfrogging it) and, once the Attractant troughs are some distance away from the trailer, the trailer is moved further afield in the desired direction.

3.6 Water Wheeling

This procedure uses the same tools as Attractant Hopping or Leapfrogging, with the single addition that when the Attractants reach a new water point, they are taken on a circuit around that water before being moved to another water point (Figure 4). The idea with Water Wheeling is to take animals to new waters progressively and, while at each water point, encouraging them to explore in all directions around that water.

It is a variant of Attractant Hopping, where managers encourage their livestock to use a broader part of the landscape. But, in this case, it is specifically aiming to make use of multiple water points within a paddock. Changing herd behaviour to use multiple water points over time allows rest and recovery in areas that may have been heavily used in the past.

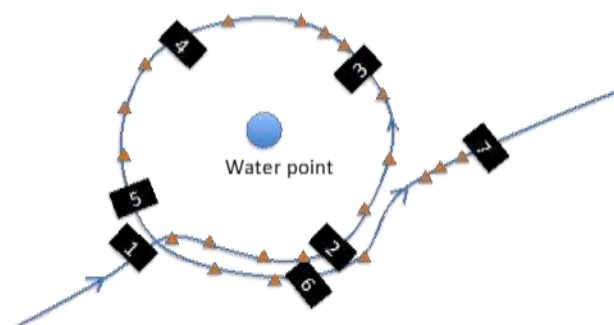


Figure 4. Water Wheeling Diagram. A diagram outlining the sequential movement of Attractant Stations (triangles) and the stronger attractant of a lick feeder (black rectangles).

The 'Water Wheeling' procedure was developed based on GPS tracking of livestock on a number of pastoral properties, which showed cattle regularly 'looping' out and back from a water point (Figure 5). Water Wheeling encourages more even utilisation around a water point. Importantly, it allows individual animals to return to a water they are most familiar with before switching to using a 'new' water point. During this project, we have seen GPS tracking data that suggest individual animals are keen to go back to their previous water to 'check it out again' before being prepared to move on to the new water. We want to work with this behaviour rather than fight against.

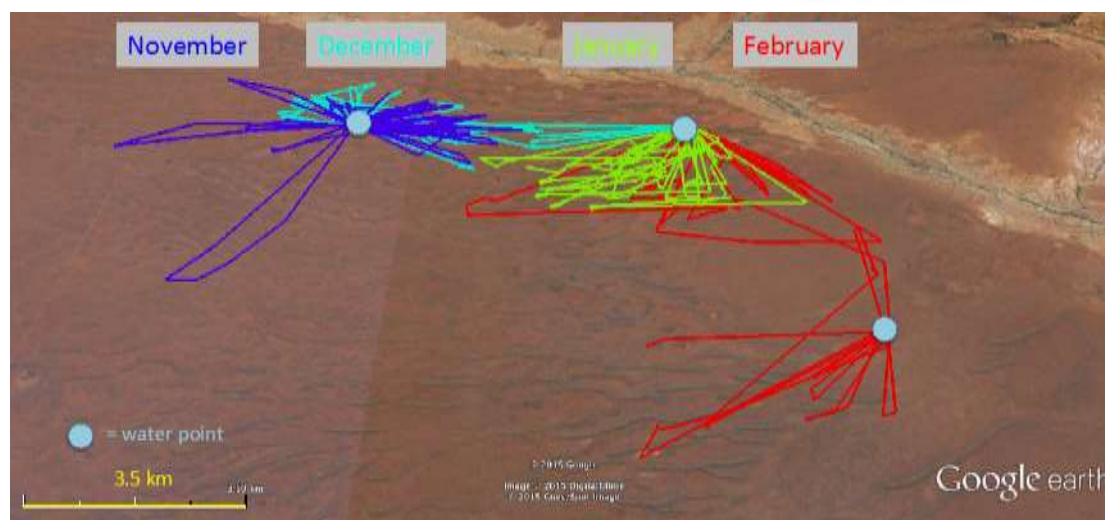


Figure 5. GPS tracks of a cow over a period of four months at Carey Downs, in the Gascoyne region of WA. Each colour represents a different month in 2014/15. In December and February, this animal moved from one water point to another. The GPS tracks showed that when the cow moved to a new water point in December, she chose to re-visit the former water point before settling at the new location for the month of January. When the cow moved to a new water in February, she did not return to the previous water point during the period of monitoring, suggesting the animal was comfortable to move to, and stay around, a new water point at that time.

3.7 Master Mob

A Master Mob is a group of experienced or trained animals that initiate strong following behaviours in other animals (Thomas et al., 2011). Efforts to influence livestock behaviours can be focussed on the Master Mob, and then the experienced Master Mob can be used to guide wider behavioural changes.

At times where it may be necessary to reduce stock numbers on a property, priority for retaining animals can be given to the Master Mob, as these animals can be used to teach desirable grazing behaviours to new arrivals in the future.

3.8 Guidance Tracks and Guidance Fences

Guidance Tracks or Fences can be used to spread the distribution of grazing into areas that would not otherwise be utilised. The aim is to allow easier access into under utilised areas by providing direct paths for livestock to follow. A distinguishing feature of Guidance Tracks or Fences is that they are strategically placed to influence livestock movement, either towards a particular direction, or away from an area that requires temporary protection. They are simple structures that can be moved (or removed) as required. Posts for Guidance Fences may be in position for long periods of time, but lines of wire or tape (electric is especially effective) can be erected as required. On one collaborating property in the Gascoyne region, lengths of Guidance fencing using electric fencing have been erected off an existing trap yard to influence the movement of cattle when they leave the water point.

Guidance tracks can be used for multiple purposes:

- Animal discovery (predators)
- Leading animals toward areas
- Leading animals away from areas
- Adapting animals to travelling in predictable directions as a mustering aid
- Spreading travel and grazing impacts



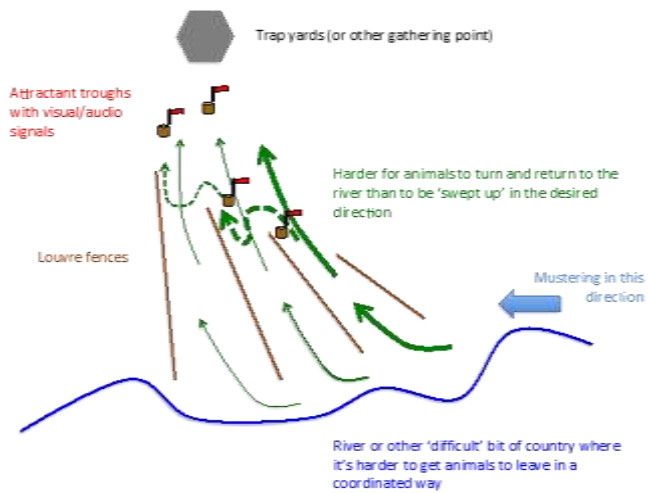
A number of different designs have been developed, based on similar principles although with different aims:

- (i) *Guidance Fences* – Cleared pathways that direct animal and people movement.
- (ii) *Louvre Fences* – Overlapping, angled, non-continuous fences that coordinate movement in desired directions.
- (iii) *Funnel Fences* – Overlapping, non-parallel and non-continuous fences that funnel and accelerate movement in a desired direction.
- (iv) *Spreader Fences* – Non-continuous fences directing animals away from erosion prone or environmentally sensitive areas.
- (v) *Guidance Tracks* – Cleared pathways that direct animal and people movement.

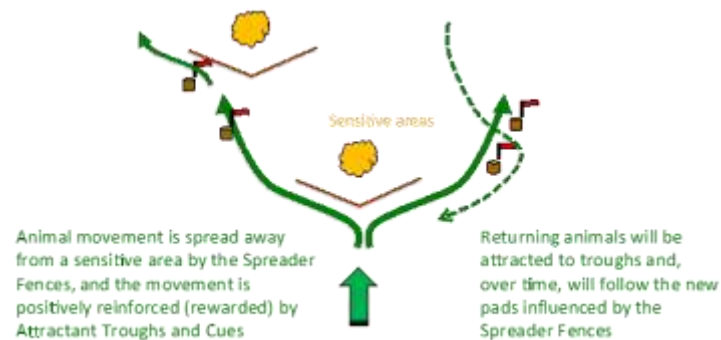
Some examples shown in Figure 6.



A.



B.



C.

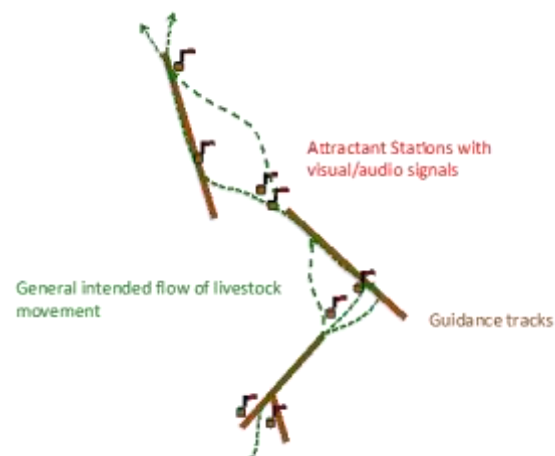


Figure 6. Examples of how Guidances Fences or Guidance Tracks, used in conjunction with Attractants, can be used to influence livestock movement. The brown lines represent Guidance Tracks or Fences, and the green dashed lines indicated the flow of animal movement. A. Funnel fences to guide the movement in a desired direction; B. Spreader fences to redirect livestock away from sensitive areas to allow rest and recovery and prevent erosion; C. Guidance tracks, which do not need to be continuous to encourage the movement of livestock in particular directions.



3.9 Skimmer Box

Skimmer Boxes are designed to enable gathering of livestock at virtually any time, thereby offering managers a choice about reducing or increasing stocking rates outside of the main mustering time. A Skimmer Boxes also allow managers to gather smaller numbers of problem animals such as cleanskin bulls, or animals that require health checks.

The way in which a Skimmer Box is used is critical to the success of its use. When combined with Stress Free Stockmanship, the use of Skimmer Boxes lets the animals feel safe in working yards, thus preparing them for easier handling. Used correctly, Skimmer Boxes offer a range of choices that trapping and mustering cannot, and they opportunities to provide familiarisation and de-stressing of animals throughout the year, in addition to the capacity to harvest animals from areas when required.

Crucial considerations are yard angles, hinging of gates and the stockmanship procedures associated with using the Skimmer Box (Figure 7). Nevertheless, they are cheap to construct; they can be permanent or temporary. A collaborating property in the Murchison region has built a Skimmer Box using electric tape, and reported rapid, positive responses in animal behaviour.

Murchison region has built a Skimmer Box using electric tape, and reported rapid, positive responses in animal behaviour.

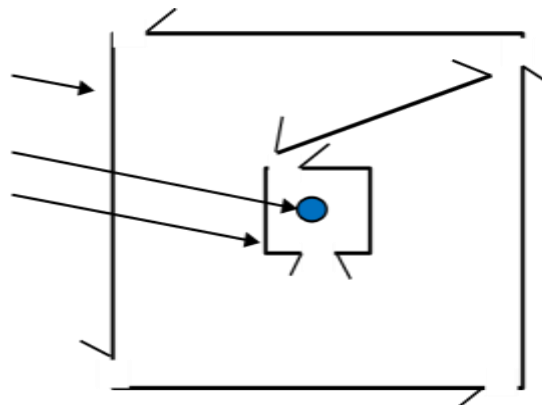


A. General layout

Exterior fence

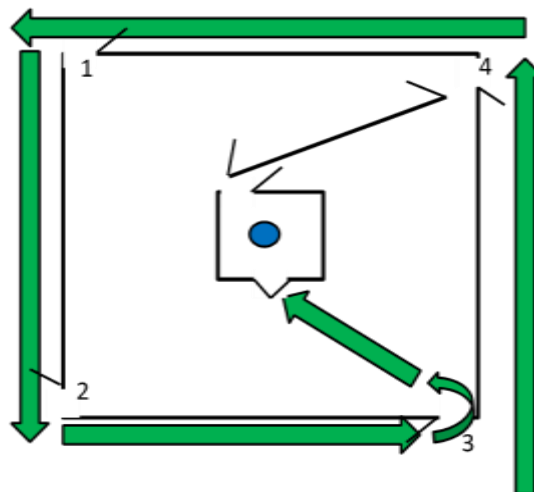
Water point

Working yards



B. Procedure for regular checks

Stockmanship procedures on regular water checking



C. Collection Day Procedure

Stockmanship procedures for 'collecting' animals in yards

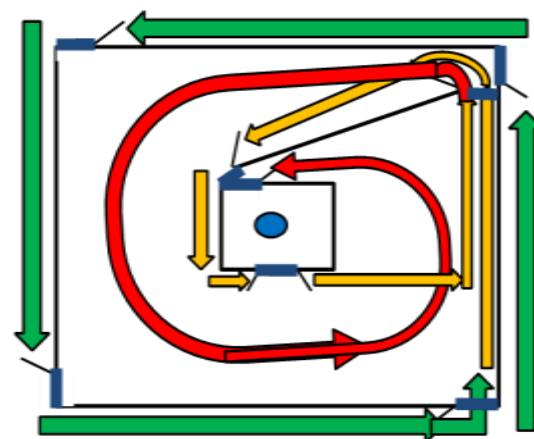


Figure 7. A representation of the design and use of a Skimmer Box. Precise dimensions depend on local situations. On regular visits to the water point, the aim is to parallel the animals that are inside the area as the operator moves along each side of the Skimmer Box. On each visit, one of gates 1, 2 or 3 is closed, and the gates that was closed on the previous visit is opened. This provides animals with the experience of gates closing (and opening) with no consequence, so they do not feel trapped. (Gates 4 is left open until collection day to prevent accidental trapping of animals in the corner where the internal wing fence is directed.) On the 'collection' day, the same procedure is followed but all the gates are closed in sequence as the operator moves along the sides of the Skimmer Box, and the internal gates are then closed in sequence as the animals walk into the central working yard.



4. Nutritional Attractants

Various Nutritional Attractants were used in the project, including:

- (i) *Coarse salt* – often recommended because livestock have what appears to be an innate desire to consume salt, and therefore has a strong attraction value except where there is already high levels of salt in vegetation (e.g. saltbushes) or in water. Also, providing salt on its own allows animals to consume their desired amounts from a cheaper source rather than potentially consuming sodium in an expensive mineral mix. Any consumption of a mineral mix is therefore more likely to indicate that the animals are requiring other minerals beside sodium chloride.
- (ii) *'Bruce's Brew'* – locally sourced ash and charcoal mixtures. The ash component is the minerals from burnt timber, and the charcoal component can act as a detoxifier in the gut due to charcoal having a 'reactive surface' that binds toxins.
- (iii) *Commercial mineral supplements (loose licks or blocks)* – a wide range of mineral licks are available, including phosphorus or urea licks and these are useful for the dual role as supplements and attractants.
- (iv) *Molasses* – Molasses has a strong smell and sweet taste that most livestock find very attractive. Judicious use of molasses can therefore provide a strong signal to animals that a reward is available. A 1:3 dilution with water, referred to as a 'molasses spritzer', to minimise costs and make it easier to apply. Pre-mixing molasses and dispensing into old tomato sauce bottles has been used to make the task clean and simple.
- (v) *Grain*, including lupins (whole or cracked).
- (vi) *Hay or chaff* – cereal or lucerne.

5. Signals

The Attractants were paired strongly with signals to help livestock identify their location, whether fixed or moved around the landscape. The signals provided sight, sound, taste or tactile cues (Figure 8). When used in combination, the signals were attached to devices called Attractant Coathangers. The signals included:

- (i) *Sight* – old CDs tied to swing in the breeze and glint in the sun; witches hats; 'flags' such as chaff bags tied to a post or tree
- (ii) *Sound* – home-made bells or chimes, wind chimes
- (iii) *Smell* – 'Molasses Spritzer', diluted molasses applied to feeders or other feedstuffs
- (iv) *Tactile* – chain, polypipe or metal objects that livestock like to chew.

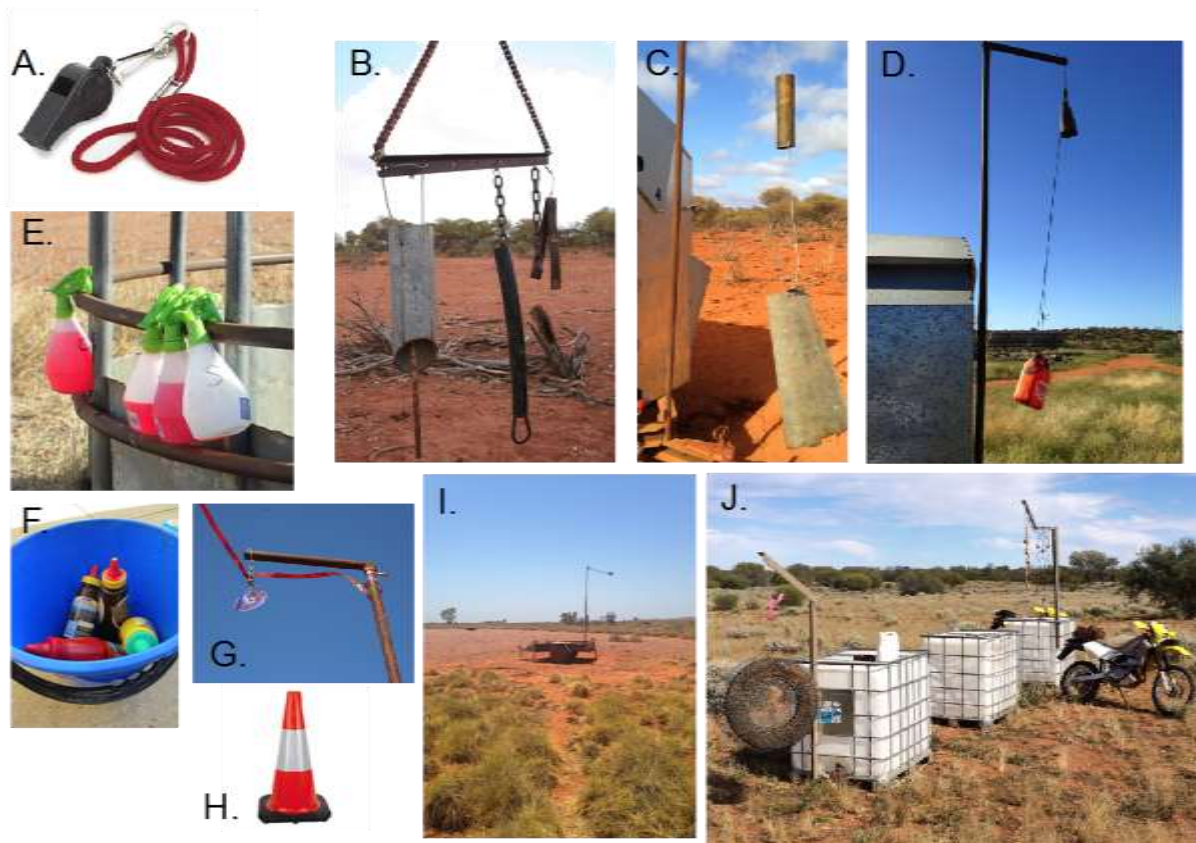


Figure 8. Examples of signals used (and in many cases made) by pastoralists collaborating in this project. (A). Whistle; (B). An Attractant Coathanger containing audible and tactile signals; (C&D). Audible and tactile signals paired with a mobile lick feeder (the bottom paddle moves in the wind to ring a 'bell' above; when the orange-coloured suspended container is played with by cattle it rings a bell above; (E). Diluted strawberry flavour used as an olfactory signal; (F). Diluted molasses in bottles for easy dispensing; (G). Bird tape and a CD used as visual signals. The CD glints in the sun and can be seen from considerable distances; (H). A traffic cone that can serves as a visual (and tactile) signal; (I). A CD fitted above a trailer containing mineral lick; (J). Attractant Coathangers fitted to 'shuttles' that serve as feeders for the nutritional attractants.

6. Main trials

6.1 Kimberley – Country Downs Station – Reliable Relocation after fire.

The owners wisely chose to establish a new 'colony' of animals at the unburnt location by forming a mixed group of older cows, heifers and a few bulls. This was likely to have strengthened group behaviour and will lead to the new behaviours perpetuating over time as the animals continue to interact and form new sub-groups over time, and when calves are born in the group/s.

In spite of all the challenges facing the station owners after a devastating fire, they achieved a major breakthrough. They showed that it is possible for cattle to choose to stay in an unburnt area rather than moving out to burnt areas starting to regenerate (Figure 9).

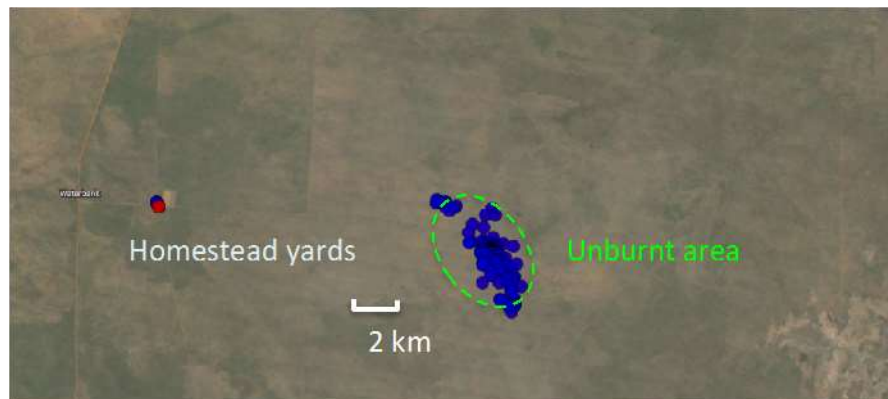


Figure 9. Cattle Movement Post Fire. The GPS location (blue dots) of two cows during the first 3 weeks after relocation to the unburnt area with the new water point. This shows the successful retention of the animals in the targeted area.

Observations and trap camera images confirmed that the application of Rangelands Self Herding methods helped the animals form allegiances as a group that were sufficient to 'over-ride' their previous experiences of grazing in other parts of the property – i.e. the application of the Self Herding created a new home range for these animals.

In the fourth week, as the amount of intervention by the managers declined, one of the animals fitted with a GPS collar moved away from the new area and returned to her original water point. The owners reported that this animal had calved a few days before she moved back to her previous home range, suggesting that (i) the management intervention allowed this cow to be comfortable enough with the new, unfamiliar location to successfully give birth and begin raising her calf and (ii) the desire to return to a previous home range is, at least temporarily, increased by maternal instincts associated with calving. Importantly, the owners subsequently reported that the cow and her calf were later seen at both the new water point and the cow's original home range. So the innovative management expanded the home range of the cow. In addition, the early-life experiences of her calf across of multiple water points and different areas of vegetation mean that the offspring has a broader range of positive experiences that will shape its ongoing behaviour and its capacity to adapt to change.

A broader implication of this work is that livestock grazing patterns can be influenced during periods after fire. This makes it possible for managers to reduce the grazing pressure on areas that are recovering after fire. In addition, land managers can create more mosaics in their landscape by controlling both fire and grazing; i.e. Rangelands Self Herding has the potential to provide a new management option for Pyric Grazing to capitalise on interactions between fire and herbivory.

6.2 Pilbara – De Grey Station – Managed Movement

The intention of this trial was to broaden the grazing distribution away from an area of high utilisation to a relatively unused portion in a large paddock. Figure 10 shows the original area of high utilisation within the large paddock and the intended direction of the Managed Movement.

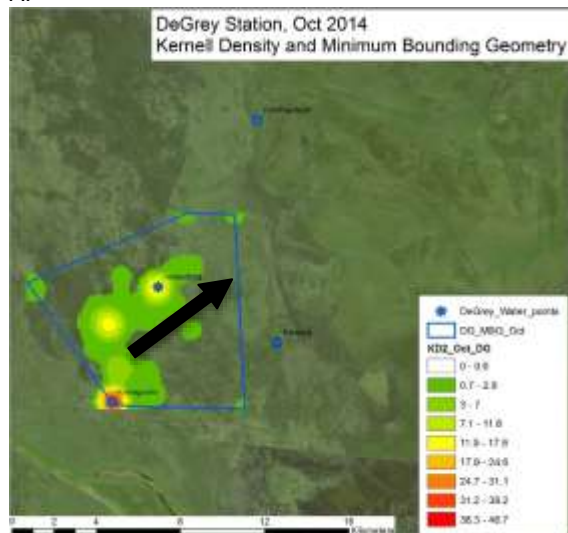
The application of Rangelands Self Herding from mid October to mid December in 2014 expanded the grazing range in the desired direction, as shown in Figure 10. These results were encouraging, especially because it showed the cattle moving out and incorporating new water points into their grazing range, without the need to turn off water to 'force' exploration into new areas. This is very important, especially under the hot conditions that were experienced during this trial because turning off water can be risky if animals do not readily move off to new water points and settle at the new location. An examination of the tracks of individual animals (from GPS data and Taggle® locations) showed marked differences between individuals. Some were more reluctant to leave their original water point, others moved to a new water (aided by the Attractant stations and Jackpot provision) and stayed at the new location for an extended period, whilst a third subset moved to a new water but still occasionally returned to their



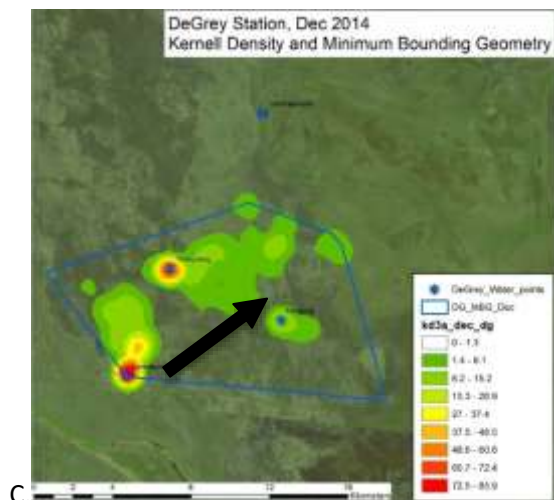
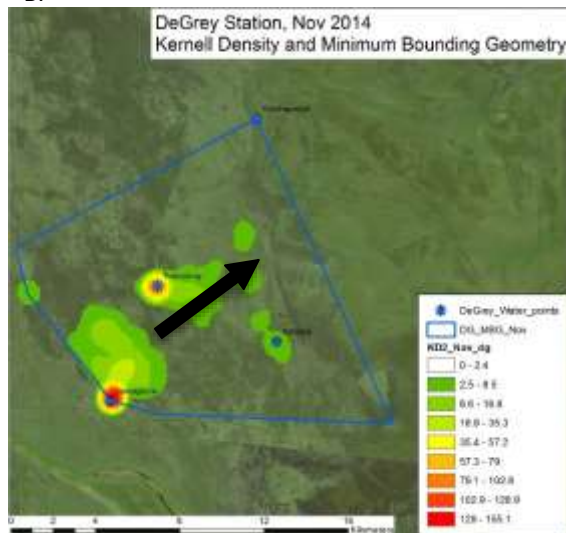
original water point. Rangelands Self Herding allows animals to make these individual choices rather than forcing all animals in a group to behave in the same way.

The Managed Movement in 2014 did not move animals as far as the landholders had intended before the wet season interrupted management interventions because access to the area was restricted and surface water led to the animals dispersing across a wide area. In 2015, the Rangelands Self Herding interventions re-commenced, with modifications to test if the effect could be strengthened. Animals were exposed to Attractants and associated signals (cues) as in the previous year, and the setting on the lick feeder was altered to allow the animals to access more feed pellets, thereby strengthening the nutritional reward for visiting the mobile lick feeder. Additional signals were used, including the use of 'witches hats' (traffic cones) as visual and tactile signals. The Attractants and signals were made familiar to the animals in the yards after they had been mustered and sorted before being taken to the paddock. About one month later, one group of cattle in the area was walked to a new water point using Stress Free Stockmanship. The Attractants and associated signals, which were now very familiar to the animals, were placed near the new water point. The managers reported a high success rate in retaining cattle at the new water; higher than they had previously achieved when they had mustered cattle to a new water point without the use of familiar Attractants and signals. Data on the positional tracking of the animals was not available due to equipment failure with the Taggle® system and GPS collars.

A.



B.



C.



Figure 10. Grazing density distributions and minimum boundary polygons over three successive months with Rangelands Self Herding (Attractant Hopping) used in 2014 to attract cattle in a north-easterly direction away from an area of high utilisation, as indicated by the blue arrow. (A). October 2014; (B). November 2014; (C). December 2014. Note the scale of the maps: the north-eastern boundary of the grazing distribution was extended by about 5 km and cattle visitations to other water points became more frequent during the trial period.

6.3 Gascoyne – Carey Downs Station

The main outcomes at Carey Downs Station were:

- (a) Focussing of grazing around the positioning of mobile lick feeders and Attractant station. This was perhaps most evident to the landholder when two lick feeders at separate locations ceased being used, and two separate mobs of cattle moved from their respective areas into a common 'new' area and water point that was in between the two locations. This showed that the Attractant Stations had been successfully retaining cattle in the vicinity around them.
- (b) An increase in the utilisation of a trap yard and water point that had not previously been used by animals over the seven years since it had been in place (Figure 11).



Figure 11. A trap yard and water point at Carey Downs Station that become well utilised during and after deployment of Rangelands Self Herding procedures.

- (c) A change in the behaviour of livestock, especially in 'cleanskin' (unmarked) cattle around water points and Attractant stations, where animals were much more comfortable in the vicinity of people and trap yards (Figure 12). This led to the successful mustering of some cleanskin bulls that had escaped previous mustering and trapping attempts.





Figure 12. Images of 'cleanskin' bulls that showed marked changes in behaviour following deployment of Rangelands Self Herding procedures, allowing for subsequent successful mustering of these animals.

- (d) Easier gathering of livestock through use of a Jackpot reward paired with the clear and strong audible signal of a whistle. On one occasion, the managers reported that 65 animals out of a mob of 70 in a paddock of several square kilometres came in to a single location when the Jackpot whistle was blown. Such behavioural responses allow gathering of livestock ahead of mustering, or can be used to relieve grazing pressure in parts of the landscape by redirecting animals from one area to another.

7. Supporting Sites

7.1 Yarrie – Reliable Relocation

In the month after the cattle were taken to the new water with familiar Attractants, the group developed a new set of experiences. They chose to stay at the new water point, even though the river was just a few kilometres away. The manager noticed the cattle behaving more as a herd, often grazing out from the water in larger groups. A very different grazing pattern was achieved, with the cattle choosing daily grazing circuits out and back from their 'new home', typically about 5-6 km loops (Figure 13). With this work, the manager did not pair visual, audible or olfactory signals to the Attractant, yet the procedure was still successful. However, the manager subsequently reported that such a positive response has not always occurred in other situations, which suggests that the use of clear signals will often be a necessary component to ensure success. In other words, an Attractant with a signal is a stronger attractant than one without a signal.



Figure 13. Contrasting grazing patterns over one-month periods. The white tracks are of a cow in a mob relocated using Rangelands Self Herding methods. The green track is of another cow in another mob about 1 month later. This second mob were managed conventionally; i.e. taken to the new water, but immediately choosing to return to the river area.

7.2 Lyndon Station and Bullara Station – Accelerated Adaptations

At Bullara Station, cattle were purchased from another property as part of a rebuilding phase as the managers transitioned from sheep to cattle. The management aim was for the new cattle to be placed and retained in a part of the property where no cattle had previously been grazing (only sheep had been in this particular area). In a



procedure similar to that used at Country Downs (Section 2.1), the manager built the familiarisation of the new cattle to nutritional Attractants that were paired with visual and audible signals whilst the animals were in the yards prior to being taken to their allocated paddock. Two animals were fitted with GPS tracking collars, which showed they remained in the area as intended (Figure 14).

The broader implication of this result is that livestock managers can have confidence in relocating animals from one area to another, or one property to another, or indeed one region to another. This provides flexibility in managing stock numbers in response to seasonal conditions or market opportunities.

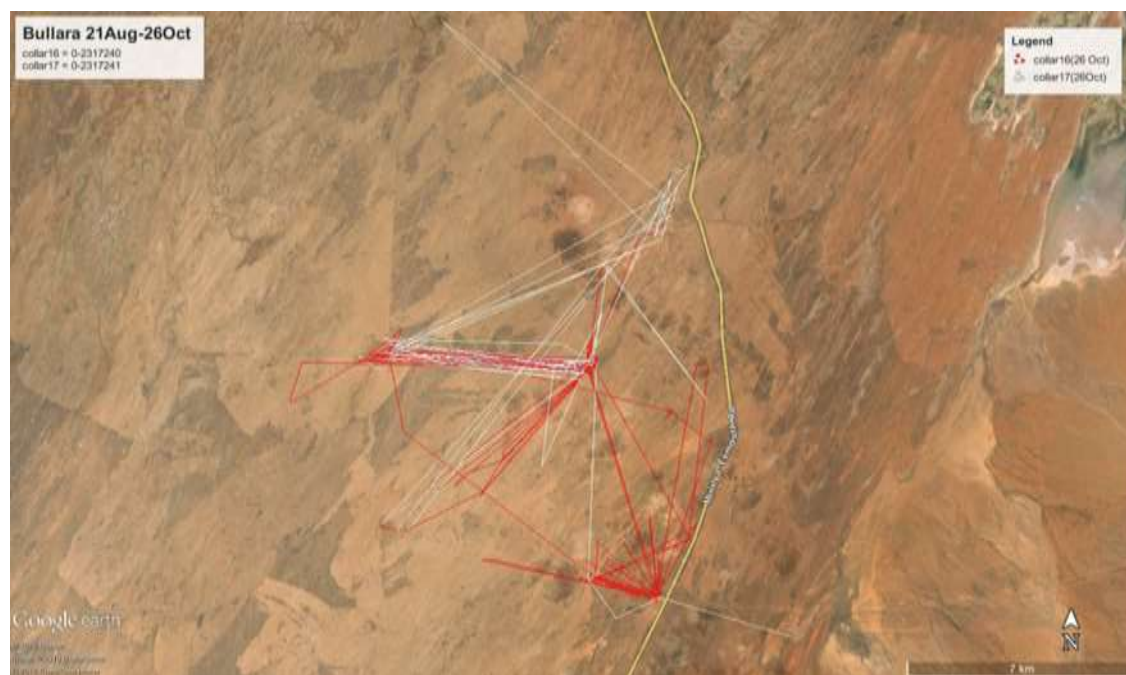


Figure 14. GPS tracking of two animals on Carey Downs. Red and white movement lines of two animals that were part of a mob relocated from one property to another, and successfully retained in the intended area (the yellow line is a highway). The animals used about four water points during the first 3 months after relocation.

On two occasions during this project, cattle were prepared for relocation from the pastoral property Lyndon Station to properties to the agricultural areas of Western Australia. Prior to departure, the cattle were de-stressed using stockmanship, and made familiar with new feeds that were paired with signals (audible - a whistle; olfactory – diluted strawberry flavouring sprayed around feed troughs; and visual – a ‘flag’). When the animals arrived at the farm, the same feedstuffs and signals were provided to them, providing elements of familiarity in an unfamiliar environment. No live weight data were able to be collected during the first month after relocation, but the verbal feedback from the producers receiving the cattle including comments that calmness of the cattle was excellent (better than normal). Further, the cattle did not need to stay in the receival yards for long before they were allowed into their paddock, and the cattle consumed feed and supplements almost immediately after arrival.

The broader implications from this work are that a relatively simple set of procedures can be used to improve the adaptation of animals to relocation, which can increase the confidence of pastoralists to manage stocking rates more flexibly by adjusting stock numbers (either up or down) according to seasonal conditions.

8. Detailed behavioural analyses

Detailed behavioural analyses were conducted for cattle with Taggle® tags at De Grey station during August-November 2014 and June-October 2015. This section outlines the findings from this study.



Initial results suggested that the cattle consistently remained at camping areas between 10 am and 7 pm each day, although tended to arrive 2 or 3 hours later when their night grazing sites were a greater distance from the camp (Figure 15). Data is reported for a single animal in this graph, and shows that this cow used multiple camping areas over several months. Some, but not all of the camping areas were also proximate to water points.

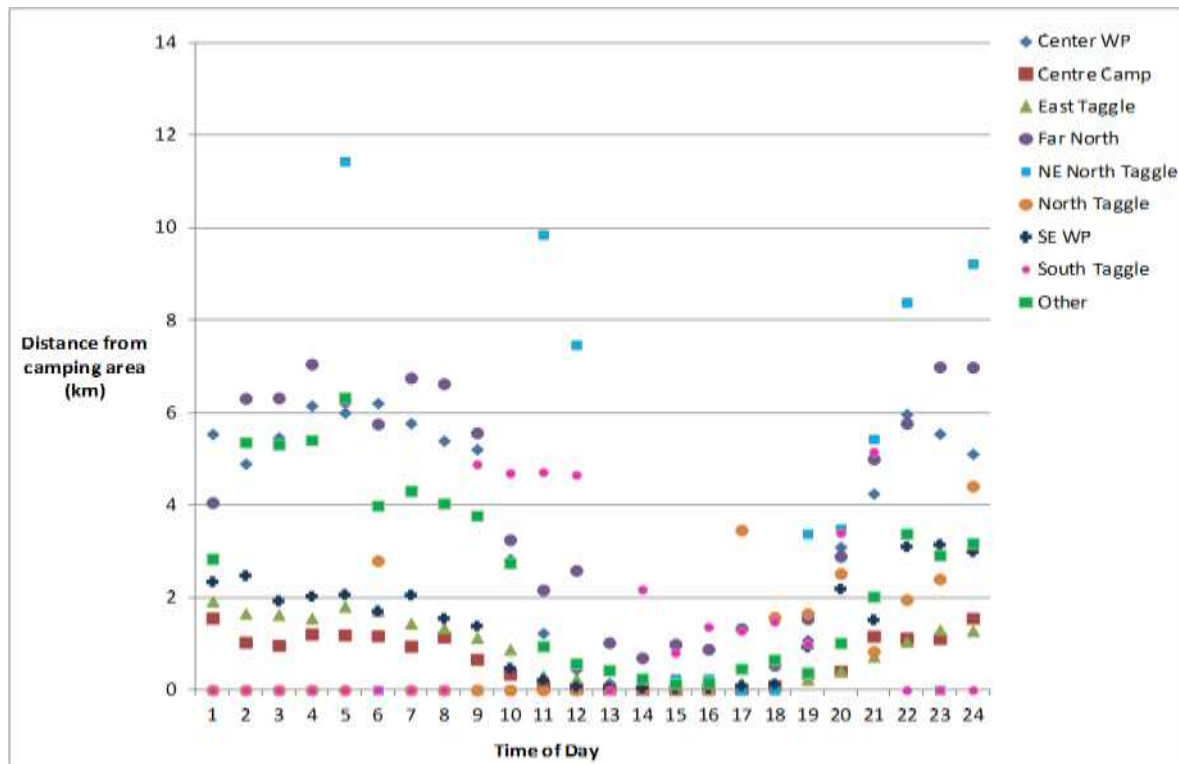


Figure 15. Diurnal pattern of the distance from daily camping areas for a single cow at DeGrey station, in the Pilbara of Western Australia during August to November 2014. Eight main camping sites and a combined average of other sites are reported.

The use of water points by individual animals was variable, with between two and five water points visited by each cow. Correspondingly, there were marked differences in the size and location of the home range of cows (Figure 16).

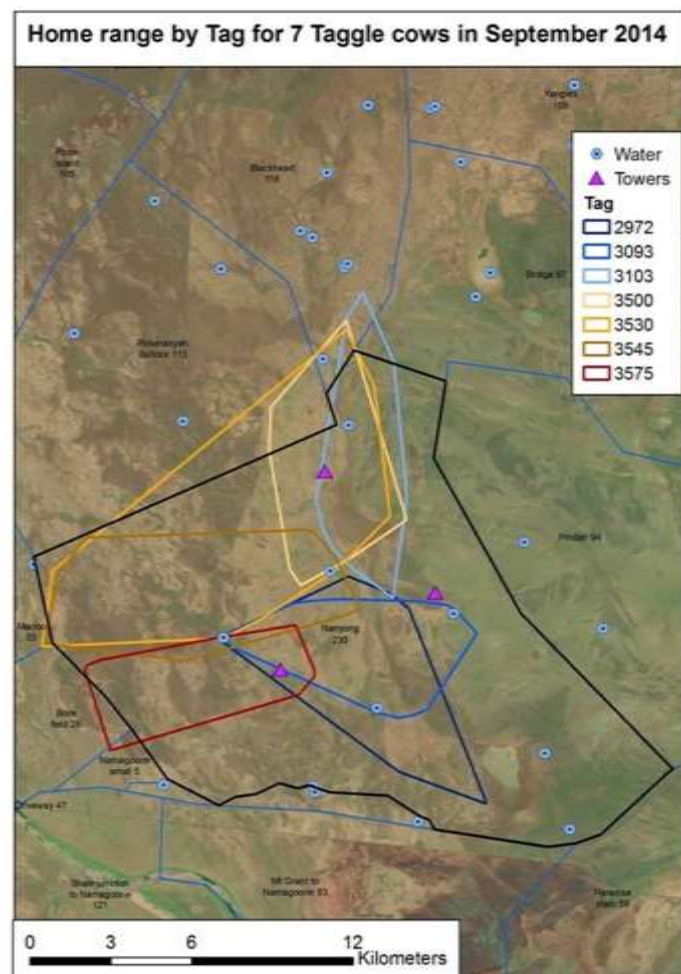


Figure 16. Minimum convex polygon of the home range of individual experimental cattle.

The frequency of returning to water (proportion of days in each month) is reported in Figure 17. This graph illustrates the difference in water point usage between the two seasons. During Spring 2014, cattle returned to water approximately 20 days per month, whereas during Spring 2015, it increased to about 28 days per month (Figure 12). Distance travelled by cattle was 28% higher during 2014 compared with 2015. Cattle reduced daily travel distance by 34% during early summer, compared with winter and spring, which were similar to each other.

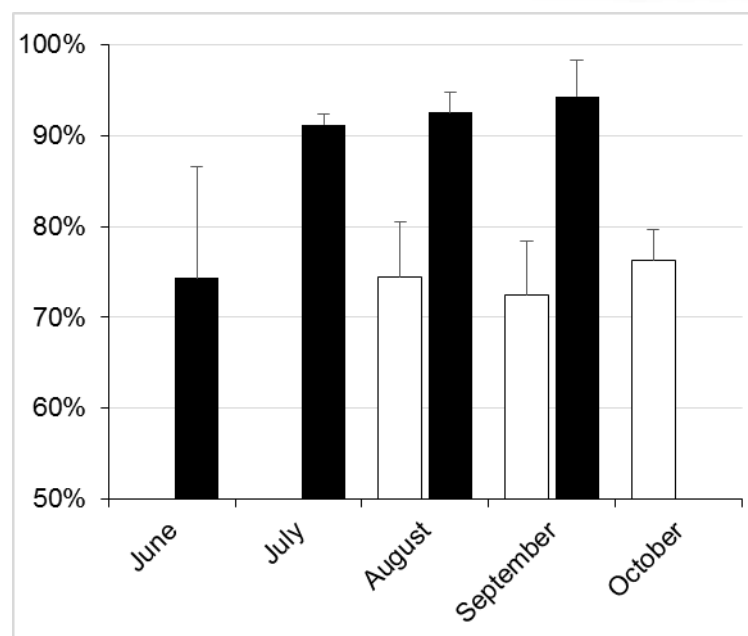


Figure 17. The proportion of days each month that cows returned to a water point, during 2014 (□) and 2015 (■).

DISCUSSION

Significance of findings

General comments

Rangelands Self Herding provides a new approach that deviates from convention by guiding animals via choice rather than exclusion or restriction. It has been developed for pastoralists and livestock managers more generally, and integrates behavioural science, animal nutrition and ecology.

The approach and application of Rangelands Self Herding has major positive implications for environment and industry, beyond the scope of this project. Self Herding and Self Shepherding offer possibilities to address issues that are usually classed as too difficult or too costly to significantly change, such as redistributing livestock grazing pressure, or flexible options to adjust stocking rates through successful relocation or movement of livestock. The importance of the adaptive, locally relevant insights that have arisen from this project will enable many other solutions to emerge if programs such as Self Herding are supported beyond the life of this project.

The immediate payoffs for pastoral enterprises include gaining the benefits of more controlled and intensive grazing without increasing management intensity or infrastructure, improved monitoring and flexibility, and livestock that initiate more exploratory grazing behaviours. Rangelands Self Herding provides practical, low-cost options for pastoralists that are suited to individual needs and local conditions. This is leading to less over- and under-utilisation of areas because animals are influenced to occupy and graze in areas that the manager chooses to impact. Rangelands Self Herding also offers ways to implement year-round musters so that managers can vary their stocking rates as feed availability changes in the highly variable environments of the rangelands. This enables flexible responses to changes in weather, ecosystems, markets, animal welfare and business factors that are not normally possible in pastoral areas.

Implications of behavioural analyses

The value of behavioural phenotyping of cows and bulls for animal selection is supported by this study. There were wide differences between individuals in behaviours such as the frequency of water point visits, number of water



points visited, size of home range and daily distance travelled. These characteristics are likely to have implications for the productivity of cattle and their offspring, and the evenness of use of the agro-ecosystem. Generally speaking, livestock managers prefer animals to utilise grazing areas and vegetation components more evenly to avoid heavy grazing pressure that is known to contribute to poor forage utilisation, reduction of productive species and land areas more susceptible to wind and water erosion.

Marked differences in water point use and distance travelled were found between seasons (2014 and 2015) for cows at De Grey Station. Cows visited water points approximately 8 times less per month during 2014 compared with 2015, suggesting that their water requirements were being met either by increased intake of green forage or greater availability of surface water. If behavioural data is able to be linked with the feed characteristics of rangeland pastures, this could be a useful tool to guide livestock managers' assessment of cattle productivity from season to season, and for different areas of their stations.

The use of devices to monitor animal location yielded some results that would be of use for livestock managers. However, the performance of the tracking systems used was not as good as expected, and these products need to be developed further for either research or commercial applications. The reason for the progressive drop off in positions from the Taggle® tracking system may have been due to accelerated battery discharge and failure, perhaps due to excessive heat, however this was not verified. While the hardware component to capture location data performed below expectations, when the hardware was working well, the wireless networks delivering the captured data to internet-based databases performed well, allowing easy access to project staff to conduct the analysis presented. However, in all studies, useful data was collected from only a small subset of tagged cows. The question of how many cattle need be monitored to provide a reliable estimate of the behaviour of the entire herd remains to be answered. The biggest factor determining the required number of animals that are monitored is the level of dispersion exhibited by the herd at any point in time. Two examples have been reported above where adoption of Self Herding principles (Carey Downs Station, section 5.3.d and Yarrie Station section 6.1) led to increased "herd grazing and herd gathering" behaviour. Re-enforcing these behaviours would require fewer tracking devices per herd. Based on our experience, the animal tracking products were too expensive and unreliable to be considered for routine use in commercial rangeland beef production at this point.

How the research can increase productivity

(i) *Mitigating on a large scale over- and under-utilisation of vegetation, and increasing the total area used for grazing by changing the willingness of livestock to move into new areas*

Despite the large areas of pastoral properties and individual paddocks in the rangelands, livestock frequently restrict their grazing to localised areas around 'preferred area, typically around water points. Consequently, there are large patch grazing effects that limit productivity. In over-used areas, vegetation often does not have the opportunity to recover adequately before being grazed, and plant abundance and diversity is reduced, with direct impacts on feed intake and production. If animals are to be encouraged to explore and use areas that are otherwise under-utilised, it will create opportunities for more rest and recovery of used areas, as well as broadening the diet of livestock and increasing the capacity of animals to meet their nutrient requirements.

This project has shown that grazing patterns can be influenced by the behaviour-based procedures, with the changes occurring very quickly and with minimal extra costs.

(ii) *Reducing the negative animal impacts on fragile ecosystems allowing sustainable grazing for the longer term*

Pastoral livestock production depends on maintaining soil condition, ground cover and a diverse vegetation base to meet the challenges of different seasonal conditions and provide flexible options for managers. Broader, public benefits of good land management extend to biodiversity, carbon, water quality and future food security. Rangelands Self Herding provides opportunities to avoid overgrazing of areas that require longer periods of rest by changing the habitat and diet preferences of livestock.



(iii) Broadening the diet of livestock to increase productivity

When livestock explore and use a wider set of areas, or 'sectors', in the landscape, they are better able to select a diet over time to meet their changing nutrient requirements. Research has shown that this attribute is particularly beneficial during the dry season when average feed quality declines (Fynn 2012). Furthermore, broadening the diet of livestock can reduce the pressure that they place on the most preferred plants, which increases the likelihood that the desirable plants remain in the landscape and increases the use of 'weed' plants or plants threatening to encroach new areas.

(iv) Improving the mating and calving percentages by increased nutrient supply and social interactions between bulls and cows/heifers

Concentrating animals using Rangelands Self Herding procedures provides the opportunity for greater interactions between herd bulls and heifers and cows. This has potential to increase calving rates and tighten calving periods. Also, using Rangelands Self Herding to improve animal nutrition (point (iii) above), or using a mobile lick feeder – e.g. with 'Attractant Leapfrogging' or 'Water Wheeling' to boost the energy or protein intake of heifers has the potential to increase fecundity.

(v) Improving the efficiency of mustering or trapping

By influencing the distribution of animals prior to mustering, and by changing the relationship between people and livestock to a more positive one, Rangelands Self Herding can improve the efficiency of mustering (i.e. a higher proportion of animals collected in a muster) and make the job easier and safer. One of the collaborating pastoralists in the project reported that mustering had become "more gathering than mustering" and also reported an increase in the number of 'cleanskin' animals collected from a difficult-to-muster area. Selling these animals increased income directly, plus improved the management of herd genetics by the removal of micky bulls. Positively changing the behaviour of livestock and improving the interactions between people and livestock have been the most common pieces of feedback received during this project, which has enormous implications to the efficiency, sustainability and profitability of the industry.

(vi) An improved ability to match stocking rate to carrying capacity by creating opportunities for more frequent harvesting of livestock between musters, which can greatly assist in marketing cattle during the year

Opportunities to change stock numbers in between the main mustering times are normally very limited. The use of Rangelands Self Herding procedures such as the Skimmer Box and Reliable Retentions (e.g. building attractions near trap yards) make it possible to adjust stock numbers if and when required.

(vii) Aiding the movement of livestock from one water point to another with minimal risks

When livestock choose to move from one water point to another, or are taken to a new water point, managers have often reported that the animals soon return to their previous home range. To prevent this occurring, it can be tempting to turn off the water at the original location, but this can be risky, especially in hot weather. By using Rangelands Self Herding procedures to attract livestock to areas (including new water points) and increasing the retention of the mob at the new water point – which has been demonstrated on multiple properties during the project – managers can have increased confidence that most animals will build the use of the new water point into their grazing behaviour. It also means that the first water point need not be turned off immediately. This allows individual animals that are slower to change (perhaps due to a stronger affinity to a particular water point) a longer time to transition from one location to the next. If a manager does decide to turn off the first water point (for example to manage total grazing pressure from feral or wild animals in that part of the landscape), the fact that their livestock have had positive experiences with the new area because of the implementation of Rangelands Self Herding, they can be more confident that their livestock will readily adapt to using that new area.

How Rangelands Self Herding can benefit profitability of enterprises and landscape health

The underlying principles of Rangelands Self Herding are designed to provide dual benefits in profitability and natural resource management –both essential elements to a sustainable industry.



Table 2: Benefits to Landholders versus Landscapes

BENEFITS TO LANDHOLDERS	BENEFITS TO LANDSCAPE
Stocking rate adjustments within a production year	As carry capacity fluctuates, livestock impact can be adjusted to mitigate damage
Broader use of the areas within paddocks	Fewer over-grazed patches
More plant growth by enabling rest and recovery periods	Fragile area protection without large financial investment
Adjusting stocking rate to carrying capacity at any time	Erosion reduction
Increased joining percentage by concentrating animals together	Retaining plant diversity by more even grazing
More efficient mustering & removal of cleanskin animals	Responsiveness to variable conditions
Reduced risk of fire removing large areas of vegetation	Doubling the number of landscape mosaics by managing using fire <i>and</i> grazing
Easier and more frequent gathering of livestock to meet market opportunities	Near real-time adjustment of stocking rates to matching feed supply and demand
Increasing animal performance when relocated to new areas, including regional relocation from rangelands to farm land	Flexible grazing pressure when required

Future Needs for Innovation Uptake

Ongoing needs for the potential benefits of Rangelands Self Herding to be more fully realised are:

- Further application of the methods and procedures that have been developed and proved in this program.
- Research to quantify the full benefits – both landscape benefits and improvements in financial performance.
- Social research activities to quantify the benefits for individuals and communities.
- A structured outreach process that can be replicated across all rangelands areas in Australia.

During the conduct of this project, it was identified that:

- Targeting specific issues with individual producers, or small groups of producers, was more effective than group workshops.
- There is a need to maintain ongoing support and extension activities to ensure the success of behaviour-based approaches.
- There is potential to engage local people for specialised training and application of Rangelands Self Herding across properties within a region, as local adaptability and support is critical to successful and ongoing implementation.
- There are good opportunities to linking Rangelands Self Herding to other activities or program such as Ecologically Sustainable Rangeland Management (ESRM) and management of Total Grazing Pressure.



COMMUNICATIONS

Revell, D.K., Maynard, B., Erkelenz P.A., Thomas, DT (2015) 'Rangelands Self Herding' - positively influencing grazing distribution to benefit livestock, landscapes and people. Proceedings of the Australian Rangeland Society Conference, Alice Springs, 12-17 April 2015.

Australian Rangelands Society Conference presentation available online:

<https://www.youtube.com/watch?v=7HZgzOhe9LY&index=9&list=PLrIXhHkpDzd2YupR5m7QI4LXF4nwe0Qj>.

'Changing animal behaviour has many benefits' Farming Ahead magazine article by the Kondinin Group – March 2015, pages 128-129.

Science Network WA - web story on feeding behaviour, based on a journal review paper by Dean Revell, but with reference to Rangelands Self Herding: Livestock feeding review reveals opportunity for better industry practice. <http://www.sciencewa.net.au/topics/agriculture/item/3500-livestock-feeding-review-reveals-opportunity-for-better-industry-practice>.

RM Williams Outback magazine – featured in the article on 'Restoring the Balance – Sustainable Agriculture' (June-July edition 2015)

Articles published on Rangelands NRM website and e-newsletter:

- "Rangelands NRM awarded two Landcare Innovation Grants"
- "Kimberley pastoralists gain a deeper understanding of animal behaviour"

Development and distribution of media release: "International expert visits as part of new rangeland 'self-shepherding' discussions" (4 April 2014)

Publication of newspaper articles in Rural Press (incl. FarmOnline)

- "Training livestock for landscapes", by Matthew Cawood (27 April 2014)
- "Self shepherding stock", by Matthew Cawood (11 June 2014)

Article published on Science Network WA site

- "Directing cattle to graze on dry land" (7 May 2014)

Rangelands Self Herding Newsletters – No's 1-5.

1. Yarrie Station: Reliable relocation away from a river
2. Carey Downs: Improving the efficiency of trap yards
3. Country Downs: Recovery after fire
4. Accelerated Animal Adaptation
5. Remote Monitoring Livestock

Material covered included case studies of the project's trial activities, outlines of how Rangelands Self Herding could be used for multiple benefits and some descriptions of Self Herding procedures.

Website: www.selfherding.com

Self Herding YouTube channel: <https://www.youtube.com/channel/UCpk5r9DfqiFpjkV6MNj15jQ>



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