Stand-off pad wintering system: effect of surface type on cow welfare and behaviour

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Removing cows off pasture to a stand-off area is becoming a common practice in New Zealand to mitigate nitrate leaching, particularly in winter. However, limited data is available on how standoff pad surface materials effect cow's welfare and behaviour. An experiment was conducted over four weeks during winter to investigate the effect of different surface types on dairy cow lying behaviour, cleanliness and lameness scores, social interactions within the herd, cow's intake and utilization and standoff pad temperatures (C^0) and moisture (%). The trial consisted of 250 kiwi-cross pregnant non-lactating dairy cows and were blocked and assigned to three feeding and stand-off treatments: grazed fodder beet in situ and stayed in the paddock for 24 hours (control); fed harvested fodder beet bulb in the paddock for six-seven hours (8:30h-15:00h) then moved to a standoff pad with a surface of woodchip (harvested); grazed fodder beet in situ for six-seven hours (8:30h-15:00h) then moved to a standoff pad with a surface of woodchip (grazed). Surface type had no effect on lying (averaging 10.35 hours/day) with 95.5% of cows lying for more than eight hours and only 0.26% of cows lying for less than five hours. Surface type also had no effect on lameness (average score of 0.06) and cleanliness (average score of 0.96) scores. Current studies show a slight or no effect for surface type on cow welfare and behaviour during winter. The significance of the results could be improved if the study was conducted over a longer period over the winter to reduce inconsistencies.

Keywords: dairy cows; standoff pads; lying behaviour; social interactions; welfare; behaviour

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Chapter 1
Introduction

New Zealand is a pasture based system of ryegrass-white clover pasture. The main issues associated with this, is the inability to grow sufficient pasture during the winter period to meet the daily feed requirements for the cattle. Ryegrass-white clover pastures have a low dry matter (DM) yield during the winter period. Winter growth typically is less than 10kgDM/ha/day (Dalley, unpublished data; www.siddc.org.nz) and for Canterbury it ranges from 0-15kgDM/ha/day (Dairy NZ, 2010). With limited growth it makes pasture based wintering systems an impractical option due to the area of land required to accumulate enough pasture to meet energy requirements (Dairy NZ, 2014; Mandok et al., 2013). Alternative options such as wintering off the platform on brassica forages such as kale and fodder beet with a higher DM yield than pastures, are becoming more a more practiced system in New Zealand (Judson, Dalley, Edwards, Stephens, & Gibbs, 2010).

The aim of drying cows off during the winter period is to regain body condition which has been lost during the lactation period (D. E. Dalley, 2011). Target body condition score for dairy cattle is four and a half at drying off and five at calving (Judson et al., 2010). If targets are achieved, then springer cows (two-three weeks before calving) should be consuming 80% of their energy requirements. This is to avoid metabolic issues such as milk fever and ketosis prior to lactation. With diligent management of feeding stock and monitoring their body condition score, farmers should be able to avoid metabolic disorders and achieve a BCS of five at calving (Dairy NZ, 2014).

Environmental issues are a significant concern during the New Zealand wintering period. This is due to damage occurred throughout the winter period as pasture grazing results in soils becoming waterlogged (particularly Southland), which makes grazing difficult and costly. Through grazing wet soils, the risk of nitrate leaching particularly from nitrogen excretion and urine concentrations (94%) is increased and soil losses into waterways (D. E. Dalley, 2011). Intensification of New Zealand dairy farming has led to increased stocking rates in both the North (at 3.28cows/ha) and South Island (at 3.23cows/ha) (Dairy NZ, 2008). With increased stocking rates this can lead to severe pugging damage and nitrate leaching potential (De Klein, Paton, & Stewart, 2000).
With the rising environmental concerns, farmers are having to implement new ideas to meet the regulations implemented and also remain productive and sustainable. The main wintering strategies, which are being implemented throughout New Zealand, include cows being transported from the milking area to the support area and winter grazed on brassica crop and silage or grazing pasture and silage. Furthermore, farmers are starting to implement standoff pads on their milking platform for

the duration of the wintering period and feed silage. Alternatively dry cows are kept in an indoor facility on or near the milking area for the duration of the wintering period and fed mixed rations (Beukes, Gregorini, Romera, & Dalley, 2011). The standoff pad provides mitigation against leaching potential and protecting pastures, however animal welfare is an issue.

The importance for animal welfare is to ensure that the Five Acts of Freedom, as stated in the Animal Welfare Act (1999) are followed. The Five Freedoms provide a simple yet understandable reasoning of why standoff wintering systems are the potential future of New Zealand dairy farming. In the context of incorporating standoff pads for dairy cows during winter the listed Freedoms 1-4 (National Animal Welfare Advisory Committee, 2010) are of particular interest in the review as fear and distress were not analysed.

1.1 Objectives

The objectives of the trial were to:

- Identify key behavioral activities, which demonstrate how standoff pad surface materials effects cow's welfare and behaviour.
- Assess the animal welfare aspects of the standoff pads and determine if they meet the requirements of the Animal Welfare Act (1999).

Chapter 2

Literature Review

2.1 Animal welfare and the five freedoms

The Animal Welfare Act 1999 (amended in 2015) established welfare obligations for which every person who owns an animal is obliged to follow. The Five Freedoms were created by Brambell (1965) in the UK and have formed a global ritual for modern animal welfare. They are recognised internationally and represent the fundamental requirements of all animals.

The Five Freedoms are used as a guideline for the report, as all aspects of the project have been identified as an act of one or more of the Freedoms. The Five Freedoms are shown below:

1. Freedom from hunger and thirst - by ready access to water and a sufficient diet to maintain full health and vigour.
2. Freedom from discomfort - by providing an appropriate environment including shelter and a comfortable resting area.
3. Freedom from pain, injury and disease - by prevention or rapid diagnosis and treatment.
4. Freedom to express normal behaviour - by providing sufficient space, proper facilities and company of the animal's own kind.
5. Freedom from fear and distress - by ensuring conditions and treatment, which avoids mental suffering (Dairy NZ, 2016b) .

2.2 Freedom from hunger and thirst

2.2.1 Feed requirements

The first freedom is that from hunger. To prevent hunger it is important to understand the nutritive requirements of livestock. These requirements can vary according to their physiological state, external environment and their feed conversion efficiency. The main requirements are energy for maintenance, pregnancy and live weight gain and loss.

Energy is the first limiting nutrient for non-lactating dairy cows to prevent hunger. A dairy cow's energy requirements for maintenance are the sum of requirements to maintain homeothermy and vital physiological processes at a zero energy balance (Mandok et al., 2013), whilst above zero energy balance is used for pregnancy or production. Metabolisable energy (ME) has been adapted as the unit of expressing the energy requirements (Rattray, Brookes, & Nicol, 2007), which is the energy available after digestion, fermentation (methane) and urine (urea) losses. Maintenance energy requirements are based on the state when body composition remains constant, when it does not give rise to any product (such as milk) and does not perform any work on its environment (Rattray et al., 2007). Holmes and Grainger (1982) suggested a figure for maintenance of 0.55MJ ME/kg $W^{0.75}$for dry cows. In New Zealand, seasonal supply farming system dairy cows have an eight-week dry spell prior to calving in spring. During this time, they require energy for maintenance, pregnancy and live weight gain (Rattray et al., 2007).

Energy requirements for pregnancy is influenced by the level of nutrition the animal is given, the faster the animals grow and the faster it reaches maturity (Maynard, 1979). It is also dependent on their physiological factors such as the stage of pregnancy and number of offspring, which can have an effect on their nutritional requirements . Energy metabolism during gestation is influenced by the increase in heat production nearing the end of gestation, this increases the additional energy requirements by the foetus for both maintenance and growth. For each additional mega joule (MJ), only about 0.13 MJME is retained in the foetus (Maynard, 1979). An increase in a cows daily ME requirements prior to birth is just over 1. 0 MJME/kg of the calf birthweight and total cost for the cow's entire pregnancy is about 60 MJME/kg of calf birthweight (Rattray et al., 2007).

Live weight gain (LWG) or loss is related to ME restrictions, as fat and protein in body tissues are mobilized to supply energy for both pregnancy and production. Rattray et al. (2007) suggests that a non- lactating adult cow requires 48 MJME/kg gained feed on a diet of 11 MJME/kg DM. Maintenance, pregnancy and LWG all have influential effects on the cow's requirements for ME. Adequate nutrition and meeting requirements is a challenge faced on many dairy farms (Rattray et al., 2007).

The crude protein is the second limiting nutrient for non-lactating dairy cows. During late gestation dairy cows require a diet with a minimum of 12% crude protein content to meet their requirements for maintenance and pregnancy (Corp, 2015). However, surplus dietary protein is generally excreted in the urine, and can contribute to environmental pollution including nitrate leaching to the ground water and nitrous oxide emission (Waghorn, 2011). Both energy and protein requirements have an influence on the animal's state of hunger, which is an indication of their welfare.

2.2.2 Feed conversion efficiency

Feed conversion efficiency (FCE) has an effect on the animal's ability to meet their energy requirements to prevent hunger. It is a key measure of feeding system efficiency on a dairy farm, as it impacts the feed cost/unit of milk and milk profit.
The NRC (2001) estimates ME requirement for maintenance to be 0.54MJ /kg of body weight $(BW)^{0.75}$ and assuming a net efficiency of use of ME for maintenance (km) to be 0.62. In contrast,

Agriculture research council (1980); Moe and Tyrrell (1972) suggested ME required for maintenance of 0.43 MJ of ME/kg of $BW^{0.75}$. Holmes et al. (2002); Nicol and Brookes (2007) further suggested that requirements are then increased once pregnancy is added up to 0.55-0.58 ME/kg of $BW^{0.75}$ for non-lactating dairy cows, which are similar to Nutrition (2001) recommendations. However, results concluded by Mandok et al. (2013) suggest that cows requirements for maintenance, pregnancy and activity is 1.07 ME/kg of $BW^{0.75}$which is 117 MJ of ME/day. This suggests that current ME recommendations are underestimated for the requirements for zero energy balance by 45%. The reasoning for inconsistent ME requirements is associated with genetic differences in maintenance, as increased milk yield breeds require 20% more ME for maintenance.
Current estimated ME requirements are too low, as supported by Mandok et al. (2013). Estimated ME values have been suggested to increase by 30-45% through good genetics and adequate diets, which meet ME requirements (Mandok et al., 2013).

2.2.3 Winter grazing systems

There are multiple alternative systems to meet cow's nutrient requirements and prevent hunger over the winter period. These systems include conventional grazing, nil grazing and restricted grazing. Through the use of grazing systems most appropriate to the season, it allows for maximum feed intake and reduces the chance of hunger and thirst welfare issues.
As well, appropriate feeding systems must ensure animals maintain their body condition score. Body Condition Score (BCS) provides a qualitative assessment of body fat and production due to its association with lactation (Roche, Kolver, & Kay, 2005). In New Zealand increasing BCS over the winter period possess a number of challenges in the New Zealand environment, as many cows fail to achieve pre-calving BCS targets (Dalley, Verkerk, Geddes, Irwin, & Garnett, 2012). Dairy NZ (2012) suggest that the ideal BCS for pre-calving is 5 for mixed aged cows and 5.5 for first and second calvers. A realistic target for farmers is to aim for 90% of the herd to be at a BCS between 4.5 and 5.5 at calving. Body condition scoring is a useful tool enabling farmers to keep accurate records of their herd's performance and make adjustments to their feeding if required.

Conventional grazing is defined as a typical New Zealand dairy grazing system where pastures are grazed all year round. This is important to our low-cost system that characterizes New Zealand farming (Bryant, Holmes, Lopez-Villalobos, Macdonad, & Brookes, 2003). However, with environmental concerns rising and lack of welfare of the animal's, farmers are having to consider alternative winter grazing options such as nil and restricted grazing.

Nil grazing is defined as a system where cows are kept off paddock and pasture is harvested and fed to animals in housing sheds. Animal excreta is collected and evenly returned to pasture via spreading

(Klein & Ledgard, 2001). Longhurst, Miller, Williams, and Lambourne (2006) suggested two alternative forms of nil grazing, being a combination of feeds pads and standoff pads and have the ability to be used on a 24-hour basis. The other option was a wintering barn which is covered shelter for housed cows, with metal roofs and soft lying surfaces.

The final grazing system is restricted grazing, this is a combination of conventional and nil grazing. From late spring to early summer animals are grazed conventionally and during autumn and winter under a nil grazing regime to reduce the risk of nitrate leaching from urine (Cuttle, Hallard, Daniel, & Scurlock, 1992; Sherwood & Fanning, 1989). Any pasture required in the autumn/winter is harvested and fed to animals, or animals are restricted to grazing times (Klein & Ledgard, 2001). According to Christensen, Hanly, Hedley, and Horne (2010) who conducted a study at Massey University, the strategic use of restricting grazing hours in autumn and winter was able to reduce the deposition of urinary nitrogen in concentrated patches in paddocks. Instead urine was collected when the cows were being stood off. Through the use of duration controlled grazing the trial was able to limit the cows to eight hours per 24-hour period to graze in situ and the remaining hours to be spent on the standoff pad. Jenkinson, Edwards, and Bryant (2014) also found that the rate of fodder beet was 90% utilization for six hours/day grazing. This study was based on non-lactating Friesian x Jersey cows varying in crop allowance (8and 6kgDM of fodder beet/day and grass silage). The grazing behaviour, DM intake and DM utilization were recorded for six hours following the morning crop allocation. After six hours the utilization of the crop was 90% and the total DM intake was 7.2kgDM/cow. Results concluded that high DM crop utilization and DM intake during six hours can be achieved, which allow for the capture of nutrients on standoff pads. Similar results were found by Thompson and Stevens (2012) who suggested cows consumed 4.8kg DM of swedes (which are in the same brassica family as fodder beet) in over five hours. This corresponds to Dobos, Fulkerson, Sinclair, and Hinch (2009) who suggested that cows achieve 70% of a cows daily intake in the first four hours of grazing on perennial ryegrass. Gregorini et al. (2009) also found that cows offered pasture once a day consumed 10kgDM/cow after three hours of grazing. Literature suggests that if cows are well transitioned then they are able to meet their daily intake requirements in a relatively short period of time. With alternative wintering systems farmers are able to meet nutrient requirements and maintain freedom from hunger and thirst.

2.3 Freedom from discomfort

2.3.1 Shelter and freedom from cold

Freedom from discomfort is achieved through an appropriate environment including shelter and a comfortable resting area. As New Zealand can have cold and wet winter periods, the climate can have an effect on the animal’s energy requirements, resulting in poor discomfort in the cold and loss of condition or fatality. Standoff facilities are used to provide animals with an area to rest on. However, the material surface of the standoff facilities is a huge influential factor for the cow's comfort.

2.3.2 Climate effect on energy requirements

The climate can have an effect on the animal's energy requirements and freedom from discomfort for maintenance, pregnancy and live weight gain. A combination of cold temperatures, wind and rain can decrease the effective environmental temperature sensed by an animal to below their ''lower critical temperature''. This is defined as additional heat which the animal generates to maintain body heat, resulting in additional requirements for ME (Rattray et al., 2007).Animals which are well fed (above maintenance) and well insulated are unlikely to experience going below the lower critical temperature in New Zealand. Ruminants have a wider thermoneutral zone than non- ruminants, due to greater capacity to regulate evaporative heat losses, and higher heat increment results from digestion. This is supported by a cow with a 20mm coat over the winter period which has the ability to withstand temperatures up to -20 degrees with wind speeds at 15kmph before reaching their lower critical temperature (Rattray et al., 2007).

Cows typically reduce grazing time and hence energy intake when they are subjected to cold temperatures (Maynard, 1979). However, current literature showed that animals are able to maintain normal physiological state under negative temperatures (up to -20degrees).

2.3.3 Shelter

To prevent freedom from discomfort animals should have access to shelter, particularly in winter. New Zealand is starting to adopt alternative wintering systems such as housing and standoff systems. Shelter is defined as providing means of protection for animals to minimize effects of adverse weather conditions, as animals can develop health problems associated with the expense of adverse weather conditions. Shelter can be provided in a number of ways, including topographical features, trees or shelter hedges, or artificial structures such as standoff pads and wintering barns (National Animal Welfare Advisory Committee, 2010). Dairy cows given shelter from adverse climatic conditions allow less energy to be used maintaining body temperatures, meaning there is more energy allocated to their physiological state (Pow & Longhurst, n.d.). Wolde (2006) demonstrated the use of housing systems versus outdoor systems. The study was completed in Southland to compare brassica wintering systems and inside wintering. Results showed that cows inside, in the second part of winter had lower weight gains/day than outside cows, 1.69 kg/day and 2.78kg/day respectively. However, cows BCS was higher in inside than the outside wintering systems, 4.6 and 4.75 before dry off and 4.9 and 4.8 before calving respectively. It was concluded that cows inside gained condition, whereas outside cows body condition remained the same, as New Zealand dairy cows are exposed to the effects of weather; heat, cold, rain, snow and rain. With the exception of young animals, mature animals are able to meet their nutritional requirements, as they are able to tolerate weather variations well. However, occasions do arise when weather extremes can create welfare risks. Farmers are encouraged to have management plans in place to provide shelter where welfare risks are likely to occur (National Animal Welfare Advisory Committee, 2010).

2.3.4 Resting

The amount of time spent resting by dairy cows is a significant contributor to dairy cows comfort and welfare (Fisher, Stewart, Verkerk, Morrow, & Matthews, 2003). If the cow is unable to rest for at least eight hours/day, then she is at risk of not meeting her daily feed intake requirements and becoming more susceptible to injury and disease. This is associated with the animal's health and comfort, which is an influential factor for the cow's overall production. Krohn and Munksgaard (1993); Dairy NZ (2014); Fisher et al. (2003) all agree that dairy cows typically will spend nine-twelve hours/day lying and a preference to lie for at least eight hours/day in a typical wintering system on crops. To do this there must be enough space and the surface must be appropriate and if not, then the lying time is likely to be significantly reduced and results in cows lying once they are returned to crop, instead of grazing, which results in underfeeding (Dairy NZ, 2014; Fisher et al., 2003).

The effect of surface materials from either the paddock or from standoff pads has an effect on the cow's freedom from discomfort. D. E. Dalley and Geddes (2012) suggests that the most comfortable surface for cows to lie on is sawdust and woodchips, which provide a soft surface for lying . Haley, De Passille, and Rushen (2001); Fisher, Verkerk, Morrow, and Matthews (2002) then go onto to suggest that hard surfaces such as concrete or muddy conditions tend to reduce the cows lying time. Stewart, Fisher, Verkerk, and Matthews (2002) found that the use of different materials for standoff pads on 18 commercial dairy farms in Southland and the Waikato affected cows standing time. Nine farms in Southland and nine in Waikato, with a total of 216 pregnant Holstein Frisian cows (12 cows/farm) were observed two-three weeks before calving. In Southland, there were three farms that used three covered sawdust pads, uncovered sawdust pads and three winter crops to keep cows off pasture. On both the covered and uncovered sawdust pads, the cows were stood off for 24 hours for four-five months from late autumn to early spring and were fed on adjoining concrete feed pads where they were feed ad libitum silage. The three winter crop farms remained on crop for the duration of winter. In Waikato there were three farms with concrete pads, three with woodchip pads and three with farm races used as a standoff for cows. On average, for the Waikato farms the cows were stood off pastures for 18 hours/day and let out to graze for an average of six hours/day. It was reported that most cows on the Waikato farms spent longer lying down per day on the woodchip pads than concrete pads. The total average lying times for all the on-farm observations in Waikato and Southland are demonstrated in Table 1. The average lying time was 11.3 hours/day on the woodchip pads, for cows from the Waikato farms, which is similar to studies by Singh, Ward, Lautenbach, Hughes, and Murray (1993) who recorded 10.3 hours/day for cows on pasture (exclusive of the Waikato trial). The lying times were recorded for the concrete pads and farm races used as standoffs, were shown to be considerably below the required minimum lying time of eight hours, suggesting that resting on these materials are suboptimal. Southland cows lying on the covered and uncovered sawdust pads and crops were all similar to lying times on the woodchip pads in the Waikato. Cows on crop were observed to lie near the crop as it was less muddy and more comfortable (Stewart et al., 2002). The on farm observations are consistent with previous findings by Fisher et al. (2002) which found that cows spent longer laying on a woodchip pad (11.9 hours/day) than they did on concrete yards (7 hours/day), race (5.7 hours/day) or a muddy sacrifice (stood off on a paddock for wet periods and then returned back to normal grazing on the milking platform) paddock (6.9 hours/day).

Overall results from the on farm observations in Southland and the Waikato suggested that lying times for cows on concrete or races were suboptimal, and crop and woodchip/sawdust allowed for better opportunities to rest. Concrete or races may be more suitable if they are used in a combination with other systems, such as woodchip standoff pads (Stewart et al., 2002).

Table 1: The effects of surface type on cow lying behaviour in Waikato (A) and Southland (B) (Stewart et al., 2002)

Stand-off Farm type		Total Lying (hrs)				
		Mean	Min	Max	Overall mean	Pooled s.e.d.
A. Waikato						
Woodchip	**1**	11.47	10.7	12.2		
	2	10.40	8.8	11.7		
	3	12.13	11.2	13.7		
					11.33[a]	
Concrete	**4**	1.85	0.2	5.5		
	5	0.07	0.0	0.5		
	6	5.40	2.0	8.7		
					2.44[b]	
Race	**7**	0.60	0.0	2.7		
	8	2.24	1.3	4.8		
	9	9.39	5.8	11.8		
					4.07[b]	**2.58**
B. Southland						
Covered sawdust pad	**1**	7.86	4.0	14.8		
	2	11.14	6.3	15.3		
	3	11.47	5.7	16.7		
					10.16	
Uncovered sawdust pad	**4**	11.04	9.2	12.5		
	5	12.71	10.0	15.0		
	6	10.68	6.5	13.7		
					11.48	
Crops	**7**	11.67	10.5	14.2		
	8	11.30	9.8	13.3		
	9	10.53	8.3	13.2		
					11.17	**1.10**

The ability for a cow to comfortably lie down for at least eight hours/day is of high importance. Comfortable bedding or lying surface needs to be substantial enough for the cow to easily lie down for this required time.

Another factor effecting cows lying times are associated with stocking density and the minimum area required for a cow to be deemed comfortable in a confined space. To do this, there must be enough space and the surface must be appropriate. Farming systems where cows graze for a few hours before being returned to a standoff area for the rest of the day, have previously failed to supply cows with enough space and proper surface to lie down on the standoff pad. This may result in cows compensating by resting in the paddock, instead of grazing during feeding time and hence underfeeding (Dairy NZ, 2014; Fisher et al., 2003).

Not suppling adequate lying areas can have an impact on cows meeting nutrient requirements, lying time and overall animal welfare (Dexcel, 2005), suggesting a minimum stocking density of $5m^2$, if cows are only on pads for 12 hrs/day. Any longer than 3 days on pads, the recommended area increased up to $8m^2$(Dexcel, 2005) . Dalley et al. (2012)also demonstrated the effect of area/cow and lying surface material on six commercial dairy farms across Southland and Otago and have been monitored since 2010. There were two systems; pasture and crop and off grazing wintering systems as demonstrated in Table 2. Results concluded that there was a clear relationship in off grazing systems, as the area/cow increased so did the lying times. The area/cow in the barn systems were generally less than those on crops, pasture and wintering pads, hence the pasture system achieved the highest lying time. Cows which were in the herd home spent less time lying and had the largest proportion of cows which failed to reach their minimum of eight hours lying target. All wintering systems with the given area (m^2/cow) as shown in Table 2, met the industry recommendations of an average of eight hours lying time. For the wintering pads, pasture and swede grazing systems, all individual cows reached the industry targets.

Table 2: Effect of lying surface and area/cow on their total lying time (hour/day) in Southland and South Otago winter 2011 (Dalley et al. 2012)

			Indicator		
Wintering system	**Lying surface type**	**Area per cow (m^2/cow)**	**Average lying time (h/cow/day) (Mean ± SD)**	**Less than 8 h lying (% cows)**	**Short-duration lying bouts (number/day) (Mean ± SD)**
Off-grazing:					
Herd Home™	Slatted concrete	3.7	8.0 ± 2.2	63	0.6 ± 0.5
Loose house barn	Sawdust	5.2	8.5 ± 1.6	37	5.0 ± 3.5
Free stall barn	Rubber matting	8.0	9.7 ± 2.0	10	0.1 ± 0.3
Wintering pad	Bark chips	12.0	11.2 ± 1.2	0	0.5 ± 0.4
Grazing:					
Crop (kale)	Soil		8.1 ± 0.8	57	3.0 ± 5.5
Crop (swedes 1)	Soil		9.6 ± 1.1	0	3.4 ± 4.0
Crop (fodderbeet)	Soil		9.8 ± 1.4	11	3.2 ± 3.1
Crop (swedes 2)	Soil		10.5 ± 1.4	0	2.5 ± 2.6
Pasture	Pasture		11.9 ± 0.5	0	0.5 ± 0.3

Both stocking density and lying surfaces are important factors which can have a significant influence on the cow's comfort and resting ability within a range of wintering systems. (Dalley et al., 2012). Typically, the more space the cows have the more opportunity for them to rest.

2.4 Freedom from pain and discomfort

2.4.1 Lameness

Lameness is one of the major health problems associated with standoff pads (Stewart et al., 2002). Poor cow comfort has been associated with lameness, which is in general an indication of poor management. Untreated serve lameness can affect a cows resting time, walking and feeding behaviour, resulting in loss of production (Green, Hedges, Schukken, Blowey, & Packington, 2002; Hernandez-Mendo, von Keyserlingk, Veira, & Weary, 2007; Warnick, Janssen, Guard, & Gröhn, 2001) and a negative impact on reproduction performance (Garbarino, Hernandez, Shearer, Risco, & Thatcher, 2004; Hernandez-Mendo et al., 2007). The major risks associated with lameness is cow comfort, cows diet and the overall management of farmers in preventing lameness. Poor cow comfort with minimal lying time, uncomfortable lying surfaces and inadequate walking surfaces, can lead to sole and heel ulcers, laminitis and hock damage/swelling. Cows with poor hygiene resulting from slurry and poor biosecurity leads to digital dermatitis, heel erosion and other infectious causes of lameness. Poor diet can increase a cow's chance of ruminal acidosis and macro and micro deficiencies, resulting in white line disease. With correct management of cow's feet, by providing adequate cow comfort, dry environments and required nutrient requirements and feet trimming if required, lameness is significantly reduced and more evenly balances the weight load on the lateral and medial claw, reducing lameness(Christoph et al., 2006).

The prevalence of lameness is increased by poor hygiene as a result of infections. The cleanliness of the cow is a good indicator for hygiene, and dry feet tends to reduce lameness as there is less chance for bacteria to invade tissues. Wet conditions, on the other hand, soften the horn and weaken or disrupt the skin barrier allowing bacteria to enter (Christoph et al., 2006).

A recent study in a Northland dairy farm by Wynn, Adams, McGowan, and Verkerk (2011), investigated the effect of surface management on cows lameness score, including two treatments of post peelings (type of woodchip) standoff pads, which were either aerated or not aerated over a six-week period, and observed the overall cow welfare. Measurements for lameness showed that <2.2% of cows were lame across both treatments. The only difference between the treatments was slightly higher lying bouts on the aerated standoff pads.

However, Chesterton, Pfeiffer, Morris, and Tanner (1989) found that lameness prevalence was a lot more common in dairy herds. A case control study on 62 dairy cows in an average herd of 185 milking cows in Taranaki, New Zealand demonstrated the occurrence of lameness on dairy farms during the milking season and also the carry over effects from previous years. There were 32 cases identified, indicating at least 10% of cow's lame during the milking season and 3% lame for at least two years prior to the investigation. Chesterton et al. (1989) also indicated that there is a significant increase in lameness prevalence in housed animals versus pasture based animals, with Webster (1987) suggesting it increases the probability of lameness up to 25%. In comparison, prevalence of lameness in Australian studies by Harris et al. (1988) suggested lameness occurrence within the herd was up to 7.5%. Dewes (1978), then goes on to explain that there is a prevalence for New Zealand dairy cattle to reach 14% lameness within the herd. This has a significant effect on the economic losses to the New Zealand Dairy industry.

Gait length is also effected by lameness and hygiene. Fisher et al. (2002) showed a greater reduction in the gait length for cows on concrete standoff pads (0.07m) than cows on woodchip (0m), laneway standoffs (0m) and small paddock standoffs (0.01m). This suggests that cows tend to reduce their gait length as they become lame under uncomfortable surfaces.

Minimising lameness can result in greater productivity and overall well-being of the animal. This could be achieved through rapid diagnosis and treatment and providing adequate bedding material when a stand-off pad farming system is used.

2.5 Freedom to express normal behaviour

2.5.1 Monitoring devices used to record cows behaviour

The changes of animal behaviour are a good indicator of animal discomfort and expressing their normal behaviour. There are devices such as accelerometer technology, which allow 24 hour monitoring, recording and reporting of cow activity. Thus, lying, standing, and stepping behaviour (step counts) can be monitored to measure animal comfort and welfare. This could be done by using the Icetag activity monitor (McGowan, Burke, & Jago, 2007) (IceRobitics, Scotland). The device can be strapped to the cow's back leg just above the hoof, and data will be stored and downloaded onto the IceTagAnalyser software on a computer. The activity monitors have huge potential to enhance research for measuring the behaviour of animals continuously, automatically and without human interference. It is important, as lying and locomotion of animals is an important indicator of animal welfare in dairy cows. (McGowan et al., 2007)

2.5.2 Social interactions

Social interactions are related to key concerns on whether or not animals are able to live a relatively natural life and express natural behaviour (Von Keyserlingk, Rushen, De passillé, & Weary, 2009). Social interactions between the animals has shown to affect their ability to lie down for the required time (eight hours) due to dominance effects from cows that were restricted in space in the wintering stalls (would also apply to standoff pads). Dominant cows may inhibit submissive cows from eating in bunks or feed pads, drinking water or lying down as standoff pads or wintering barns/stalls can effect cow's social interactions through confined spaces and inadequate bedding such as hard surfaces and moist conditions. Limited space can result in aggressive behaviour amongst cattle. If space is limited, cows will often meet each other at very close range with limited escape options. Fresh cows, heifers or newly moved cows into the herd, are often in the submissive group. Social interactions tend to be more frequent when in narrow spaces or alleys where they have difficulty passing other cows (DeLaval Milk Production, 2007). The effect of social interactions is similar to Hussein (2016) who demonstrated different stocking rates and herd size for 252 spring calving Frisian x Jersey cows grazing perennial ryegrass and observed for three months' early lactation to determine their dominance values (DV). Cows on low stocking rate (LSR), medium stocking rate(MSR) and high stocking rate (HSR), had DV scores of 40.7, 50.3 and 43.9 respectively. The interactions/cow were 10, 3, and 14 respectively. The total interactions were 297, 589 and 475 respectively. Social dominance was suggested to be positively related to age and size of animals such as BCS and LW (Phillips & Rind, 2002; Schein & Fohrman, 1955b; Sołtysiak & Nogalski, 2010). Dickson, Barr, Johnson, and Wieckert (1970); Guhl and Atkeson (1959); Potter and Broom (1987) all suggested that confined spaces in indoor feeding systems have an effect on cows social interactions. Hussein, Al-Marashdeh, Bryant, and Edwards (2016) further explained in relation to the different stocking rates, the smaller the group, the fewer social interactions between cows in larger MSR groups, as it could be due to lack of recognition between group mates, which ends in relationship breakdown and aggressive behaviour. Hussein et al. (2016) also found that larger groups resulted in fewer interactions which is in agreement with (Lindberg & Nicol, 1996) who claimed that larger groups lead to fewer interactions. Social interactions in confined areas such as the wintering barns and standoff pads can effect cows comfort and natural behaviour, through dominant cows restricting submissive cows from lying and exhibiting normal behaviour.

2.6 Conclusion

The main purpose for using standoff pads in New Zealand is to reduce soil pugging and nitrate leaching to the ground water. The New Zealand dairy industry is exploring a range of standoff surface materials in order to identify low cost materials and to meet animal welfare requirements. Current literature suggests that cow welfare is determined by the Five Acts of Freedom from the Animal Welfare Act (1999). Freedom from hunger was recognised as animals meeting their nutrient requirements at their physiological state, how efficiently they are able to metabolise energy and the means of alternative wintering systems, which allow for the most appropriate wintering system. Freedom from discomfort is perceived through the materials of the standoff pads and how they affect the cows behaviour, which appear to have a large influence on their lying ability and was suggested that cows were required to have at least eight hours resting otherwise that had an effect on their state of welfare (Dairy NZ, 2014; Fisher et al., 2003; Krohn & Munksgaard, 1993). Lameness was found to be the number one issue associated with freedom from pain, injury and discomfort. Current literature suggests that lameness can have adverse effects on the cow's performance and productivity, also implied that the surface material of the pads was highly prominent with regard to the cause of lameness in dairy cattle. Finally, the ability to express normal behaviour was determined by the lying behaviour, which was suggested that cows were required to have at least eight hours resting, otherwise this had an effect on their welfare. Social interactions between the animals was also apparent to show their ability to lie down for the required time, due to dominance effects from cows that were restricted in the pads due to discomfort. Overall standoff facilities are an applicable option for dairy farmers wanting to mitigate against nitrate leaching and maintain required animal welfare standards.

Chapter 3

Materials and Methods

3.1 Experimental Site and location

The experiment was conducted with the approval of the Lincoln University Animal Ethics Committee. The forage crops and standoff facilities were located on the Lincoln University Ashely Dene dairy farm (-43.395 degrees East, 172.21 degrees North) on Lismore/ Balmoral shallow stony loam soil structure (Landcare Research, 2013). The experimental design was a parallel group design comparing three treatment wintering regimes. Treatment one cows stayed in the paddock for 24 hours and grazed fodder beet whole crop (control). Treatment two cows stayed on a woodchip stand-off for 17 hours and were offered harvested fodder beet bulb in the paddock (woodchip harvested). Treatment three cows stayed on a woodchip stand-off for 17 hours and grazed fodder beet in situ crop (woodchip grazed). A farm map is shown (appendix A) to show where the groups were located. Two hundred and twenty five kiwi-cross, pregnant, dry cows were ranked according to calving date (8th August) and live weight and randomly allocated to one of the three treatments. Each group was offered 8 kg DM fodder beet and 4 kg DM of Lucerne and barley baleage/cow/day.

Photograph 1: Woodchip (pulled) and eating fodder beet (10:00h)

3.2 Management of animals

All cows were transitioned onto fodder beet crops from the 1st of June 2016 by slowly increasing the allocation of fodder beet over two weeks. Construction of the stand-off areas delayed commencement of the experiment until the 10th of July 2016. Cows were transitioned onto the stand-off areas for five days.

Cows were moved between the standoff pad and paddock, where they received supplement (08.30 h) followed by crop (10.00h) and returned to the standoff pads (15.00h). The area per cow on the stand-off pad was the same each day ($10m^2$/cow), in line with the recommended 8-$10m^2$ /cow for wintering pads with no on-off grazing (Dairy NZ, 2014), while the area in the paddock was increased each day by 1-$2m^2$/cow. Total area of each paddock for the three treatments were 5.98ha (control), 1.99ha (woodchop harvested) and 2.99ha (woodchip grazed). By the 10th of July the paddock area was equivalent to 1-2 m2/cow in all treatments. Cows walked between 100-800m/day return to the standoff pad. Water was available ad lib from trough's in paddocks and stand-off. As treatment cows commenced calving (8th August), allocation area's and stand-off areas were adjusted to maintain a constant allocation for the duration of the trial.

3.3 Crop Measurements

3.3.1 Intake pre and post grazing

Pre grazing herbage mass (kgDM/ha) was for each crop determined (fodder beet crops 10 times between 6th May- 28th August). Total fresh weight of all crop material (fodder beet bulb pulled and leaf separately weighed) contained in three metre drill row lengths of fodder beet, and recorded in the field. A sub-sample of two plants (fodder beet plant) per replicate were split into leaf or bulb and were diced and crushed through a blender - leaves were washed and placed in paper bags. Samples were then force draft dried (Conthem Thermotec 2000 standard oven) at 65^0C to constant weight for DM percentage.

The Utilization percentage of each fodder beet crop and supplement received by cows was determined (27th July and 2nd August). Total fresh weight of fodder beet (after grazing) contained in six randomly positioned quadrats ($1m^2$) was recorded in the field.

Total fresh weight of barley and lucerne supplement (before and after eating) was also measured in six randomly positioned quadrats ($1m^2$) along the fence line and marked with spray paint to identify where the samples were taken. Subsamples of the fodder beet and supplement were collected to be force draft dried (Conthem Thermotec 2000 standard oven) at 65^0C to constant weight for DM percentage.

Photograph 2: Woodchip (grazed) grazing fodder beet (10:00h)

3.3.2 Nutritive value

For the NIRS, after the sample (fodder beet bulb) was dried it was ground into fine particles (<1mm) and was scanned to find nutritive value. The same process was duplicated for the leaf. This yield information was used to calculate break size for each paddock and therefore DM and nutritive value of the cow's dietary intake.

A large handful of supplement (lucerne and barley silage) was taken at each time of sampling to determine DW, DM and NIRS. For DW, the silage sample was cleaned and weighed. It was then dried in the oven for 24-48 hours and reweighed for DW and DM determination. The sample was then ground into particles (<1mm) and was scanned to determine NIRS.

Photograph 3: Fodder beet bulb being prepared for blending and oven drying

3.4 Animal Measurements

3.4.1 Lying time

Prior to the behavioural trial, all cows were fitted with an AfiAct pedometer above their rear fetlock joint for the duration of the trial (see AEC 598 R for a further description of these methods). Information on lying time, lying bouts, standing, and cumulative steps were sent every minute (if cows were within range of the data storage box), otherwise accumulated and transferred once cows were in range. Data was collected daily and analysed through a software programme , which generated total lying times per cow, lying bouts, standing time and steps. The percentage of cows lying <five hours, >than five hours but <eight hours and >eight hours was also found.

Pedometers were required to be validated against visual observations, similar to Borchers, Chang, Tsai, Wadsworth, and Bewley (2016) data. Ten cows were picked at random to visually observe their lying and walking behaviour for two hours, twice per day, for five consecutive days prior to the trial. Observations were recorded every five minutes. Visual lying times were compared with the pedometer lying times and graphed to produce a R^2 correlation (R^2.96), which was similar to Borchers et al. (2016) data.

3.4.2 Social Interactions

Social interactions were recorded based on the master chart, which was provided by (Schein & Fohrman, 1955a). Observation occurred twice a day on the paddock (8:30h) and the standoff pad (15:00h) for two hours each. Observation included bunting, pushing, mounting and allogrooming. Behaviours were allocated points, from bunting being four to allogrooming being one. Bunting interactions included any physical contact with the head to another cow implying force. Pushing interactions was when cows would purposely push another cow to get to feed or just walking past. Mounting interactions was seen through cows mounting one another. Allogrooming interactions were shown through signs of affection such as licking and gentle rubbing. Cows initiating the interaction won and opposing cows lost, allowing a dominance value for each individual cow that was observed.

3.4.3 Lameness

Lameness scores were randomly allocated to 25 individual cows in each treatment (twice a week, for the three-week trial). Cows lameness was determined by a scoring range from 0-3 (Dairy NZ, 2016a). Cows were recorded when walking down the track to paddock or from supplement to crop.
Lameness scoring explained:

Lameness score 0, this cow is walking evenly, and no action is required. Lameness score 1 is a result of not walking evenly, minor action is required. Lameness score 2, cow is lame and action is required. This cow is lame and needs to be recorded, drafted and examined within 48 hours.
Lameness score 3, this cow is very lame. Urgent action is required, cow should be drafted and examined as soon as possible within 24 hours and may require a vet (Dairy NZ, 2016a).

3.4.4 Cow cleanliness

Cow cleanliness was determined through the Dairy NZ hygiene scoring chart. The scoring ranged from 0-2 (as seen in Appendix b).
Cows with a score of zero had no dirt or less than 10% (a hand size) is splashed with fresh or dry material.
Cows with a score of one have at least a hand-sized area of dirt, but less than 50% of the area is dirty.
Cows with a score of two have more than 50% of their body as very dirty and hair is difficult to see. The tail may have significant dags.
The hygiene scoring enables farmers to estimate the current cleanliness of a herd and the standoff facilities. Most cows should ideally be between zero or one. If there is more than 20% of cows scoring two, then they may be at greater risks of animal health issues and milk quality issues.

Photograph 4: Woodchip (pulled) on fresh woodchips

3.5 Standoff pad measurements

Standoff pad temperatures (C^0) moisture (%) and relative humidity (%) were recorded daily (8:00h) with a moisture-testing device (FLIR MR77). Weather was recorded as well as relative humidity of air and air temperature. Standoff pads were tested for ground temperature (C^0), moisture (%) and relative humidity (%) (in a 10cm hole) in three random location on the pad (three on occupied and three on non-occupied woodchip pads). All measurements on the control were also taken, excluding the relative humidity. All data was recorded and transferred to excel.

Photograph 5: Cows first encounter on the woodchip standoff pads

Photograph 6: Comparison of occupied and non-occupied woodchip pads during a frost

3.6 Statistical Analysis

Materials (control, woodchip harvested and woodchip grazed) were considered treatments and cows as replicates for the trials. Animal behaviour observations, lying time, lameness, hygiene and social interactions were analysed with the general analysis of variance (ANOVA) (GenStat 16.0 VSN International LTD., 2014). All data was transformed to become normalised. A least significant difference test was used to identify differences amongst means when ANOVA was significant.

Chapter 4

Results

4.1 Climate

Rainfall and air temperature prior to the study and for the duration of the study, June and July 2016. The average monthly rainfall and temperature is shown in Figure 1.

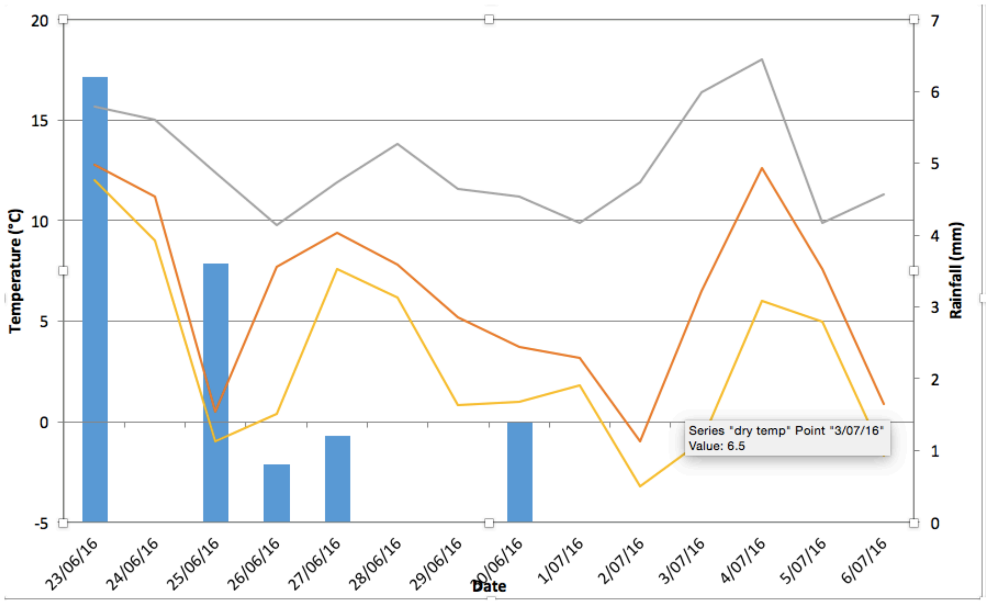


Figure 1: Average daily: maximum (grey line), mean (orange line), and minimum (yellow line) air temperatures (0C) and total rainfall (blue bars) (mm). Figure is calculated from June to July 2016, from the Lincoln, Broadfields weather station (-(43.630N, and 172.47^{0} E) 11.2km from Ashely Dene Main Block (NiWa, 2007)

4.2 Intake pre and post grazing

Total intake for pre and post grazing and utilization rates (shown in Table 3) were not statistically analysed due to minimal data collected. Cows on the control treatment consumed an average intake/cow of 7.00kgDM/day of fodder beet and 6.15kgDM/day of lucerne and barely supplement. Cows on the woodchip (grazed) consumed an average intake/cow of 6.26kgDM/day of fodder beet and 3.12kgDM/day of lucerne and barley supplement. Cows on the woodchip (harvested) consumed an average intake/cow of 7kgDM/day of fodder beet and 5.3kgDM/day of lucerne and barely supplement. All treatments had relatively high utilization rates for fodder beet and lucerne and barley silage; control (100%, 98%), woodchip harvested (100%, 100%) and woodchip grazed (92%, 71%) respectively.

Table 3: Pre mass (t/ha), post mass (t/ha), utilization (%) and intake (kgDM/cow) values for fodder beet and lucerne and barley supplement

Utilization and intake values	Week 2 (02/08/2016)		
	Control	Woodchip Harvested	Woodchip Grazed
Pre grazing mass (tDM/ha)	17.5	-	17.8
Post grazing mass (tDM/ha)	0.01	-	1.47
Utilization of crop (%)	100%	100%	92%
Intake of crop kgDM/cow	7.0	7.00	6.26
Intake of supplement kgDM/cow/day	6.1	5.3	3.1
Utilization of supplement (%)	98%	100%	71%
Amount offered of crop kgDM/cow/day	-	364.0	-
Amount refused of crop kgDM/cow/day	-	0.12	-

Total nutritive values for the fodder beet and lucerne and barely supplement (Table 4) were not statistically analysed. Cows were given an average ME value in 12.5MJME/kg/cow/day of fodder beet and 8.2 MJME/kg/cow/day of the lucerne and 10.8MJME/kg/cow/day of barely supplement. This equated to a total of 87.5MJME/cow/day of fodder beet, 41.0MJME/cow/day of lucerne and 32.5MJME/cow/day for barley supplement. Total MJME intake/cow was 161MJME/cow/day. All cows had an average CP (%) intake of 14.55% for fodder beet and 12.9% for lucerne and 13.1% for barley.

Table 4: Nutritive values for fodder beet and lucerne and barley supplement

Nutritive values	Fodder beet		Supplement	
Parameters [1]	Bulb	Leaf	Lucerne	Barley
% of diet	40.6	26	9.6	23.7
%DW	14.7	14.0	50.2	50.2
DM%	90.4	81.5	52.3	67.7
OM%	98.4	86.6	90.5	89.5
NDF	14.7	30.2	53.7	0.0
ADF	11.8	13.4	40.6	23.8
CP%	8.6	20.5	12.9	13.1
AVE CHO	78.3	23.8	7.4	11.2
DOMD%	96.7	83.8	47.5	64.1
ME	12.7	12.4	8.2	10.8

[1]DW= dry weight; DM=dry matter; OM=organic matter; NDF= neutral detergent fibre; ACF= acid detergent fibre; CP= crude protein; CHO= carbohydrate; DOMD= Digestible organic matter content; ME= metabolisable energy.

4.3 Behaviour

4.3.1 Lying behaviour

Total lying times (Figure 2) did not significantly (P>0.05) differ between treatments. Cows had an average lying time/day for the control (10.7 hours/day), woodchip pulled (10.1 hours/day) and woodchip grazed (10.3 hours/day). The percentage of cows which lay down <5hrs was not statistically significant (P=0.09) between treatments with a grand mean of 0.26% (Figure 2) of cows lying <5hrs. The percentage of cows which laid >5 but <8hrs was not statistically significant between treatments with a grand mean of 6.5% (Figure 2) of cows lying >5 but <8hrs. The percentage of cows which lay down >8hrs (P 0.540) was not statistically significant between treatments (P=0.54), with an average mean of 95.5% (Figure 5) of cows lying >8hrs.

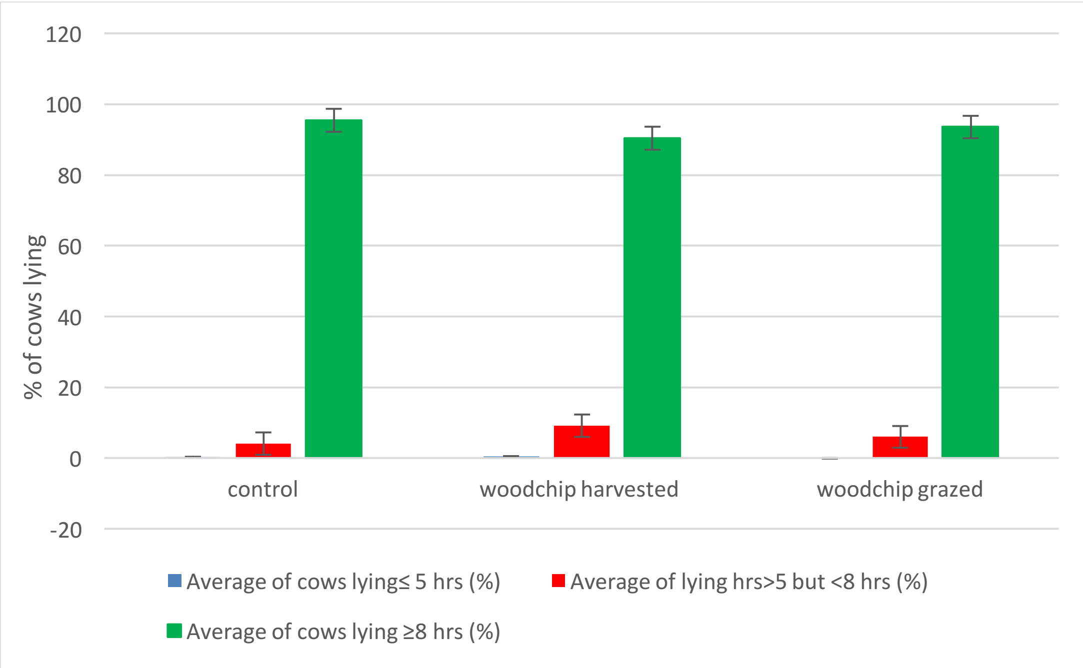


Figure 2: Lying times (%) for cows lying <5hrs, >5but <8hrs and >8hrs on the control, woodchip pulled and woodchip grazed.

4.3.2 Social interactions

There was one significant result between material and time of day. The grand mean for all treatments for dominance values were 39.8 and 3.22 for total average interactions (Table 5). ANOVA following a log10 transformation was performed to normalize data. With the data transformed it was able to be concluded that there was a significant interaction between material (treatment) and time of day (P=0.09). Cows on woodchip (harvested) (44.2) and woodchip (grazed) (42.5) had higher dominance values in the afternoon, whereas cows on the control (41.9) were higher in the morning (Table 5). However, average number of interactions/cow in the morning were higher than the afternoon; woodchip (harvested) (4.31 vs 3.1) and woodchip (grazed) (4.6 vs 2.6). The control had more interactions/cow in the morning than the afternoon (1.2 vs 3.5).

Table 5: Social interactions with number of average interactions and average dominance values for control, woodchip (harvested) and woodchip (grazed)

Treatments	Control	Woodchip harvested	Woodchip grazed
Paddock (morning)			
Av. No. of interaction/cow	3.5	4.3	4.6
Total interactions	270.0	302.0	346.0
Dominance Value (=57.3 *ASIN ((win + losses))^$^{0.5}$)	41.9	37.2	37.3
Standoff pad (afternoon)	Control	Woodchip harvested	Woodchip grazed
Av. No. of interactions/cow	1.2	3.1	2.6
Total Interactions	91.0	216.0	197.0
Dominance value	37.3	44.2	42.5

4.4 Lameness

The average lameness score for all cows was 0.06 and the control woodchip (harvested) woodchip (grazed) as shown in Table 6 was 0, 0.13 and 0.1 respectively, and was not significant between treatments (P= 0.48). All treatments had a standard error of mean (SEM) of 0.07.

Table 6: Lameness scoring for control, woodchip (harvested) and woodchip (grazed)

Date	Control	Woodchip harvested	Woodchip grazed
21/07/16	0		0.17
22/07/16	-	0.16	0.16
26/07/16	0	0.00	-
27/07/16	-	-	0.00
28/07/16	0	-	-
29/07/16	-	0.35	-
30/07/16	-	-	0.20
2/08/16	0	0.05	-

4.5 Cow cleanliness

The average cleanliness score for all treatments was 0.96 and the control, woodchip (harvested), woodchip 2 (grazed) as shown in Table 7 was 0.99, 0.91 and 0.85 respectively, and was not significantly different (P= 0.38). All treatments had a SEM of 0.11.

Table 7: Cow cleanliness score for control, woodchip (harvested) and woodchip (grazed)

Date	Control	Woodchip harvested	Woodchip grazed
19/07/16	1.00	0.83	
21/07/16	0.95		0.90
22/07/16		0.86	0.95
26/07/16	0.86	0.95	
27/07/16			0.55
28/07/16	1.15		
29/07/16		1.00	
30/07/16			1.00

4.6 Standoff pad temperature and moisture content

The temperatures of surface of pad and moisture percentage for areas with cows and without cows, for the woodchip pads are shown in Figure 3,4,5 and 6. The temperature for the control is shown in Figures 5 and 6. The ground temperature was shown to be lower in the control (0.75^{0}C) than the woodchip harvested (3.7^{0}C) and woodchip grazed (3.0^{0}C) with the two woodchip pads being very similar. The ground temperature tended to be cooler on the unoccupied side of the woodchip harvested (3.4^{0}C) and woodchip grazed (1.45^{0}C). The moisture percentage for the control, woodchip (harvested) and woodchip (grazed) were 70, 88 and 84% respectively.

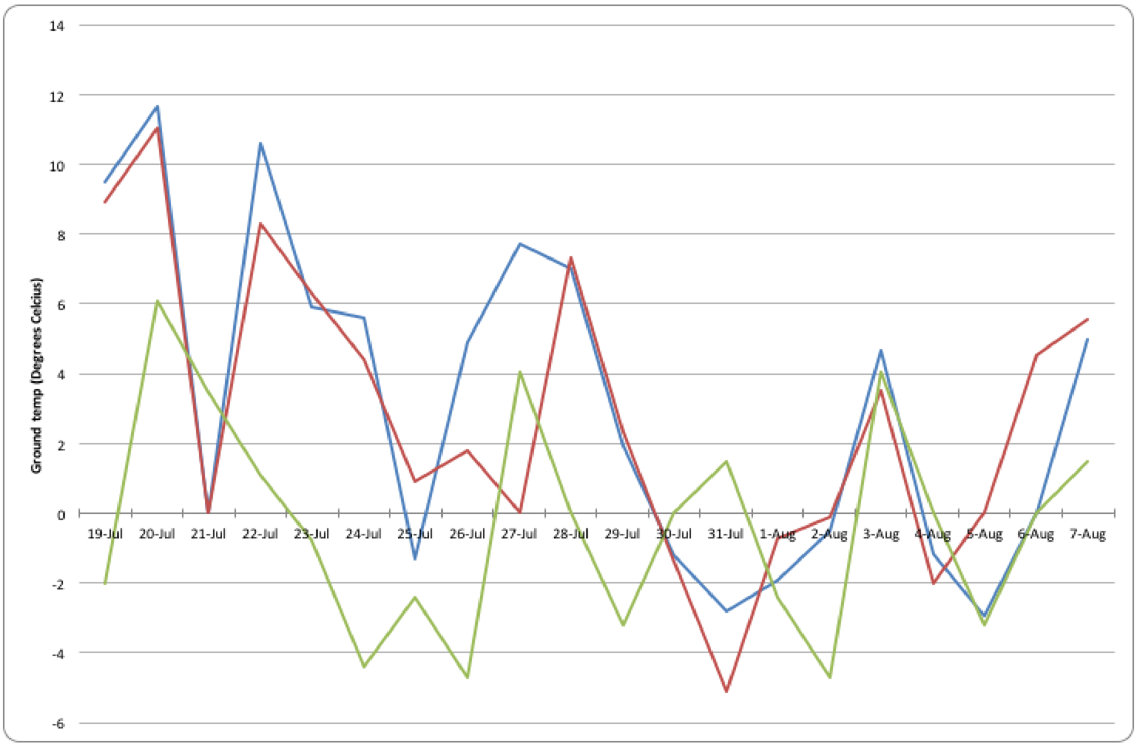


Figure 3: Ground temperature for control, woodchip (harvested) and woodchip (grazed) where cows were occupied. Green line= control, blue line= woodchip (harvested) and red line= woodchip (grazed).

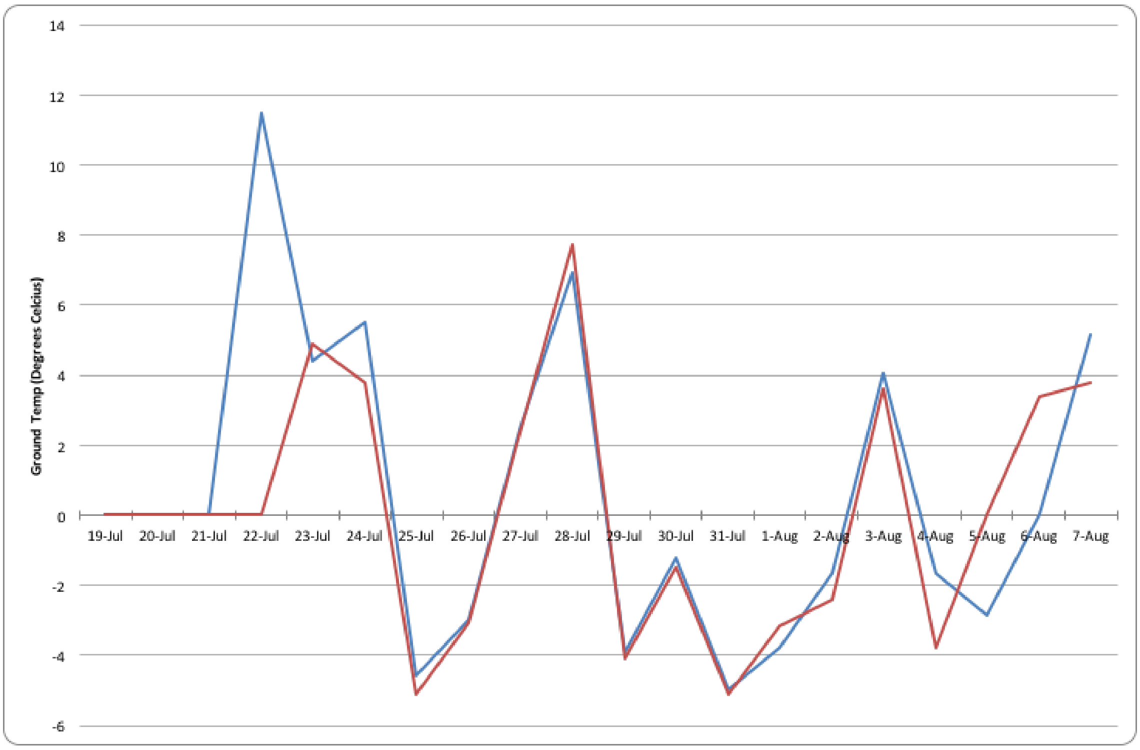


Figure 4: Ground temperature for control, woodchip (harvested) and woodchip (grazed) where cows were not occupied. Blue line= woodchip (harvested) and red line= woodchip (grazed)

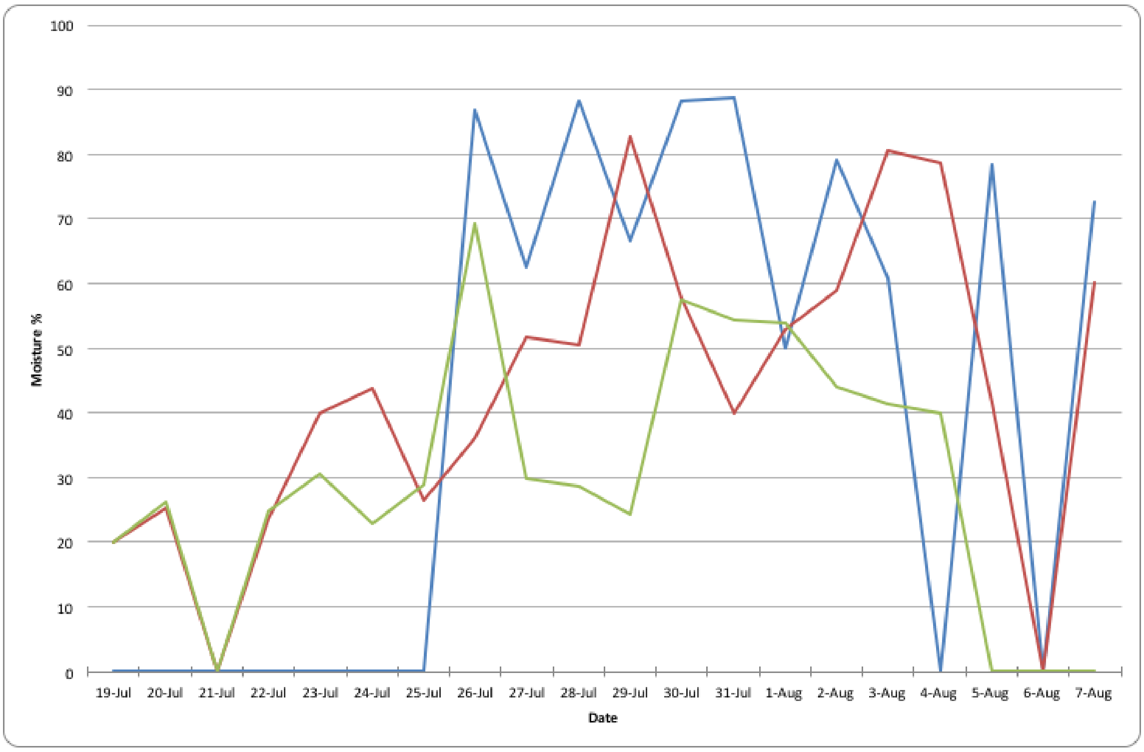


Figure 5: Moisture (%) for control, woodchip (harvested) and woodchip (grazed) with cows occupied on treatments. Green line= control, blue line= woodchip (harvested) and red line= woodchip (grazed).

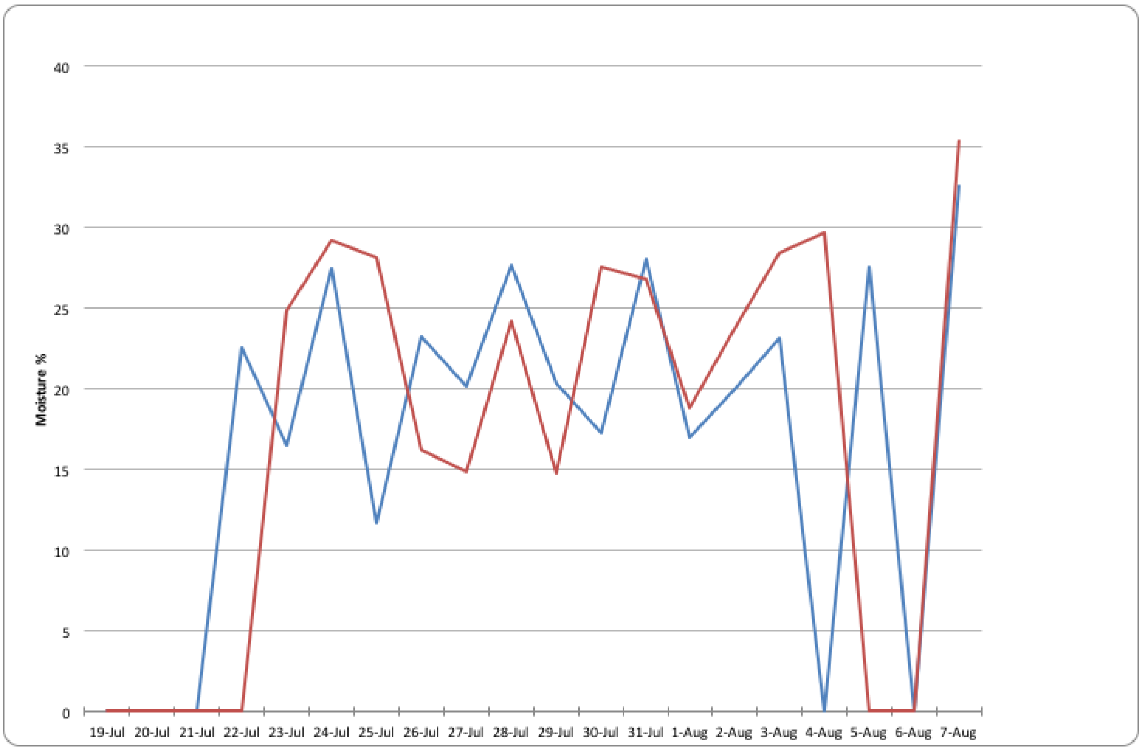


Figure 6: Moisture (%) for woodchip (harvested) and woodchip (grazed) with no cows occupied on treatment. Blue line= woodchip (harvested) and red line= woodchip (grazed).

Chapter 5

Discussion

5.1 Intake, utilization and nutritional requirements

The utilization rates and intake values were only recorded in week 2 of the observations. During week one cows were adapting from 24 hour grazing to duration controlled grazing. The change was from 24 hours grazing crop to six-seven hour/day grazing. Utilization for the fodder beet was higher in the control and woodchip harvested, than grazed in situ. Harvested fodder beet required less energy to eat as the bulb was highly palatable and had 100% utilization. The control also had 100% utilization as cows had spent the majority of winter on the crop, and more time to graze in paddock. There was a slight reduction (92%) in the woodchip grazed, which could be the difference between the harvested vs grazed fodder beet.

Overall utilization rates were similar to studies by Edwars et al. (2014) on Canterbury fodder beet crops, which resulted in utilization rates of 99.6%

Cows met their energy and protein requirements through the fodder beet, lucerne and barley silage supplement. The fodder beet provided 87.5MJME/cow/day, lucerne silage provided 41.0MJME/cow/day and barley silage provided 32.5MJME/day, which resulted in a total of 161.0MJME/cow/day. The crude protein (%) for fodder beet was 14.6%, lucerne was 12.9% and barley was 13.1%. This was similar to Rattray et al. (2007) who suggested that a non-lactating adult cow requires 48MJME/kg gained feed on a diet of 11MJME/kgDM. Holmes (1981) also suggested that the maintenance figure of 0.55MJME/kg $W^{0.75}$ for dry cows. On top of this the total cost for pregnancy is about 60MJ/kg of calf body weight.

Corp (2015) suggested at least 12% crude protein is required for late gestation, which was well below the CP% of the fodder beet provided for the Ashely Dene trial (2016).

The supportive literature suggests that the animals are meeting their requirements for energy and protein to remain free from hunger.

5.2 Behaviour

5.2.1 Lying behaviour

There was no statistical significance between any of the three treatments. The effect of lying time between the control, woodchip (harvested) and woodchip (grazed) showed that the majority of cows lay down more than eight hours, with an average mean for all treatments was 95.5% of cows lying for

8 hours and a mean of 10.35 hours/day. Cows had an average lying time/day for the control (10.71 hours/day), woodchip harvested (10.05 hours/day) and woodchip grazed (10.29 hours/day). In contrast, only 6.5% of cows only laid for more than five hours but less than eight hours. Very few cows laid for less than five hours (0.26%). With this information we are able to conclude that the majority of animals were meeting their average requirements for more than eight hours lying of lying time as recommended in the (Ministry for Primary Industries, 1999).

This effect of lying is similar to Stewart et al. (2002) who reported the use of wintering options with different materials for standoff pads and crops on 18 commercial dairy farms in Southland and the Waikato. It was reported for both the Southland and Waikato farms tended to favor the woodchip standoff pads against harder surfaces such as concrete standoff pads or raceways. The average lying time for the farm observations in Waikato were 11.33 hours/day and for Southland 11.48 hours/day. The Southland study also demonstrated the lying times for the crop resulting in an average lying time of 11.17 hours/day. All results are similar to Singh et al. (1993) who recorded 10.3 hours/day for cows on pasture.

The reason for increased lying times on the control treatment compared to the standoff pads, was due to cows being on the fodder beet crop for 24 hours throughout the winter period. In contrast, cows on the standoff pads were only introduced to the pads for the first time, four weeks prior to calving. This resulted in limited transition time for the animals to properly adapt to the standoff pads. In contrast the control group was on crop for the entire winter. The effect of grazing for 24 hours and then suddenly being restricted to six-seven hours/day grazing was a difficult transition for cows going onto the standoff pads. As a result, six cows became susceptible to ruminal acidosis, due to the restricted grazing time and not meeting their nutritional requirements and gorging the following day on fodder beet. This was fixed through extending their grazing time after the incidence. Overall the lying times did not reflect this issue as the majority of animals met their lying requirements of eight hours or more.

5.2.2 Social interactions

The average mean of interactions for the control, woodchip (harvested) and woodchip (grazed) was 41.9, 37 and 37 for the paddock (morning) and 36.5, 44.1 and 42.5 for the standoff pad (afternoon) respectively. The total average interactions/cow were 3.55, 4.31 and 4.61 for the paddock (morning) and 1.20, 3.09 and 2,63 for the standoff pads (afternoon) respectively. Results showed that there was less interactions for the two woodchip groups and slightly more interactions in the control group for the morning. The mean dominance values (DV) for the control, woodchip (harvested) and woodchip (grazed) was 41.9, 37 and 37 for the am respectively and 36.5, 44.1 and 42,5 for the afternoon respectively. The grand mean for the DV for all the treatments was 39.8 and total interactions/cow was 3.22. Once the data was transformed (log10 transformation) there was a significant interaction between the material of the surface and time (P<0.091 from the least significant difference test at 10% significance). This showed that there was a difference between the control morning in contrast to the other treatments. It also showed that the control typically demonstrated more interactions and a higher DV in the morning. This is due to being fed silage and offered their break at this time. Results for both the woodchip groups had more interactions and a higher DV in the afternoon once they were returned to the standoff pads. This was likely to be due to the confined space in the pads, as more aggressive behavior was observed, typically if animals were lying or about to lie down. This could have effected their lying ability on the standoff pads. However, results suggested that there was no significant difference between the morning and afternoon interactions and DVs. Therefore, if cows were given more time to adjust then results could have presented less interactions and a lower DV on the standoff pads.

Interactions and DV score could also have been effected by the alternations made to the mob every week, as cows were removed (between 5-10 cows/group) before calving to go into the springer mob. This had the ability to effect the animals rearranging their hierarchy, hence more interactions.
The effect of social interactions is similar to Hussein et al. (2016) who demonstrated different stocking rates and herd size for 250 spring calving Frisian x Jersey cows grazing perennial ryegrass, and observed for three months' early lactation to determine their DV scores. Cows on low stocking rate (LSR), medium stocking rate (MSR) and high stocking rate (HSR) had DV scores of 40.7, 50.3 and 43.9 respectively. The interactions/ cow were 10, 3, and 14 respectively. The total interactions were 297, 589 and 475 respectively. Social dominance was suggested to be positively related to age and size of animals such as BCS and LW (Phillips & Rind, 2002; Schein & Fohrman, 1955b; Sołtysiak & Nogalski, 2010). Dickson et al. (1970); Guhl and Atkeson (1959); Potter and Broom (1987) all suggested that confined spaces in indoor feeding systems have an effect on cows social interactions. Hussein et al. (2016) further explained in relation to the different stocking rates, the smaller the group the fewer social interactions between cows in larger MSR groups as it could be due to lack of recognition. Hussein et al. (2016) also found that larger groups resulted in fewer interactions which is in agreement with Lindberg and Nicol (1996) who claimed that larger groups lead to fewer interactions.

5.2.3 Lameness

The effect of treatments on lameness for the control, woodchip (harvested) and woodchip (grazed) was small with little lameness in any treatment groups. There was no significant difference between any of the treatments. The grand mean for all treatments was 0.067.

This effect is similar to results shown by Wynn et al. (2011) in a Northland dairy farm where the effects of surface management for standoff pads and cows lameness score with two treatments, which were either aerated or unaerated woodchip standoff pads, were examined. Results showed minimal effects on lameness as there was only <2.2% of cows that were lame on the woodchip treatments. Additionally, Fisher et al. (2002) associated a reduction in the gait length was also related to lameness. A greater change in reduction in gait length (starting from 0m, no change) was shown on harder surfaces such as concrete (0.07m) than cows on woodchip (0m) and small standoff paddocks (0.01m). The woodchip standoff pad on the Ashely Dene trial was similar to Fisher et al. (2002) results but not for the paddock situation as there was minimal lameness reported on the control paddock.

The reason for minimal lameness within the treatments, was due to the short time frame (four weeks) for which the cows were observed. If cows had a longer observation period (12 weeks) then more prominent results may have occurred. Lameness could potentially have developed on the standoff pads, due to uneven surfaces on laneways where cows walked maximum 800m twice a day to paddock. The control cows showed minimal signs of lameness on the crop paddock as a result of being used to the conditions and no walking to and from the standoff pads. This was demonstrated through the average lying scores as mentioned above.
The impact of the control versus woodchip standoff pads did not significantly affect the cow's lameness.

5.3 Surface effects

5.3.1 Hygiene

The effect of hygiene for the three treatments control, woodchip (harvested) and woodchip (grazed) was small with minimal changes in cow's hygiene scores in any of the treatment groups. There was no significant difference between any of the treatment. The grand mean for all treatments was 0.959. There was limited literature for hygiene scores for standoff pads in New Zealand. The reason for minimal difference between the hygiene scores and treatment is likely to be due to the limited amount of time cows spent on the standoff pads, as mentioned before cows were only on the standoff pads for the four weeks. Hence it is difficult to see a significant difference in the change of hygiene scores. Ideally the animals on the woodchip standoff pad would be cleaner than the control cows, particularly if it was a very wet and muddy winter. However, due to Canterbury's warmer than average winter animals remained relatively clean. There was minimal impact from the treatments and the cow's hygiene.

5.3.2 Standoff pad and control; moisture and temperature levels

The ground temperature was shown to be lower in the control (0.5^{0}C) than the woodchip harvested (2.0^{0}C) and woodchip grazed (3.0^{0}C) with the two woodchip pads being very similar. The ground temperature tended to be cooler on the unoccupied side of the woodchip harvested (3.4^{0}C) and woodchip grazed (1.45^{0}C), as measurements were taken after the cows had left the standoff pad, the woodchips held the heat from where cows had been lying or urinating.

The moisture percentage for the control, woodchip (harvested) and woodchip (grazed) were 70, 88 and 84% respectively. The moisture percentage was low for the first week in the occupied woodchip pads, but gradually increased as urine and feces built up over time. The pads were not cleaned in the observation period (three weeks). The unoccupied pad remained as low 35% and did not rise over this for the entire observation period. The control paddock remained reasonably low apart from the odd rainy day.
There was not a significant difference between the control and the woodchip pads which had any effect on the cow's welfare or behaviour.

5.4 Implications

The implications for a duration controlled grazing system on standoff pads to be beneficial and sustainable, require efficient management practices to be in place. If farmers are to implement standoff pads into their wintering systems, cows should be on the pads as soon as they are dried off through till calving. Transition onto the pads is essential for at least two-three weeks to ensure cows are comfortable on the pads. This could be achieved by slowly decreasing cow's times on the crop and transition onto the pads. Once cows have adapted, a duration controlled grazing system can be implemented for at least six hours/day and on the standoff pad for 17 hours/day. Fresh water should be available at all times. If cows are on the standoff pads for the duration of winter then their behavior is likely to adapt to the alternative system, for example, there would be less aggressive social interactions, cows would not be at risk of acidosis, and cows would be comfortable and well-conditioned ready for calving. Cows would also be used to confined spaces (effects social interactions). If cows are well adapted the recommended 10m^2/cow should be enough space for the cows to remain comfortable. Cows could be split into different age groups as mentioned in the literature, age has been seen to have an effect on animal's social interactions. If heifers were kept together it could significantly reduce competition between the older cows.

Identification of sick animals or stock not meeting their nutritional or lying requirements, should be removed from the others and treated separately to ensure a healthy return into the herd.

5.5 Future work

The future work for New Zealand dairy wintering systems is significant. Standoff pads are potentially one of the cheapest and effective wintering systems in comparison to wintering barns. Currently only the minority of farmers have implemented the standoff pads into their farming systems. There is a greater need for more research with covered (typically for Southland) and uncovered standoff pads to allow for greater shelter from harsh winters. The different material for the standoff pads is another important factor to consider, ideally cows require an even surface that is going to provide a comfortable surface for the cows to lie on. Materials such as woodchip, small gravel, sand and carpet are all examples of comfortable surface materials.

Furthermore, the education evolved around the use of standoff pads will need to be significantly increased. Areas such as the effluent system will be unknown to a lot of farmers, as the collection of any liquid needs to be dealt with appropriately, as well as adequate cleaning of the standoff pads. The transition period onto the standoff pads is a critical factor, as if cows are not well transitioned this can be fatal, due to not meeting their nutritional requirements on a DCG (particularly on fodder beet) because of the restrictions. Farmers should be well educated before they attempt implementing the DCG into their system.

Future work could also be done in other parts of the country as Southland, Waikato, Canterbury and Northland appear to be the most focused points for the research. The more model farms, the higher the interest and initiative other farmers will have to give it a go.

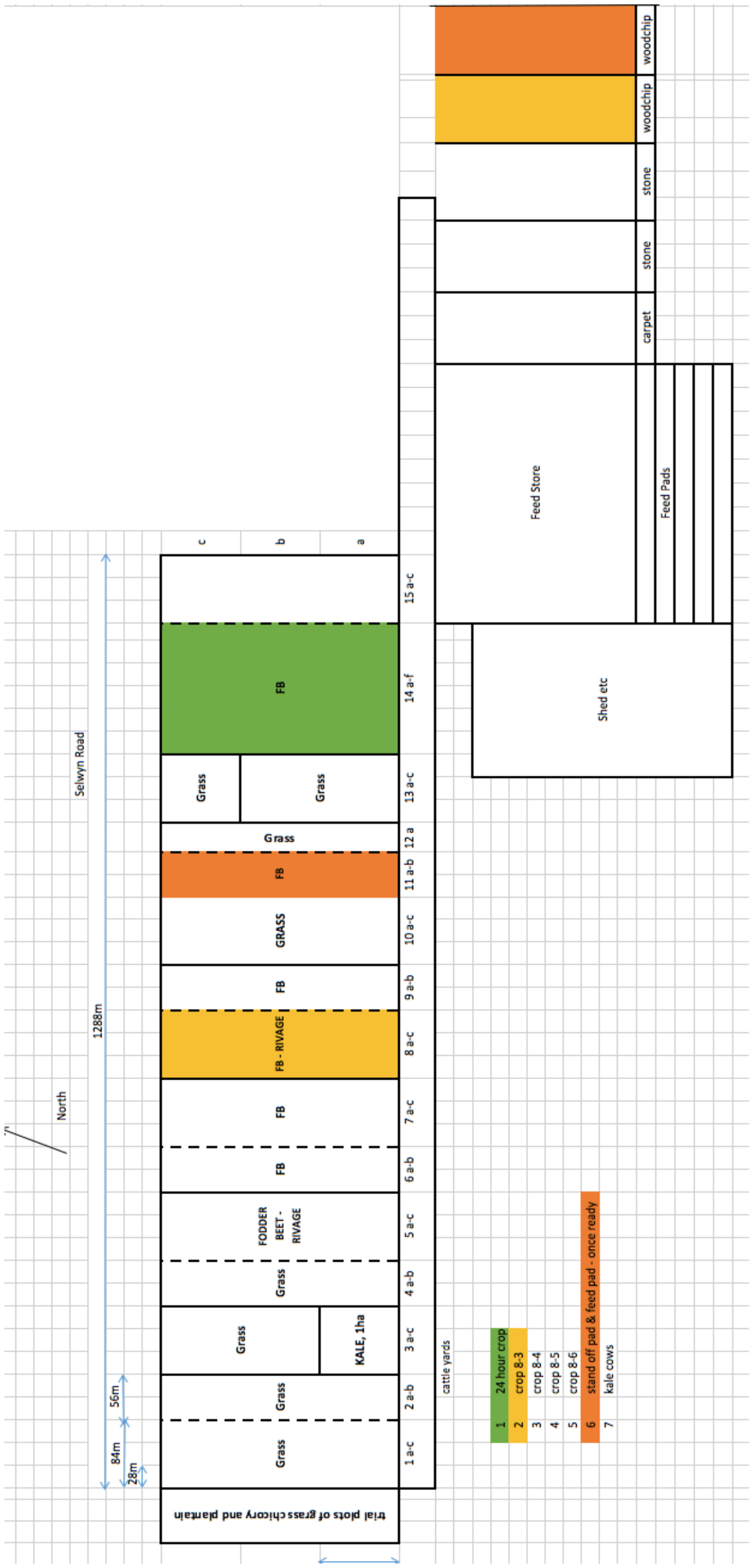
The welfare of the animals also needs to be more focused on, and ways in which farmers can monitor and change accordingly to meet the best animal requirements. The use of the Five Acts of Freedom (from the Animal Welfare Act, 1999) provide a useful tool for farmers to follow.

5.6 Conclusion

In conclusion, for cows wintering on standoff pads, it was found that surface type had no effect on lying, cleanliness and lameness score. There was only one significant result; social interactions. Having identified that there was limited significance in relation to the treatments on lying, lameness and hygiene and social interactions on the cow's welfare and behaviour, further research is required. A longer study, covering the whole wintering season, is required to affirm these results. In addition, using these determinants for welfare and behaviour on wintering standoff pads, may contribute to a significant reduction in nitrate leaching into New Zealand pastures.

Appendix A

Ashely Dene farm map

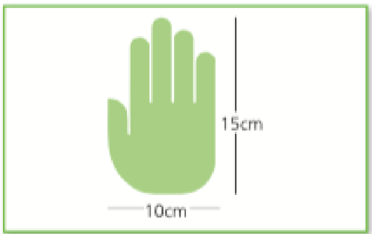


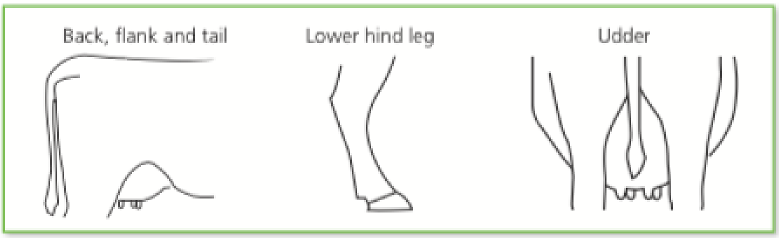
Appendix B

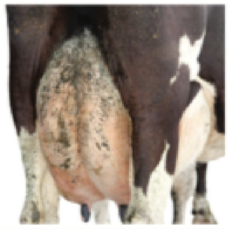
Cleanliness Scoring

Housed cow cleanliness score card

This simple scoring system helps you to estimate the current cleanliness of your herd and your housing facility. Most cows in most herds should score 0 or 1. If you have more than 20% of your cows scoring 2, they may be at greater risk of animal health issues and milk quality may be affected. When you have scored the cows, go to **dairynz.co.nz/clean-cows** to find out what your herd's score indicates.





Score		Back, flank and tail	Lower hind leg	Udder
0 Clean	No dirt or less than 10% (a hand-size) is splashed with fresh or dry material.			
Total number of cows with any body part scored @ 0 =		Tally		
1 Dirty	There is at least a hand-sized area of dirt, but less than 50% of the area is dirty.			
Total number of cows with any body part scored @ 1 =		Tally		
2 Very dirty	More than 50% of the area is very dirty and hair is hard to see. Tail may have significant dagging.			
Total number of cows with any body part scored @ 2 =		Tally		

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