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Farm context and winter grazing practices in the Waikato beef and sheep industries

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Prepared by:
Dr Geoff Kaine
Geoff Kaine Research

For:
Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
HAMILTON 3240

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Peer reviewed by:
Dr James Turner
Dr Ross Monaghan Date June 2014

Approved for release by:
Ruth Buckingham Date February 2015

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Executive Summary

The influence of farm context on the winter grazing practices of sheep and beef farmers in the Waikato is investigated in this report using data from a survey of 450 sheep and beef farmers commissioned by Waikato Regional Council. Farm context is the set of factors in a farm system that influences the benefits to be had from adopting a particular management practice or technology (Kaine 2008). The sheep and beef farming systems investigated here include bull and beef cattle enterprises, sheep and lamb enterprises, and dairy cow and heifer grazing enterprises.

The survey on the use of winter grazing practices by sheep and beef farmers in the Waikato region was based on Davies (2012) and sought information on the prevalence of a range of wintering practices including the feeding out of hay, silage and supplements, changing rotation lengths and grazing practice, shifting stock around the farm, selling stock, and standing off of stock. The survey is described in detail in Versus Research Ltd and Reed (2014). Theoretically, differences arise in the use of these practices because of differences in farm context (Kaine 2008; Davies 2012; Kaine 2014).

The contextual differences of most interest here are the proneness of farms to waterlogging and pugging. Differences in the frequency and extent of waterlogging and pugging on farms create differences in grazing pressures, forcing farmers to employ different stock management practices (Davies 2012). Waterlogging and pugging are of particular interest as the way in which they combine to influence farmers' grazing management in winter is crucial to:

- Assessing the flexibility, if any, sheep and beef farmers may have in their choice of winter grazing practices
- Assessing the likely costs to sheep and beef farmers of changing winter grazing practices.

The influence of proneness to waterlogging and pugging on winter management practices was analysed by classifying sheep and beef farmers into farm context segments based on their assessment of the proneness of their farm to pugging, and the proportion of their farm that was pugged in a normal winter. Differences were expected across the segments in the management practices farmers employed during winter.

The results confirmed that the practices farmers used to manage sheep and beef over winter were strongly influenced by the frequency and extent of pugging that farmers experience over winter, and pugging was primarily a function of biophysical characteristics of the farm that influence drainage (such as soil type, rainfall, and farm topography). The main findings were that:

- Farmers in the contexts that experience the most severe pugging and waterlogging were the most likely to manage stock over winter by using a combination of practices such as grazing stock on larger areas, putting them in drier and better paddocks, changing their rotation, putting stock on sacrifice paddocks, putting lighter stock on steeper country, and selling

stock. Generally speaking, farmers in other contexts used these practices and were less likely to have to use a combination of practices.

- There was a statistically significant and substantial association between farmers' reports of the severity of pugging and waterlogging they encountered and the soil types and drainage on their farms. This suggests that the practices farmers choose to use to manage stock over winter are strongly influenced by biophysical environmental factors. Consequently, any restriction on the practices farmers may employ to manage stock over winter is likely to severely affect the productive and financial capacity of their farms.

- Farmers that experienced the most severe pugging and waterlogging were somewhat restricted in the range of practices they could employ to manage stock in winter because of the severity of conditions on their farms. On the whole, these farmers were less likely than farmers in contexts where conditions were not quite as severe to use practices such as grazing stock on larger areas, putting beef cattle, sheep, lambs on drier and better paddocks, putting lighter stock on steeper country and changing their rotation.

- Farmers in all contexts appeared to limit the extent to which they changed their management of bulls, dairy cows and dairy heifers in winter. Their flexibility in accommodating winter conditions generally, and waterlogging and pugging in particular, came from changing their management of sheep and beef cows and, to a lesser extent, lambs.

- There was substantial diversity in the different combinations of practices used in winter to manage sheep and beef. An implication of this finding is that there will be differences among farmers in the impact on the productive and financial capacity of their farms of any restriction on the practices they may employ to manage stock over winter.

The findings lead to the conclusion that the adoption of management practices by sheep and beef farmers are motivated by production benefits and these benefits arise from the biophysical characteristics of sheep and beef farms. These characteristics, and the management practices used as a consequence, varied substantially across farms and districts. This means that sheep and beef farmers are likely to suffer serious economic losses should they be prevented from using some practices in the future and the seriousness of these losses will vary across farms. Conversely, farmers that do not use some practices are likely to suffer serious economic losses should they be compelled to use them in the future, and the seriousness of those losses would also vary across farms.

In principle, the variety in winter grazing management could be summarised into a relatively small number of representative winter grazing systems for sheep and beef based on livestock classes and management practices. These would represent the main types of winter grazing management systems used by sheep and beef farmers in the Waikato.

Introduction

The influence of farm context on the winter grazing practices of sheep and beef farmers in the Waikato is investigated in this report. Farm context is the set of factors in a farm system that influences the benefits to be had from adopting a particular management practice or technology (Kaine 2008). The sheep and beef farming systems investigated here include bull and beef cattle enterprises, sheep and lamb enterprises, and dairy cow and heifer grazing enterprises.

The Waikato Regional Council commissioned a survey on the use of winter grazing practices by sheep and beef farmers in the Waikato region based on Davies (2012). The survey is described in detail in Versus Research Ltd and Reed (2014)[1]. The survey sought information from 450 farmers on the prevalence of a range of wintering practices including the feeding out of hay, silage and supplements, changing rotation lengths and grazing practice, shifting stock around the farm, selling stock, and standing off of stock. Theoretically, differences arise in the use of these practices because of differences in farm context (Kaine 2008; Davies 2012; Kaine 2014).

The contextual differences of most interest here are the proneness of farms to waterlogging and pugging. Differences in the frequency and extent of waterlogging and pugging on farms create differences in grazing pressures, forcing farmers to employ different stock management practices (Davies 2012). Waterlogging and pugging are of particular interest as the way in which they combine to influence farmers' grazing management in winter is crucial to:

- Assessing the flexibility, if any, sheep and beef farmers may have in their choice of winter grazing practices
- Assessing the likely costs to sheep and beef farmers of changing winter grazing practices.

The influence of proneness to waterlogging and pugging on winter management practices was analysed by classifying sheep and beef farmers into farm context segments based on their assessment of the proneness of their farm to pugging, and the proportion of their farm that was pugged in a normal winter. Differences were expected across the segments in the management practices farmers employed during winter.

In the next section the classification of farmers into farm context segments is described. Differences among the segments in extent, frequency and duration of pugging are investigated, as well as differences in the biophysical characteristics of the farms in each segment. This is followed by an analysis of the differences among contexts in management practices. The implications of the results are discussed briefly in the final section.

[1] Similar research has been conducted on dairy enterprises. See Davies and Topperwien (2011), Versus Research Ltd and Davies (2012) and Kaine (2014).

Farm context segments

The 450 respondents to the Council survey were classified into farm context segments for managing stock in winter based on their assessments of:

- The proneness of their farm to pugging, and
- The frequency with which they experience waterlogging.

Proneness to pugging was rated by respondents on a four-point scale from not at all prone to very prone (Versus Research Ltd and Reed 2014). The frequency with which waterlogging was experienced was rated by respondents using a five-point scale ranging from never to every year.

Respondents were classified into farm context segments using SPSS (IBM 2012). The classification method and measure of dissimilarity employed were Wards and squared Euclidean distance, respectively (Aldenderfer and Blashfield 1984). Examination of the agglomeration schedule indicated a substantial increase in the agglomeration coefficient at the formation of five segments; consequently a six-segment solution was selected for analysis (Aldenderfer and Blashfield 1984, 55-57).

The profiles of the farm context segments with respect to the proneness to waterlogging and pugging are summarised in table 1. The characteristics of the farm contexts in terms of extent, duration and impacts of waterlogging and pugging are reported in tables 2, 3 and 4. The characteristics of the farm contexts in terms of location, livestock types, topography, soil type, drainage and rainfall are reported in tables 5, 6 and 7 (see also figures 1 to 7).[2]

Overall, an inspection of the tables reveals that differences in the proneness and severity of pugging across the farm contexts are associated with differences in the extent and duration of waterlogging. Differences in proneness to waterlogging and pugging were associated with differences in soil type and drainage. Although the topography of farms was similar across the contexts, they differed in regard to soil types, with farms that were more prone to waterlogging and pugging having a much greater proportion of clay-based soils, and a much smaller proportion of ash-based soils, than farms that were less prone to waterlogging and pugging.

There were only a couple of differences of note between the farm contexts in regard to fertiliser practices, soil testing, winter cropping and the use of sacrifice paddocks. One difference was that a smaller proportion of farms in contexts that were not prone to waterlogging or pugging were likely to apply nitrogen in autumn. Another was that a relatively high proportion of farmers in contexts that were prone to pugging across a small area of the farm in winter were more likely to have a sacrifice paddock in winter.

Each of the contexts is described in detail below.

[2] Note that only the results of overall significance tests are reported. The results of post-hoc and pairwise tests are available on request from the author.

Farm context one: Pugging and frequent, extensive waterlogging
The farms with this context were prone or very prone to pugging and extensive waterlogging in most years. Waterlogging was experienced across more than a quarter of the area of the farms in this context and lasts for two weeks or more (tables 1 and 2). Waterlogging and pugging limited pasture growth in winter, had an unfavourable impact on pasture composition and prevented fully grazing land in winter on a majority of farms in this context. A relatively high proportion of farms in this context had similar problems in spring. Pugging was perceived to have an unfavourable impact on soil structure on a majority of farms in this context (table 3). A relatively high proportion of farmers in this context described pugging as reducing the time they could graze pasture (see table 4).

Farms in this context were concentrated in the Waipa and the Waikato districts (see table 5). On average, the farms in this context were relatively small with a relatively high proportion running beef cows and a relatively low proportion running sheep (table 6).

A relatively high proportion of farms in this context reported that their rolling country was composed of clay and clay loam soils that had mixed or poor drainage (see table 7). A relatively small proportion of farms in this context reported ash soils on their rolling and steep country. The mean annual rainfall for farms in this context was relatively low.

Farm context two: Some pugging and frequent waterlogging
The farms with this context were prone to pugging and frequently experience waterlogging. Generally, the farms in this context experienced waterlogging every two or three years. Up to a quarter of the area of the farms in this context could be waterlogged and waterlogging might last for up to two weeks at a time (tables 1 and 2). As was the case with context one, waterlogging and pugging limited pasture growth in winter, had an unfavourable impact on pasture composition and prevented fully grazing waterlogged land in winter on a majority of farms in context two. Again, as was the case with the farms in context one, a relatively high proportion of farms in context two had similar problems in spring. Pugging was perceived to have an unfavourable impact on soil structure on a majority of farms in this context (table 3). A relatively high proportion of farmers in this context described pugging as reducing the time they could graze pasture (see table 4). A relatively high proportion of farmers in this context had a sacrifice paddock in winter.

Farms in this context were concentrated in the Waikato district (see table 5). On average, the farms in this context were relatively large with a relatively small proportion running sheep (table 6).

A relatively high proportion of farms in this context reported that their rolling country was composed of clay and clay loam soils that had mixed or poor drainage (see table 7). A relatively small proportion of farms in this context reported ash soils on their steep country. The mean annual rainfall for farms in this context was relatively low.

The key difference between the farms in contexts one and two is that the farms in context one experienced more extensive and frequent waterlogging compared to the farms in context two.

Farm context three: Some pugging
The farms with this context were prone to pugging but only experienced waterlogging rarely, if at all (tables 1 and 2). For most farms in this context pugging did not limit pasture growth in winter or spring, have an unfavourable impact on pasture composition, prevent grazing in winter or spring, or have an unfavourable impact on soil structure (table 3). Most farmers in this context reported that they could graze pasture all day without pugging unless conditions were particularly severe (table 4).[3] A relatively high proportion of farmers in this context had a sacrifice paddock in winter.

Farms in this context were concentrated in the Waipa and the Waikato districts (see table 5). The average size of farms in this context was near the mean (see table 6).

A relatively low proportion of farms in this context reported that their rolling country was composed of clay and clay loam soils that had mixed or poor drainage (see table 7). A relatively high proportion of farms in this context reported ash soils on their rolling and steep country. The mean annual rainfall for farms in this context was relatively high.

The key difference between the farms in context three and those in contexts one and two is that the farms in context three do not experience waterlogging.

Farm context four: Frequent waterlogging
The farms with this context were not prone to pugging but experienced waterlogging in most years. Generally, waterlogging occurred across less than a quarter of the area of the farms in this context and usually only lasted for a week or two or less (tables 1 and 2). Waterlogging and pugging limited pasture growth and prevented fully grazing land in winter on many farms in this context. Relatively few farms in this context had similar problems in spring. Pugging was perceived to have an unfavourable impact on soil structure on some farms in this context (table 3). A relatively small proportion of farmers in this context described pugging as reducing the time they can graze pasture (see table 4).

Farms in this context were concentrated in the Waipa and Waikato districts (see table 5). On average, the farms in this context were relatively large with a relatively high proportion running beef cows (table 6).

A relatively high proportion of farms in this context reported that their rolling country was composed of clay and clay loam soils that had mixed or poor drainage (see table 7). Mean annual rainfall was close to average.

[3] Note that respondents who rarely, if ever, experienced waterlogging but did experience pugging (such as those in context three) were asked to answer questions about grazing waterlogged pastures in spring and winter.

The key difference between the farms in context four and those in preceding contexts (contexts 1, 2 and 3) is that the farms in context four do not usually experience pugging.

Farm context five: Infrequent waterlogging
The farms with this context were not prone to pugging and only occasionally experienced waterlogging. Generally, waterlogging occurred across less than a quarter of the area of the farms in this context and only lasted for a day or two at a time (tables 1 and 2). Waterlogging limited pasture growth in winter on many farms in this context. However, the majority of farms in this context were unaffected by pugging or waterlogging with regard to growing and grazing pasture in spring, pasture composition and soil structure. Very few farms in this context had problems with waterlogging in spring (table 3). A very small proportion of farmers in this context described pugging as reducing the time they can graze pasture (see table 4).

Farms in this context were concentrated in the Waipa, Waikato and Otorohanga districts (see table 5). On average, the farms in this context were relatively small with a relatively low proportion running beef cows and a relatively high proportion running sheep (table 6).

A relatively low proportion of farms in this context reported that their rolling country was composed of clay and clay loam soils that had mixed or poor drainage (see table 7). A relatively high proportion of farms in this context reported ash soils on their rolling country. Mean annual rainfall was relatively high.

The key difference between the farms in context five and those in previous contexts is that the farms in context five do not usually experience pugging and only occasionally experience waterlogging.

Farm context six: No waterlogging or pugging
The farms with this context did not experience pugging or waterlogging (tables 1 and 2). Consequently, farms in this context were unaffected in winter or spring by pugging or waterlogging with regard to pasture growth, grazing pasture, pasture composition and soil structure (tables 3 and 4).

Farms in this context were spread across Otorohanga, Taupo and Waipa districts (see table 5). A relatively low proportion of farms in this context were in the Waikato. The average size of farms in this context was near the mean. A relatively high proportion of the farms in this context were running sheep (table 6).

A very low proportion of farms in this context reported that their rolling country was composed of clay and clay loam soils that had mixed or poor drainage (see table 7). A very high proportion of farms in this context reported free draining pumice soils on their flat and rolling country. Mean annual rainfall was relatively high.

Table 1: Farm context segments for sheep and beef

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Percentage of respondents	22	8	18	12	14	26
Proneness to pugging*						
Very prone	33	-	9	-	-	-
Prone	67	100	25	-	-	-
Not very prone	-	-	67	66	81	-
Not at all prone	-	-	-	34	19	100
Proneness to waterlogging*						
Every year	45	-	-	52	-	-
Most years	53	-	-	48	-	-
Every second or third year	-	68	-	-	42	-
Every five years or so	-	32	-	-	58	-
Rarely or never	-	-	100	-	-	100

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context
Total number of survey respondents was 450

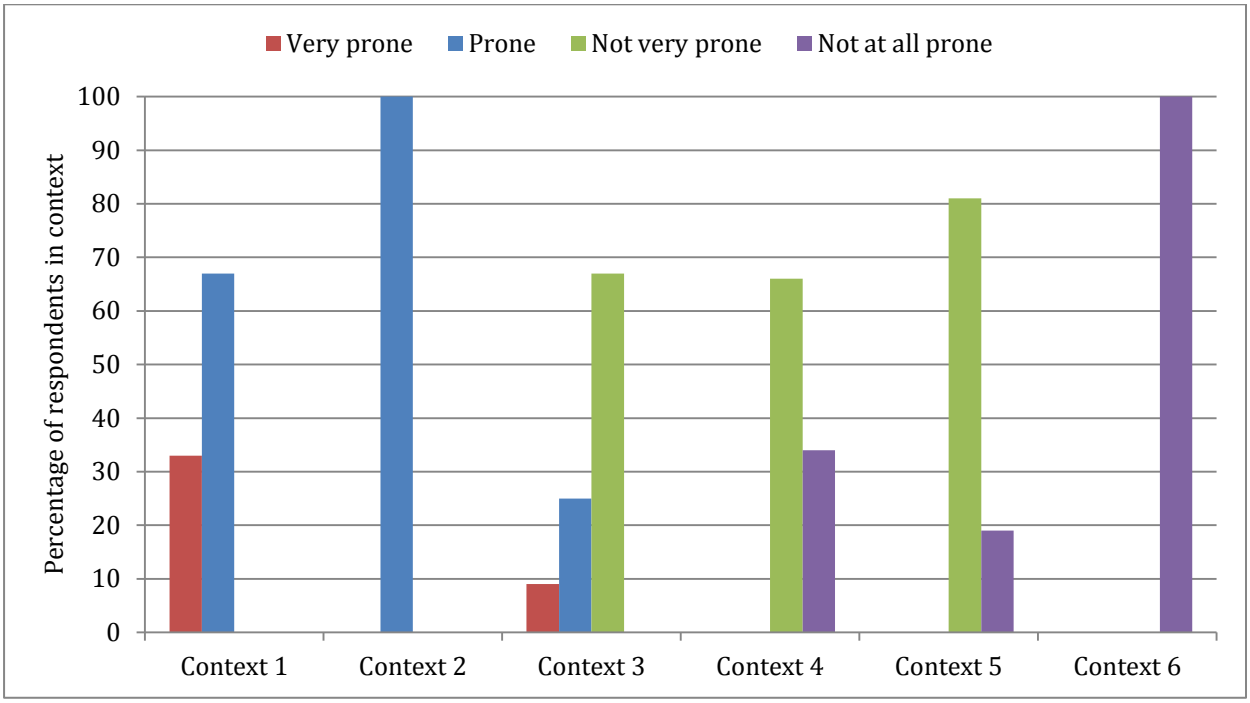

Figure 1: Farm context and proneness to pugging

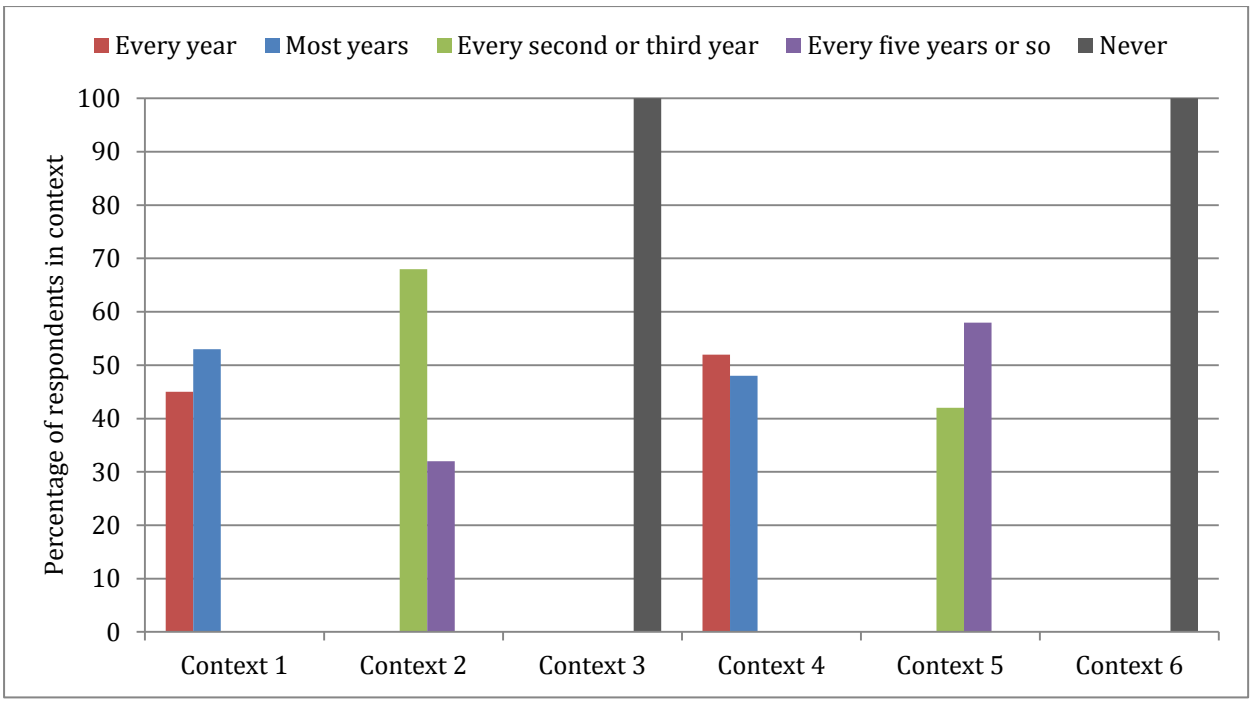

Figure 2: Farm context and proneness to waterlogging

Table 2: Farm context and waterlogging characteristics

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Extent of waterlogging*						
None of it	3	3	100	7	13	100
Less than 25%	26	65	-	62	74	-
Between 25% and 50%	32	18	-	13	7	-
Between 50% and 75%	11	9	-	11	5	-
More than 75%	27	6	-	8	2	-
Continuity of waterlogging*						
A day or so at a time	33	35	-	40	64	-
A week or two at a time	37	50	-	38	34	-
Continuously for about a month	19	15	-	18	2	-
Continuously for two months or more	10	-	-	4	-	-
Does waterlogging						
Prevent fully grazing waterlogged land in winter*	58	47	-	47	34	-
Limit pasture growth on waterlogged land in winter *	70	65	-	58	60	-
Fully grazing waterlogged land in spring*	36	29	-	16	15	-
Limit pasture growth on waterlogged land in spring*	41	32	-	18	26	-
Have an unfavourable impact on pasture composition*	55	47	-	31	31	-

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context

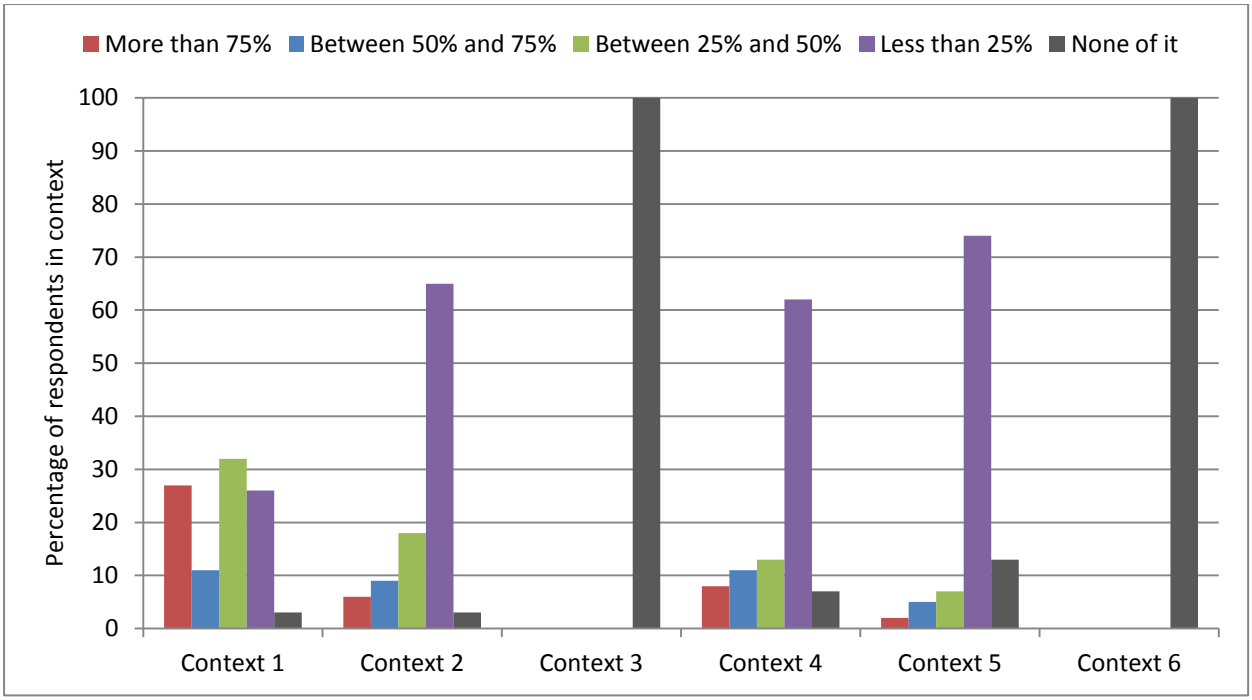

Figure 3: Farm context and extent of waterlogging

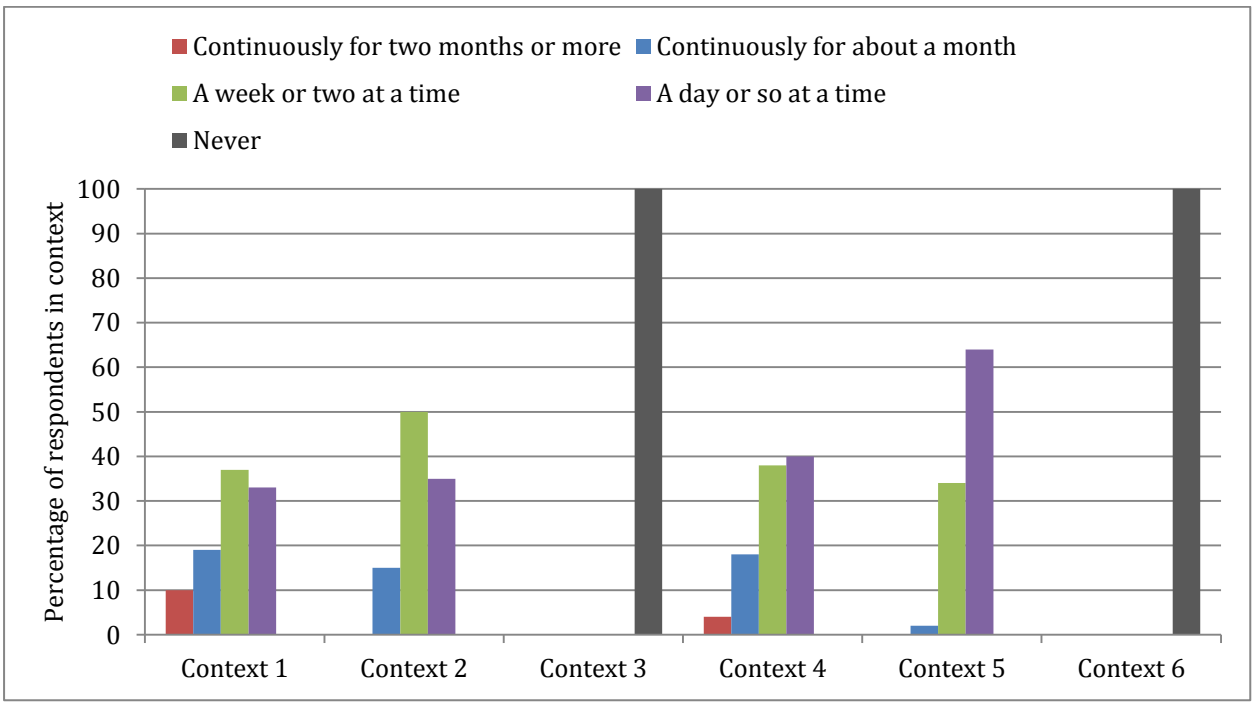

Figure 4: Farm context and duration of waterlogging

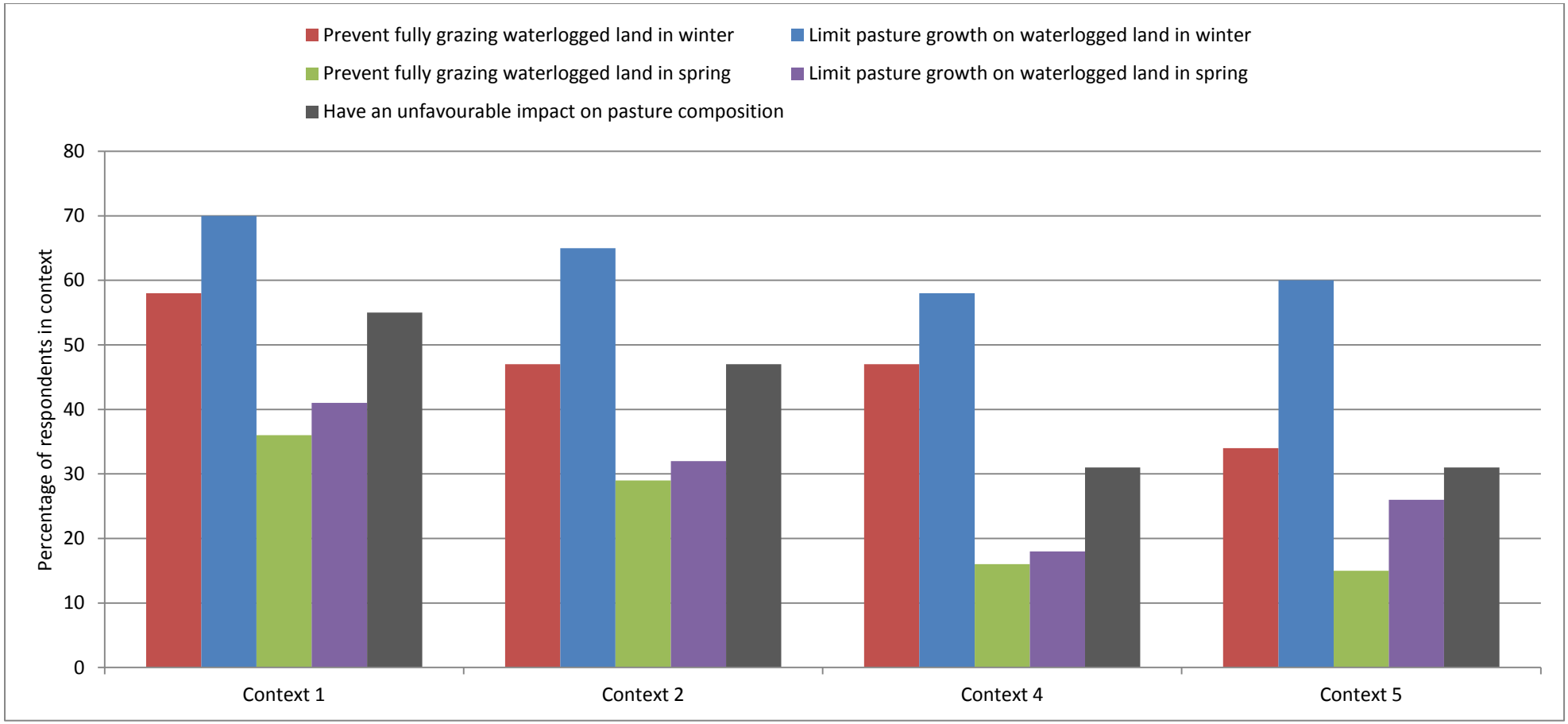

Figure 5: Farm context and effects of waterlogging

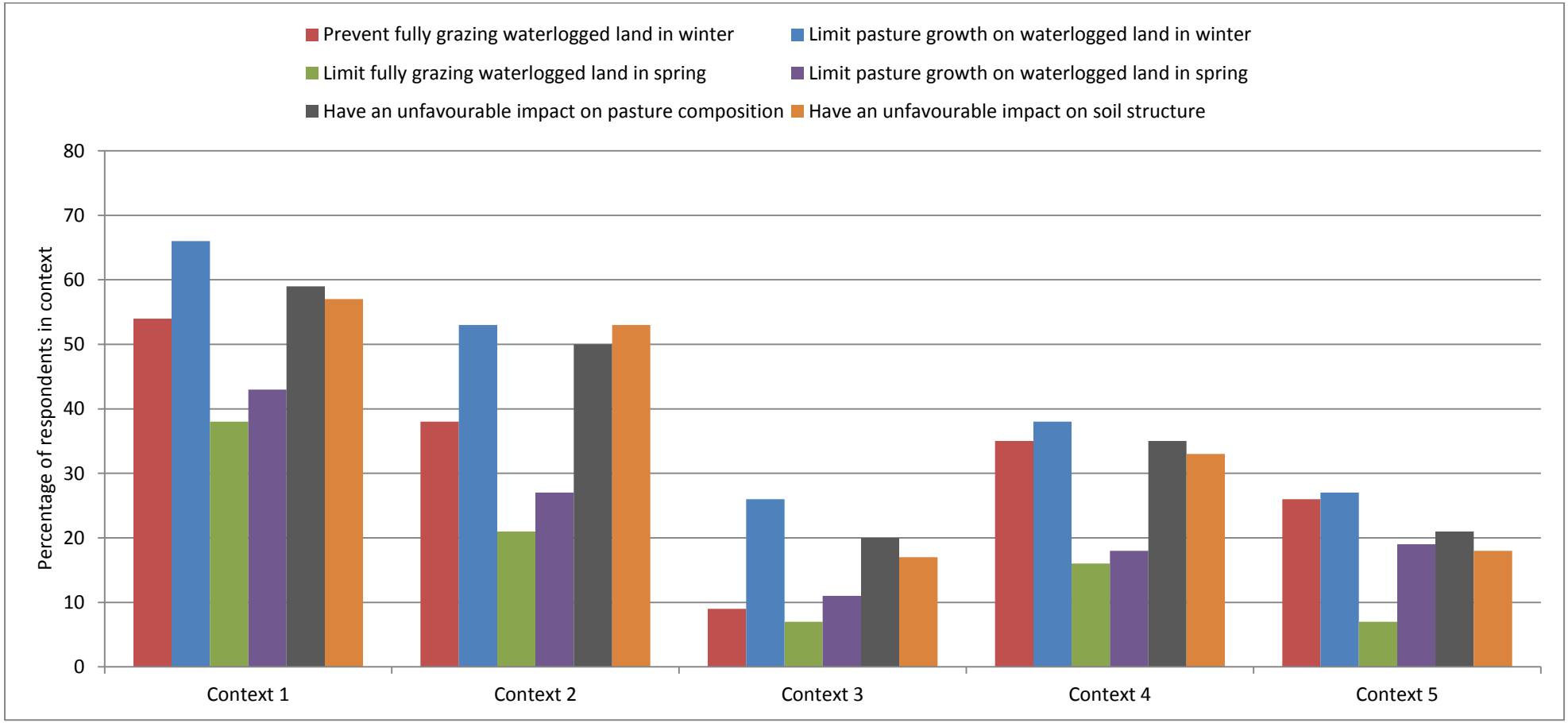

Figure 6: Farm context and effects of pugging

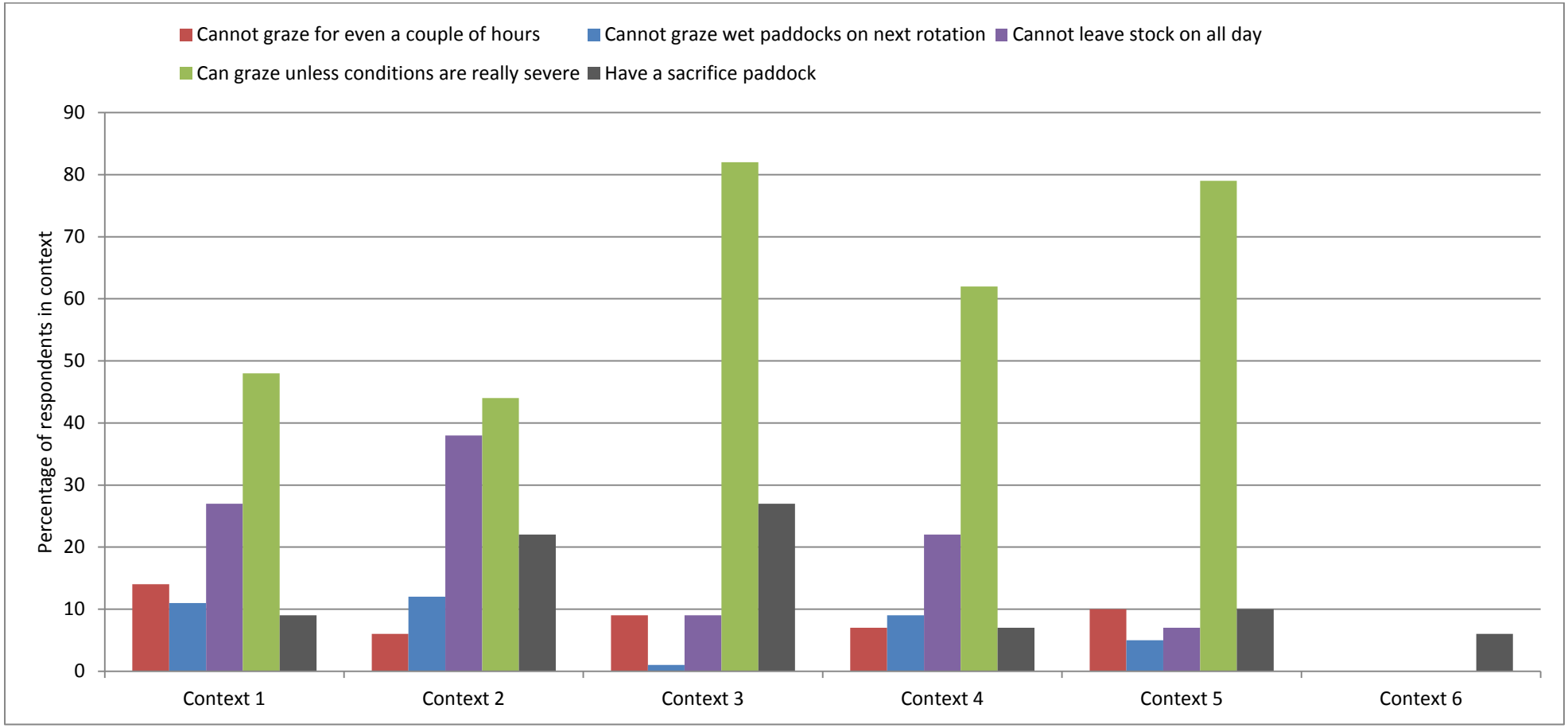

Figure 7: Farm context and descriptions of pugging and waterlogging

Table 3: Farm context and pugging effects

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Does pugging:						
Prevent fully grazing waterlogged land in winter*	54	38	9	35	26	-
Limit pasture growth on waterlogged land in winter*	66	53	26	38	27	-
Limit fully grazing waterlogged land in spring*	38	21	7	16	7	-
Limit pasture growth on waterlogged land in spring*	43	27	11	18	19	-
Have an unfavourable impact on pasture composition*	59	50	20	35	21	-
Have an unfavourable impact on soil structure*	57	53	17	33	18	-

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context

Table 4: Farm context and descriptions of pugging and waterlogging

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Cannot graze waterlogged paddocks for even a couple of hours without damage*	14	6	9	7	10	-
Can graze waterlogged paddocks initially but cannot graze wet paddocks on next rotation without experiencing pugging damage*	11	12	1	9	5	-
Can graze waterlogged paddocks for a few hours without damage but cannot leave stock on all day*	27	38	9	22	7	-
Can graze pretty well all day without pugging unless conditions are really severe*	48	44	82	62	79	-
Don't experience pugging*	-	-	-	-	-	100
Have a sacrifice paddock in winter*	9	22	27	7	10	6

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context

Table 5: Farm context and location*

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Matamata-Piako	3	12	1	2	3	3
Otorohanga	2	6	10	9	18	16
South Waikato	1	3	3	2	5	2
Taupo	-	-	11	-	2	13
Waipa	20	6	27	18	21	20
Waikato	68	65	37	62	45	33
Waitomo	4	6	7	7	7	7
Rotorua	1	3	3	-	-	7

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context

Table 6: Farm context and enterprise characteristics

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Bulls	27	24	22	27	26	28
Dairy heifers	20	32	31	33	32	35
Dairy cows	6	12	15	9	10	18
Beef cows*	85	77	75	86	66	71
Sheep*	34	41	54	51	61	53
Lambs	26	32	33	33	39	35
Stocking rate (Stock units/ha)	11.9	12.5	12.9	10.7	11.4	12.8
Mean farm size (ha)	157	375	199	306	172	201

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context except where indicted otherwise
Stocking rate calculated using conversions reported in Beef and Lamb NZ (2013)

Table 7: Farm context and soil, drainage and rainfall characteristics

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Differences in soil type:						
Pumice on flats*	2	19	13	-	13	26
Pumice on rolling country*	3	8	16	10	4	28
Ash on rolling country*	44	54	64	60	75	66
Clay loam on rolling country*	33	38	9	28	12	9
Clay on rolling country*	45	46	38	20	28	14
Ash on steep country*	48	43	85	74	68	72
Clayness*:						
Clay	59	59	35	55	40	21
Free	24	27	56	33	50	67
Poor	16	15	10	13	10	12
Drainage*:						
Free draining	65	59	82	76	87	85
Poor draining	6	9	5	4	5	4
Mixed	29	32	14	20	8	11
Rainfall*:						
Mean rainfall (mm)	1300	1316	1389	1367	1443	1422

Notes: * Denotes statistically significant differences across contexts
Values are percentage in each context except where indicated.

Winter management practices

Sheep and beef farmers used a variety of management practices to manage conditions over winter. The most commonly used practices were:

- grazing stock on larger areas, or on better or drier paddocks, changing rotation length (except for bulls),
- putting sheep, lambs and beef cows on steeper country or selling them,
- back fencing, strip grazing or break feeding dairy heifers, dairy cows and beef cows,
- feeding hay or silage to bulls, dairy heifers, dairy cows and beef cows, and
- feeding purchased supplements to bulls, dairy heifers and beef cows.

A number of differences were found in the way farmers in different contexts managed stock over winter. Differences in the management of bulls, dairy heifers, dairy cows, sheep, lambs and beef cows are reported in tables 8 through 14.

These differences are also illustrated graphically in figures 8 to 15. Each axis in these figures represents one of the six farm contexts. Each line in the figures represents a management practice. The intersection of a management practice line with a farm context axis represents the percentage of farms in that context that use the management practice. These figures may be interpreted as follows:

- The more circular the shape of a practice line, the smaller the differences in the percentage of farms in each context using the practice. For example, as shown in figure 8 for dairy heifers, moving them to drier and better paddocks.
- The less circular the shape of a practice line, the greater the differences in the percentage of farms in each context using the practice. For example, as shown in figure 9 for dairy cows, grazing them on a larger area and more paddocks.
- The closer a management practice line is to the origin the lower the percentage of farms using the management practice. For example, as shown in figure 8, only a small percentage of farmers stand off dairy heifers.
- The further a management practice line is to the origin the higher the percentage of farms using the management practice. For example, as shown in figure 8, altering rotation length for dairy heifers.
- The more similar the shape of two practice lines the smaller the differences in the use of those management practices across contexts. For example, as shown in figure 8 for dairy heifers, moving them to drier and better paddocks or altering rotation length.
- The less similar the shape of two practice lines the greater the differences in the use of those management practices across contexts. For example, as shown in figure 9 for dairy cows, grazing them on a larger area and more paddocks or altering rotation length.

Bulls

With respect to the management of bulls, farmers in contexts one and two, those most prone to pugging and waterlogging, were relatively more likely than farmers in other contexts to put bulls in a sacrifice paddock over winter (table 8). Farmers in contexts three and five were relatively more likely than farmers in other contexts to shift bulls to drier or better paddocks over winter. This is because they didn't experience waterlogging or only infrequently and so have a greater opportunity to implement this practice than farmers who experience more severe pugging or waterlogging such as those in contexts one, two and four

Dairy heifers
With respect to the management of dairy heifers, farmers in context two in particular were relatively more likely than farmers in other contexts to stand off dairy heifers in winter (table 9). Farmers in contexts one and two, the contexts most prone to pugging and waterlogging, were more likely to shift heifers to drier or better paddocks as well as altering their rotation. Farmers in contexts that were less prone to waterlogging were more likely to manage conditions over winter by either moving heifers to drier and better paddocks or by changing their rotation.

Dairy cows
With respect to the management of dairy cows, farmers in contexts one and two, those most prone to pugging and waterlogging, were relatively more likely than farmers in other contexts to manage dairy cows in winter by changing their rotation (table 10). Farmers in context four, who experience waterlogging but not pugging, were more likely than farmers in other contexts to put dairy cows in sacrifice paddocks.

Farmers in context five, who do not experience pugging and only experience waterlogging occasionally, were more likely than other farmers to manage conditions over winter by set stocking dairy cows on a larger area and moving them to drier and better paddocks.

Beef cows
With respect to the management of beef cows, farmers in contexts one and two, those most prone to pugging and waterlogging, were relatively more likely than farmers in other contexts to manage beef cows in winter by grazing them on a larger area, putting them in drier and better paddocks, putting them in sacrifice paddocks, putting them on steeper country, and selling them (table 11). Farmers in contexts that were less prone to waterlogging and pugging were less likely to use any of these practices, either individually or in combination.

Farmers in context five, who do not experience pugging and only experience waterlogging occasionally, were more likely than farmers in contexts three and four to manage beef cows in winter by grazing them on a larger area, putting them on steeper country and selling them.

Farmers in context six, who do not experience pugging or waterlogging, were less likely than farmers in other contexts to manage beef cows in winter by

putting them in drier and better paddocks and feeding them purchased supplements.

Sheep
With respect to the management of sheep, farmers in contexts one and two, those most prone to pugging and waterlogging, were relatively more likely than farmers in other contexts to manage sheep in winter by grazing them over a larger area, putting them in drier and better paddocks, putting them in sacrifice paddocks, changing their rotation or selling them (table 12). Relatively speaking, fewer farmers in other contexts used these practices and so they were less likely to use them in combination.

Those farmers in contexts two and five, who reported occasional waterlogging, were more likely than farmers in other contexts to put sheep on steeper country.

Lambs
With respect to the management of lambs, farmers in context two were relatively more likely than farmers in other contexts to manage lambs in winter by grazing them over a larger area, putting them in drier and better paddocks, and putting them on steeper country (table 13).

Farmers in context five, who do not experience pugging and only experience waterlogging occasionally, were more likely than other farmers (except those in context two) to manage conditions over winter by putting lambs on steeper country.

Table 8: Farm context and wintering practice (bulls)

Wintering practice:	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Put them in a sacrifice paddock*	22	25	11	7	-	3
Move them to drier / better paddocks*	44	38	50	33	56	18

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.10$)
** Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are percentage in each context with bulls

Table 9: Farm context and wintering practice (dairy heifers)

Wintering practice:	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Stand them off**	15	36	4	17	5	-
Move them to drier / better paddocks**	65	73	44	39	45	27
Alter rotation length**	80	82	36	56	55	46
Do not change how I manage the farm*	-	-	16	17	5	24

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.10$)
** Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are percentage in each context with dairy heifers

Table 10: Farm context and wintering practice (dairy cows)

Wintering practice:	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Set stock over a larger area**	-	25	8	20	67	14
Put them in a sacrifice paddock**	17	-	-	40	-	-
Graze them on larger area/ more paddocks**	17	25	8	20	83	33
Alter rotation length*	67	50	8	-	50	38

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.10$)
** Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are percentage in each context with dairy cows

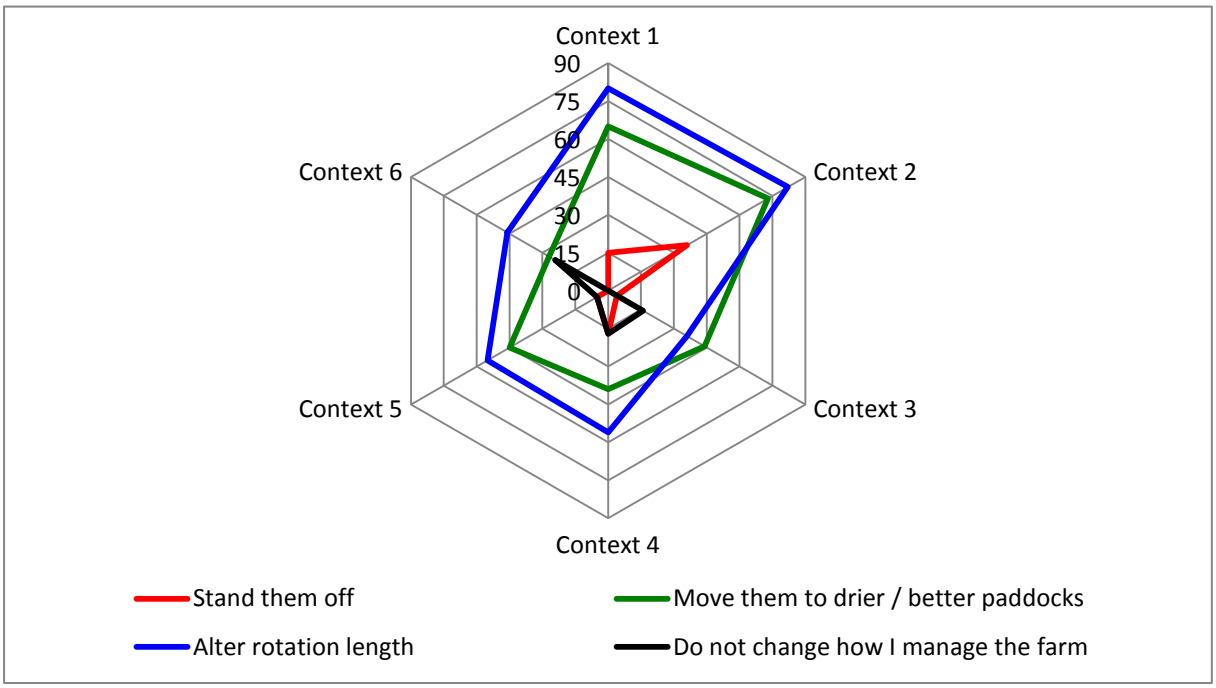

Figure 8: Farm context and wintering practice for dairy heifers

(Values are percentage of those with dairy heifers in each context)

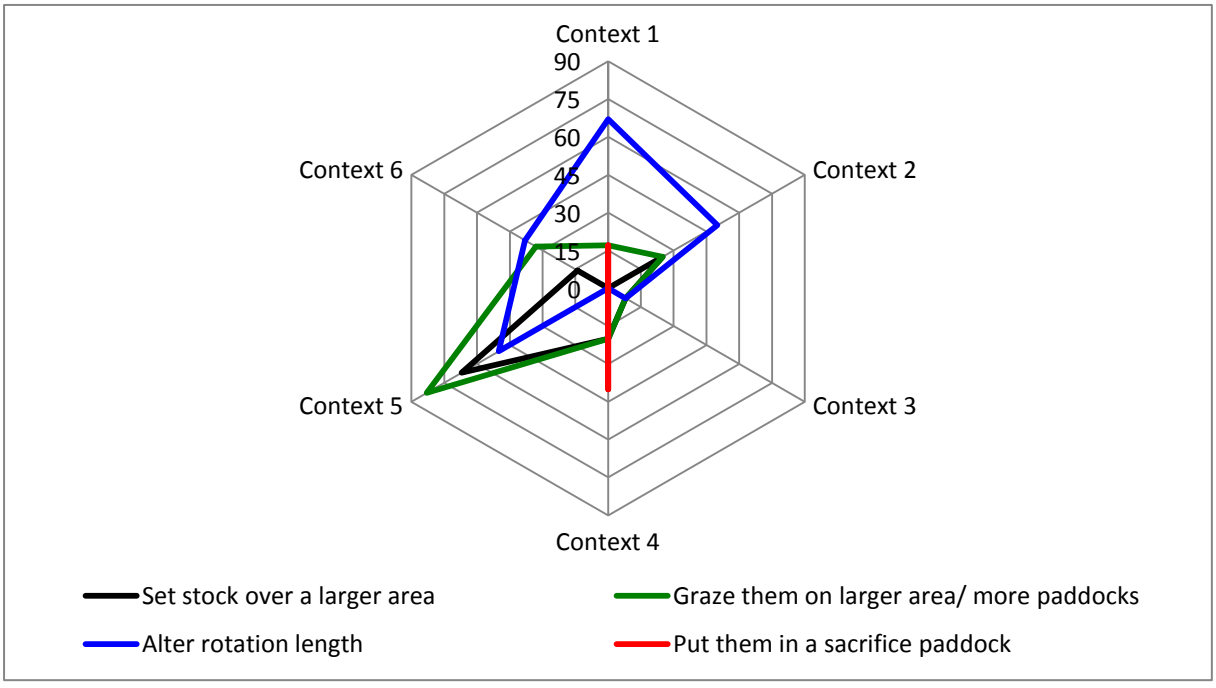

Figure 9: Farm context and wintering practice for dairy cows

(Values are percentage of those with dairy cows in each context)

Table 11: Farm context and wintering practice (beef cows)

Wintering practice:	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Reduce rotation length**	37	58	28	23	44	33
Put lighter cattle on steeper country**	35	54	21	21	39	16
Put them in a sacrifice paddock**	17	23	7	4	5	6
Graze them on larger area/ more paddocks*	43	50	25	26	42	29
Move them to drier / better paddocks**	58	66	31	45	39	26
Feed out purchased supplements**	35	39	33	21	37	14
Feed out hay and silage**	49	56	33	34	59	50
I sell some cattle before winter**	46	73	28	17	46	30
I put them on a winter crop**	1	19	7	13	5	10
Do not change how I manage the farm**	10	4	31	17	7	26

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.10$)
** Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are percentage in each context with beef cows

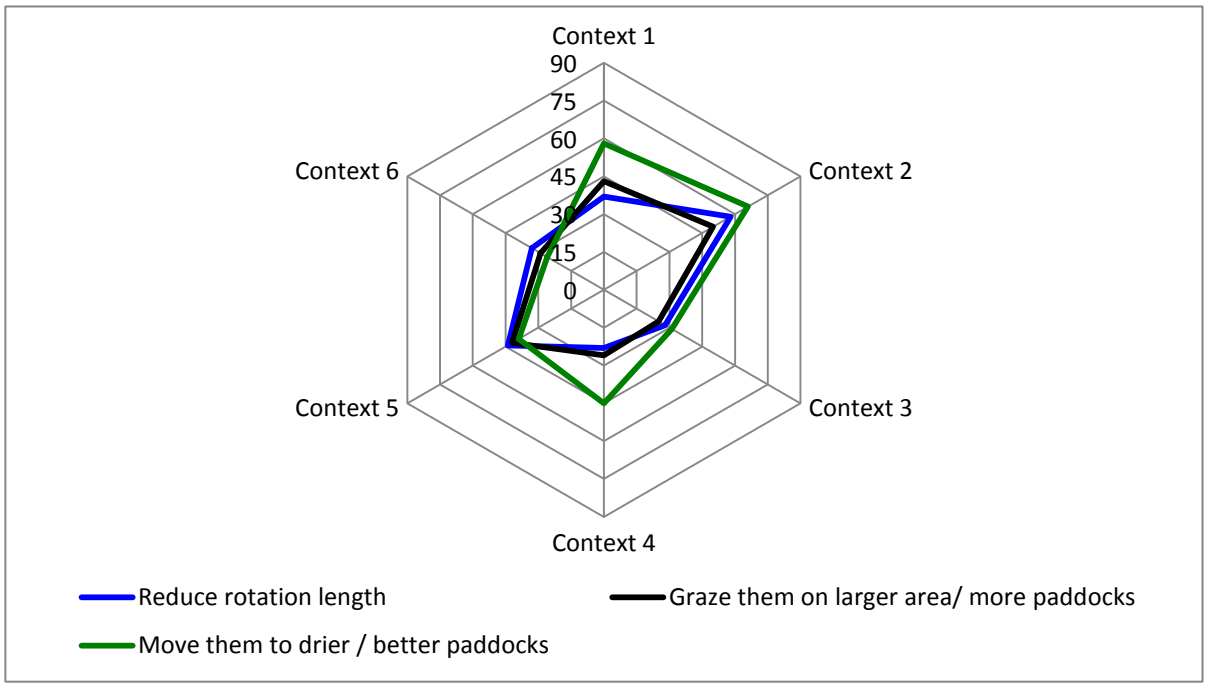

Figure 10: Farm context and wintering practice for beef cows (a)

(Values are percentage of those with beef cows in each context)

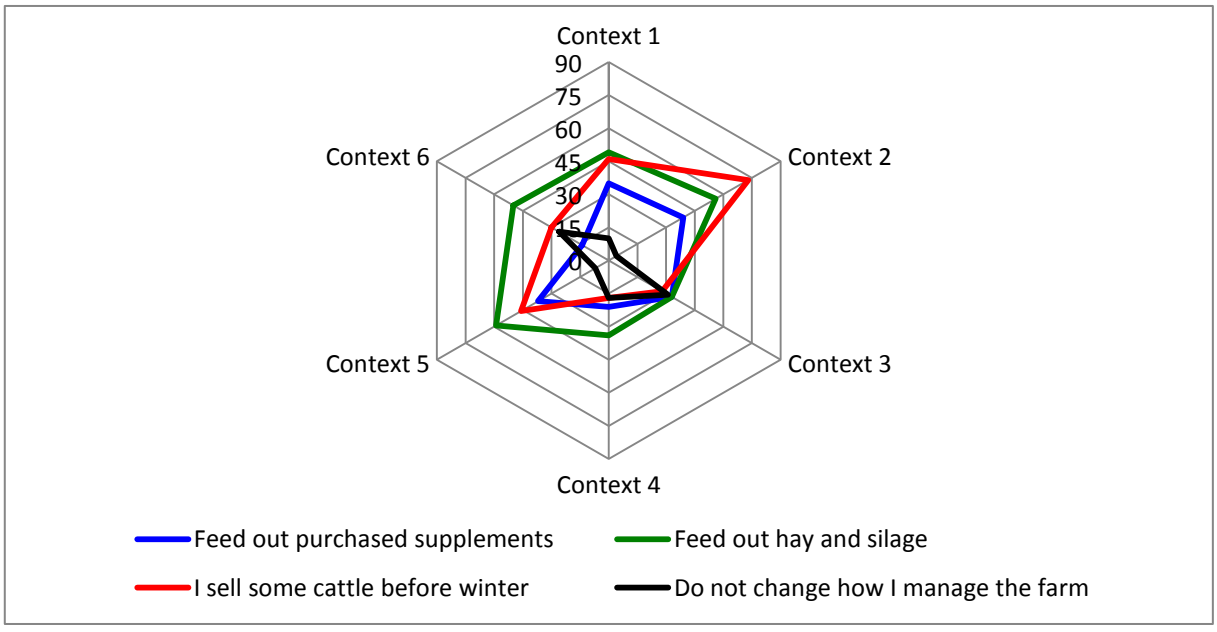

Figure 11: Farm context and wintering practice for beef cows (b)

(Values are percentage of those with beef cows in each context)

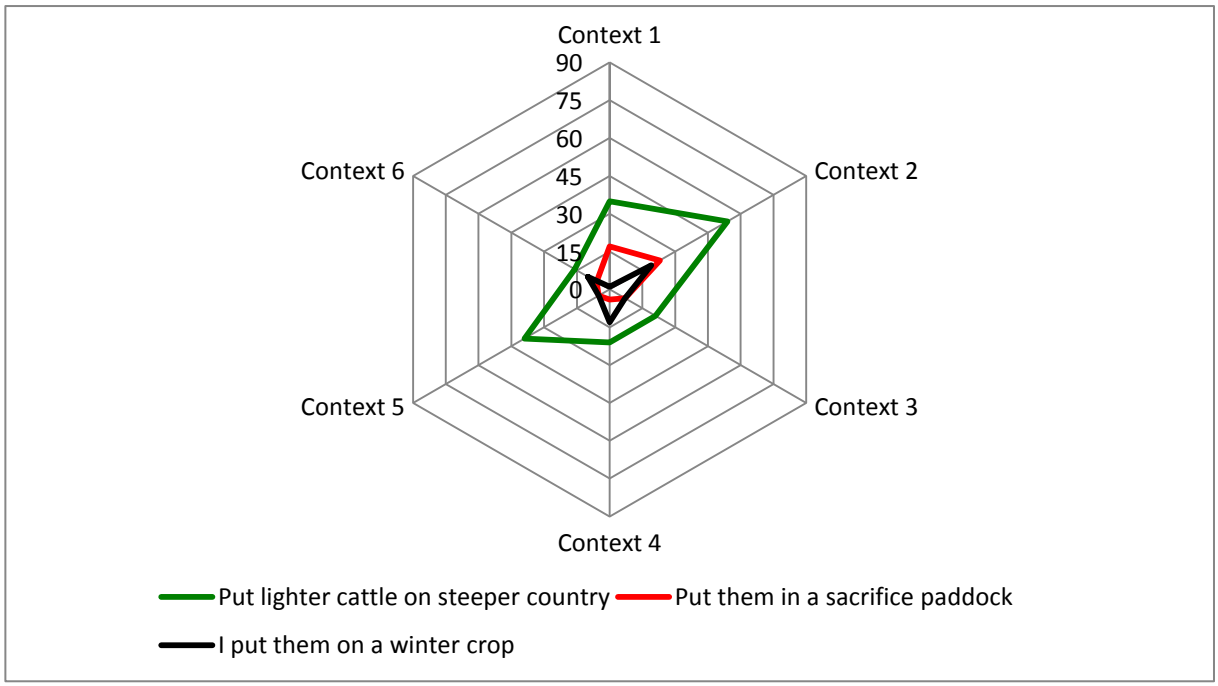

Figure 12: Farm context and wintering practice for beef cows (c)

(Values are percentage of those with beef cows in each context)

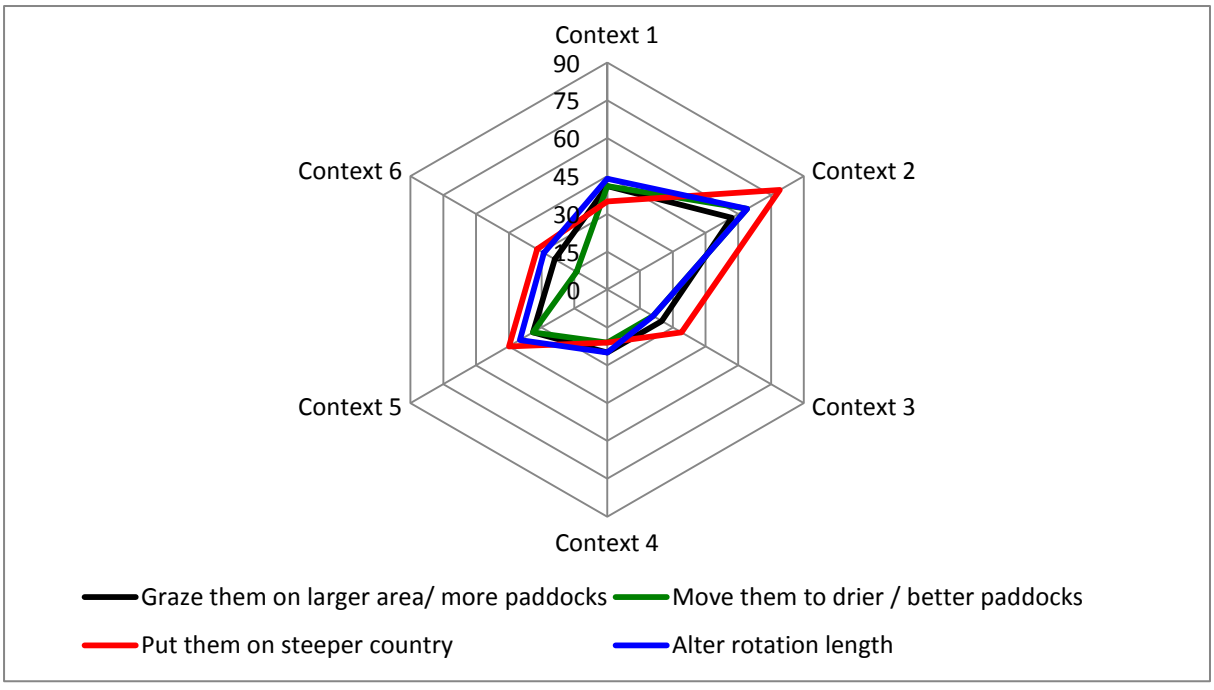

Figure 13: Farm context and wintering practice for sheep (a)

(Values are percentage of those with sheep in each context)

Table 12: Farm context and wintering practice (sheep)

Wintering practice:	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Graze them on larger area/ more paddocks*	41	57	25	25	34	24
Move them to drier / better paddocks**	41	64	21	21	34	14
Put them on steeper country**	35	79	34	21	45	32
Put them in a sacrifice paddock**	17	23	7	4	5	6
I sell some of them before winter**	32	43	11	7	18	25
Alter rotation length**	44	64	21	25	40	29
Do not change how I manage the farm**	23	-	41	36	21	38

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.10$)
** Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are percentage in each context with sheep

Table 13: Farm context and wintering practice (lambs)

Wintering practice:	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Set stock over a larger area**	19	64	15	28	33	20
Move them to drier / better paddocks**	31	73	26	11	38	17
Put them on steeper country**	23	73	19	17	42	29

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.10$)
** Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are percentage in each context with lambs

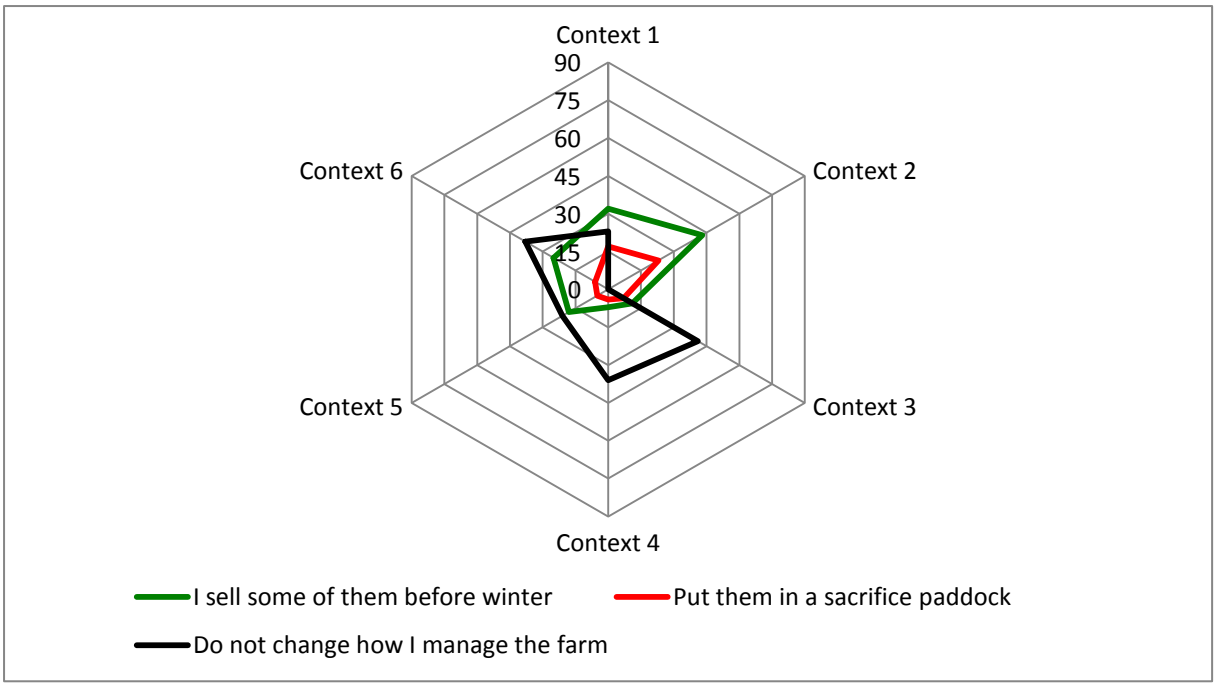

Figure 14: Farm context and wintering practice for sheep (b)

(Values are percentage of those with sheep in each context)

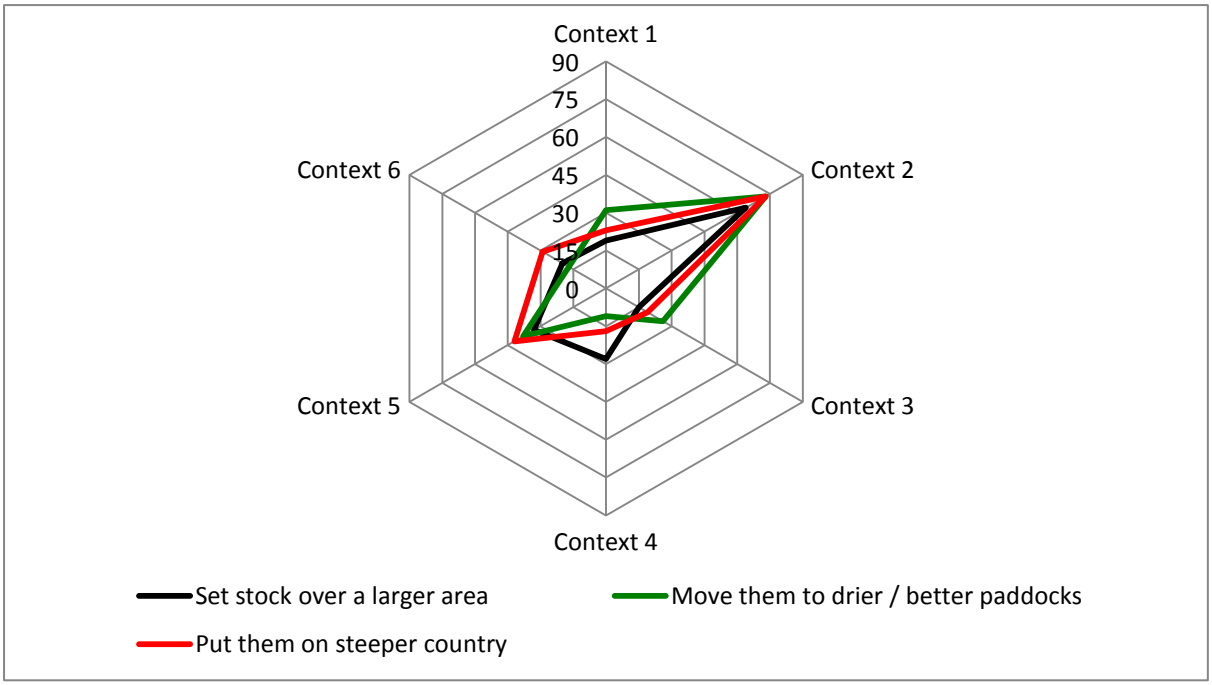

Figure 15: Farm context and wintering practice for lambs

(Values are percentage of those with lambs in each context)

Table 14: Farm context and number of wintering practices

	Context 1 *Pugging and frequent extensive waterlogging*	Context 2 *Some pugging and frequent waterlogging*	Context 3 *Some pugging*	Context 4 *Frequent waterlogging*	Context 5 *Infrequent waterlogging*	Context 6 *No waterlogging or pugging*
Bulls	2.6	2.3	2.1	1.6	2.6	1.4
Dairy heifers*	4.1	4.3	2.7	2.6	3.5	2.3
Dairy cows*	3.0	2.5	1.5	1.8	4.5	2.0
Beef cows*	4.0	5.3	2.6	2.8	4.0	2.7
Sheep*	2.3	3.7	1.8	1.6	2.3	1.9
Lambs*	1.7	3.8	1.6	1.7	1.9	1.7

Notes: * Denotes statistically significant differences across contexts ($p \leq 0.05$)
Values are average number of practices use

Discussion

A number of patterns are evident in the results.

First, and generally speaking, farmers change grazing management practices in winter to accommodate pugging and waterlogging, and the extent of the change increases with the severity of pugging and frequency and duration of waterlogging. Farmers in contexts one and two, the contexts that experience the most severe pugging and waterlogging, are the most likely to manage stock over winter by using a combination of practices such as grazing stock on larger areas, putting them in drier and better paddocks, changing their rotation, putting stock on sacrifice paddocks, putting lighter stock on steeper country, and selling stock. Generally speaking, fewer farmers in other contexts (segments 3, 4, 5 and 6) use these practices and they are less likely to have to use a combination of practices to manage each livestock class (see table 14).

Second, there is a statistically significant and substantial association between farmers reporting of the severity of pugging and waterlogging they encounter and the soil types and drainage on their farms. This suggests that the practices farmers choose to use to manage stock over winter are strongly influenced by biophysical environmental factors. In other words, farmers choose a set of practices to manage stock over winter that are cost effective and practical given the biophysical characteristics of the environment within which they operate. Consequently, restrictions that prevent farmers using these practices to manage stock over winter are likely to severely affect the productive and financial capacity of their farms.

Third, farmers in context one, which experiences the severe pugging and waterlogging, were somewhat restricted in the range of practices they can employ to manage stock in winter because of the severity of conditions on their farms. On the whole, farmers in this context were less likely than farmers in contexts where conditions were not quite as severe to use practices such as grazing stock on larger areas, putting beef cattle, sheep and lambs on drier and better paddocks, putting lighter stock on steeper country and changing their rotation.

Fourth, farmers in context six, which does not experience pugging or waterlogging, were the least likely to have to change grazing management to accommodate conditions in winter.

Fifth, on the whole, farmers in all contexts appear to limit the extent to which they change their management of bulls, dairy cows and dairy heifers to grazing them on larger areas, better paddocks and changing their rotation (excepting bulls). Their flexibility in accommodating winter conditions generally, and waterlogging and pugging in particular, comes from their management of sheep and beef cows and, to a lesser extent, lambs. Farmers in all contexts appear to change their management of beef cows and sheep over winter using some combination of grazing them on larger areas, drier and better paddocks, putting

them on steeper country, feeding supplements, hay and silage, changing their rotation and selling them.

Sixth, there is diversity in the different combinations of practices used in winter to manage sheep and beef. The most commonly used practices were grazing stock on larger areas, or on better or drier paddocks, changing rotation length, putting stock on steeper country or selling stock, implementing back fencing, strip grazing or break feeding, feeding hay or silage and feeding purchased supplements.

As a generalisation, farmers in contexts one and two, who experienced the most severe pugging and waterlogging, tended to use various combinations of three or more of these practices with most types of livestock. Farmers in drier contexts who experience little if any pugging and waterlogging often only had to use a couple of these practices with each type of livestock. An implication of this finding is that there will be differences among farmers in the impact on the productive and financial capacity of their farms of restrictions on the practices they may employ to manage stock over winter.

The results confirm that the management of sheep and beef is heavily influenced by the frequency, extent and duration of pugging and waterlogging that farmers experience during winter and spring. The duration, extent and frequency of pugging and waterlogging is primarily a function of biophysical characteristics of the farm that influence drainage (such as soil type and rainfall).

Conclusion

The results presented here confirm that the practices farmers use to manage sheep and beef over winter are driven by the frequency and extent of pugging and waterlogging that they experience over winter. The duration and frequency of pugging and waterlogging is primarily a function of biophysical characteristics of the farm that influence drainage (such as soil type and rainfall).

The results indicate that there is extensive variety in the combinations of practices that farmers use to manage stock in winter, with the combination any one farmer uses being a function of the biophysical characteristics of their farm.

These results, which are summarised in figure 16, lead to the conclusion that the adoption of management practices for sheep and beef such as grazing stock on larger areas, or on better or drier paddocks, changing rotation length, putting stock on steeper country or selling stock, feeding hay or silage and feeding purchased supplements are motivated by production benefits and these benefits arise from the biophysical characteristics of sheep and beef farms.

The variety in winter grazing management could be summarised into a relatively small number of representative winter grazing systems for sheep and beef based on livestock classes and management practices. These would represent the main

types of winter grazing management systems used by sheep and beef farmers in the Waikato.

Farm context factors such as soil type, location, susceptibility to and extent of pugging and waterlogging, and management practices were significantly different across the six winter grazing contexts. This means that farmers could suffer serious economic losses should they be prevented from using some practices in the future. Conversely, farmers that do not use some practices could suffer serious economic losses should they be compelled to use them in the future.

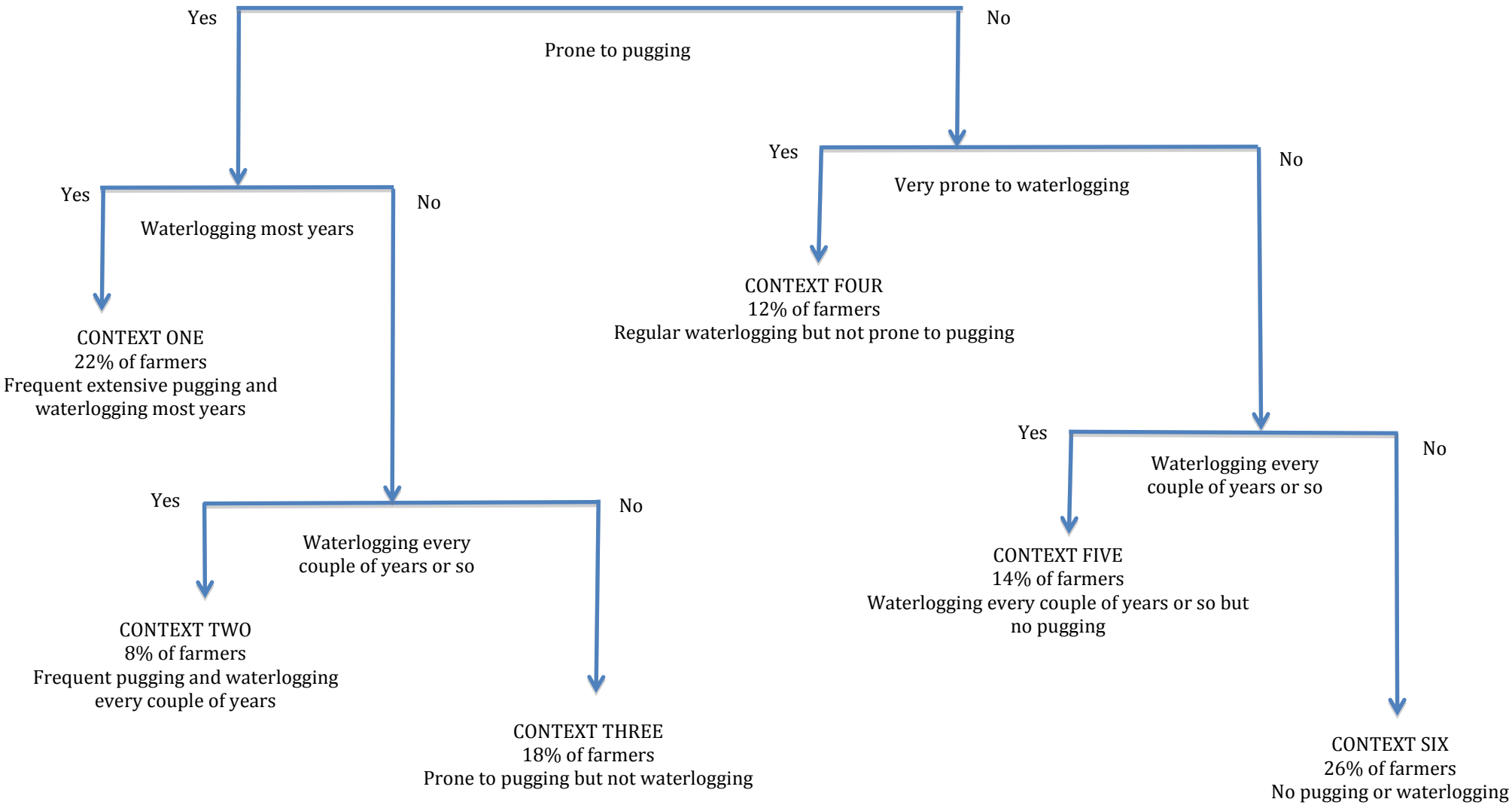

Figure 16: Farm context tree for wintering sheep and beef

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Appendix 1: Winter grazing management practices

Winter grazing management practices on sheep and beef farms in the Waikato and Waipa River catchments that were included in the survey undertaken by Versus Research Ltd and results reported in Versus Research Ltd and Reed (2014).

1. Set stock over a larger area
2. Put stock on a sacrifice paddock
3. Feed out purchased supplements
4. Feed out hay or silage
5. Move stock to drier/better paddocks
6. Move stock to flatter paddocks
7. Alter rotation length
8. Graze stock on a winter crop
9. Back fence, strip graze or break feed
10. Stand them off
11. Graze stock on a larger area/more paddocks
12. Return stock to owner before waterlogged soils are a problem
13. Put stock on the steeper country
14. Sell some of the stock before winter
15. Reduce rotation length
16. Move to set stocking across the whole farm
17. Doesn't change how I manage the farm