Impact of beef cattle grazing systems on treading damage and forage supply

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Abstract

Levels of treading damage were measured for a range of cattle feeding regimes and grazing managements which were compared during winter and spring. These paddock- and systems-based results provide a context within which component research on soil and plants can be interpreted. Soil surface damage was higher in farmlets with heavier cattle (390 kg vs. 200 kg steers) and on paddocks where feeding was restricted through the use of a slow rotation (100–120 days vs. 35–45 days). Where cattle grazed under wet conditions, with a pre- and post- grazing herbage mass of 2400 and 650 kg DM/ha respectively, damage levels reached 60-70% of the soil surface. Under these conditions, 300-350 kg DM/ha of initial forage on offer was pushed onto or into the surface soil; and pasture growth rates during early-mid spring would be reduced by 10 kg DM/ha/day. In practice the objective of grazing plans and management should be to minimise these negative impacts within the constraints of the required feeding regimes. Recommendations are made for the alignment of stock class and enterprise with land capabilities and the feed allocation processes of a winter rotation.

Keywords: cattle grazing systems, forage supply treading damage

Introduction

As a consequence of market forces, greater numbers of heavier cattle are being finished on North Island hill country farms. This means that a greater area and range of soils are being exposed to the potential damage of soil and pasture as a result of treading. Short-term losses in pasture density and production can occur; and surface soil damage provides the potential for sedimentation of waterways (Sheath & Carlson 1997; Nguyen *et al.* 1997). Longer-term effects on soil compaction (Greenwood & McNamara 1992) and aquatic life (Quinn *et al.* 1994) are also possibilities.

Studies at Whatawhata Research Centre seek to determine the impact of treading processes on soil-

water properties and forage supply. This paper reports on the levels of treading damage which occurred under a range of cattle feeding regimes and grazing managements during winter and spring. The results provide a context within which component research on soil and plants can be interpreted. Several practical planning and management recommendations are made with the view of minimising any negative impacts.

Methods

Farm systems compensation (Experiment 1)

A farm systems experiment was run for 2 years, studying the effects of two different winter management systems on cattle performance (e.g., liveweight gain) and soil treading damage. This paper deals only with the treading damage issues.

The experiment consisted of a 2×2 factorial design with 2 replicates, giving a total of 8 self-contained farmlets. Treatments were either rising 1-year (R1-200 kg liveweight) or rising 2-year (R2-390 kg liveweight) Angus steers which were managed in a fast (FR) or a slow rotation (SR) during the winter period (early Maymid August). From mid August on, the SR treatments were allowed to consume any saved feed on their farmlets.

Each farmlet consisted of about 45% easy rolling contour and 55% steep hill land with the R1 farmlets being 7.2 ha and the R2 farmlets 11.9 ha in area. Farmlets were stocked with 15 Angus steers and either 50 or 30 Romney ewes for the R1 and R2 farmlets, respectively. Cattle were run on separate blocks from the ewes through winter and spring. The steep hill soils could be broadly described as Waingaro steep soils, a northern yellow-brown earth derived from argillaceous greywacke (Bruce 1976). The easy contoured areas are a mix of yellow-brown earth (Kawa hill soils) and yellow-brown loam (Dunmore hill soils).

During late winter, all grazed paddocks were assessed for treading damage. This occurred over a 6-week period in the first year of the study (16.7.93–20.8.93) and a 7-week period in the second year (8.7.94–24.8.94). At the completion of each grazing, paddock assessments of treading damage involved measurements at 100 points (2 mm diameter) along fixed transect lines. If present, visual treading

damage (Sheath & Carlson 1997) and bare ground was recorded at each point; and land class was categorised as either stock camp, easy contour ($<25^{\circ}$) or steep contour ($>25^{\circ}$).

During the first experimental year, rainfall was high until the beginning of the treading study (i.e., early July), but during the study conditions were relatively dry (Table1). Rainfall pattern in the second year was somewhat reversed, with high rainfall occurring during the study period (i.e., July–August).

Controlled growth path (Experiment 2)

During the winter and spring of 1995, an experiment was run to study nutrition and seasonal interactions in cattle performance. The design was a 3×2 factorial, with no replicates. Treatments were 3 pasture allowances (high, medium and low) by 2 sex/breed differences (Friesian bulls or Angus steers). All treatments were allocated 10 rising 2-year-old cattle. The experiment was broken into 2 periods of 8 weeks duration, viz winter (16 June–10 August) and spring (11 September–6 November).

All land grazed within the experiment was of an easy contour (easy contoured soil type as described; <15° slope). Pre-graze pasture mass was similar between treatments and differing pasture residuals were used to generate the feeding allowances. Different paddock areas were allocated to each treatment in order to achieve these residuals. Grazing durations were 3–4 days (i.e., 2 shifts per week) for all treatments.

Damage level for each paddock was assessed as described for Experiment 1. Gravimetric soil moisture levels (0–75 mm) were also assessed for each paddock at the end of the grazing duration. Rainfall was 23% above the long-term average during both the winter and spring experiments (Table 1).

Table 1 Rainfall (mm) for the relevant experimental months of 1993–1995 and the long-term site mean.

	June	July	August	September	October
1993	245	39	129	89	78
1994	134	250	153	263	165
1995	261	287	142	184	170
Long-term mean	176	175	160	136	137

In order to estimate the amount of pasture which was buried during grazing, 36 quadrats (0.32 m \times 0.26 m) were marked out after grazing each week (6 per treatment) to cover the full range of damage levels. Plots were assessed for treading damage and then 8 soil cores (45 mm diameter) were taken from each plot. Above-ground herbage was removed from the cores, and then cores were broken up and pasture leaf and pseudostem trodden onto and into the soil was removed, washed, dried and weighed. Linear regressions, which relate the effect of treading damage to the amount of herbage trodden onto and below the soil surface, were developed for the winter and spring experiments.

Results

Experiment 1

During the 6-week study period of the first year, the pre- and post-graze herbage mass for the SR treatments were 3100–3300 kg DM/ha and 700 kg DM/ha respectively (Table 2). Under these nutritional conditions approximately 30% of the cattle block was grazed and this represented an equivalent rotation length of 120 days. Where cattle were moved more rapidly in the FR farmlets (i.e., 45-day rotation length), 80–90% of the paddocks in the cattle blocks were grazed. The pre- and post-grazing combinations for the FR farmlets were 2300–2500 kg DM/ha and 1000–1200 kg DM/ha, respectively.

Table 2 Grazing conditions in Experiment 1 and the resultant levels of treading damage and bare ground.

Stock class and rotation speed	Steer liveweight (kg)	Land area grazed (%)	Grazing rotation length (days)	Pre-graze herbage mass (kg DM/ha)	Post-graze herbage mass (kg DM/ha)	Steep land trodden (%)	Treading damage (% and SE)	Bare ground (% and SE)
1993								
R1, FR	212	97	45	2547	1183	12.4	34.2 ±1.7	13.1 ±1.6
R1, SR	198	33	123	3175	682	9.4	35.0 ± 2.7	26.4 ±3.2
R2, FR	406	79	46	2367	994	10.5	39.0 ±1.8	19.5 ±1.9
R2, SR	377	27	115	3306	699	9.1	54.6 ±1.5	36.1 ±3.5
1994								
R1, FR	208	130	37	1912	1118	24.6	17.9 ±1.4	12.4 ±1.2
R1, SR	197	38	103	2410	823	17.6	36.0 ±2.8	22.4 ±2.5
R2, FR	366	134	40	2150	1155	18.4	21.3 ±1.5	10.9 ±1.2
R2, SR	338	40	99	2630	758	18.3	46.0 ±3.1	24.3 ±2.8

Where cattle were grazing to lower residuals in the SR treatments, higher levels of bare ground were recorded. Only in the R2 farmlets was this reflected in higher soil surface damage levels. Within the R1 treatments, damage levels were similar. The heavier R2 steers (\approx 390 kg) caused more damage and bare ground than the R1 steers (\approx 200 kg) when comparisons are made within their rotation treatments.

During the 7-week study period of the second year, post-grazing levels were managed to achieve a similar outcome to the first year. However, all pre-graze levels were lower and consequently all treatments moved more rapidly (i.e., shorter rotation length). For the SR farmlets 40% of the paddocks were grazed, whereas all paddocks in the FR farmlets were grazed at least once. As in the first year, the grazed paddocks of SR farmlets had greater levels of damage and more bare ground. Similarly, the heavier R2 cattle caused more soil surface damage.

A more detailed description of the average damage levels recorded for each week of both study years are given in Figures 1 and 2. During winter 1993, the significant feature was the similarity in damage pattern between the R1, SR cattle and the two FR farmlets. During winter 1994, a similar situation occurred until the week of 26 July. Thereafter, soils were wetter, damage levels were higher and the R1, SR farmlets recorded similar damage to their older and heavier counterparts.

Experiment 2

This experiment sought to compare the nutritional responses of R2, Friesian bulls and Angus steers during winter and spring and concurrently provided the opportunity to measure treading impacts associated with these treatments. Because there were no significant differences in treading damage between bulls and steers, data are averaged for the three nutritional treatments across these two stock classes (Table 3).

Figure 1 Treading damage (% soil surface) during winter 1993 of Experiment 1.

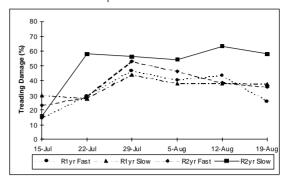
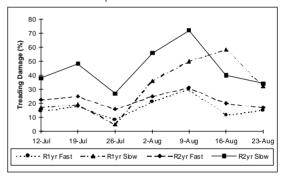


Figure 2 Treading damage (% soil surface) during winter 1994 of Experiment 1.



For both winter and spring, pre-grazing herbage mass was managed to similar levels of 2400 kg DM/ha. To generate the nutritional differences, residual grazing levels ranged from 600 to 1400 kg DM/ha in winter and 700 to 1600 kg DM in spring. The low residual/allowance treatments were therefore similar to the R2, SR farmlets of the previous experiment; and the high residual/allowance more closely represented the R2, FR

 Table 3
 Grazing conditions in Experiment 2 and the resultant levels of treading damage and lost herbage.

	Steer liveweight (kg)	Total area grazed (ha)	Pre-graze herbage mass (kg DM/ha)	Post-graze herbage mass (kg DM/ha)	Treading damage (%)	Trodden pasture (kgDM/ha)
Winter						
High allowance	441	13.09	2458	1394	39.3	240
Medium allowance	424	8.58	2407	987	53.5	300
Low allowance	408	5.76	2379	647	64.3	346
SED					2.05	
Spring						
High allowance	533	14.07	2468	1599	23.0	196
Medium allowance	511	8.76	2473	1162	30.7	235
Low allowance	472	5.57	2451	728	36.6	265
SED					3.2	

farmlets during winter. Cattle were heavier in this experiment and, combined with wet soil conditions (Figure 3), overall treading levels were higher in winter compared with Experiment 1.

As grazing residuals were reduced, the levels of soil surface damage increased. Where nutritional allowance was lowest, an average of 64% of the soil surface was damaged in paddocks grazed during the winter. Under drier soil conditions in spring, treading damage levels were approximately half those of the corresponding winter treatments.

Figure 3 provides greater detail on rainfall, soil moisture and the resultant, damage levels during winter 1995. Throughout the study period, soil moisture levels were high, sometimes exceeding the plastic limit (72% oven dry weight) for this soil type. Under these controlled experimental conditions, levels of treading damage remained relatively consistent within treatments.

While soil moistures were at or below 70% during spring (Figure 4), the treading damage was low and treatment differences were not great. Only during a wet 2–3-week period, when soil moisture approached the plastic limit, did damage levels match those during the winter in terms of both absolute level and treatment relativity.

Within this experiment, the amount of herbage trodden onto and below the soil surface was estimated. The linear regressions that relate trodden herbage (H-kg DM/ha) to levels of soil surface damage (D-%) are:

Winter H =
$$4.23 D + 74 (r^2 = 0.33**)$$

Spring H = $5.11 D + 78 (r^2 = 0.51**)$

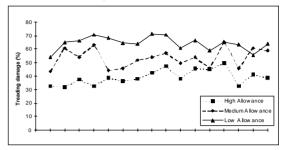
In translating these relationships into the context of Experiment 2, this suggests that the average amount of trodden herbage for a single grazing, ranged from 240 to 340 kg DM/ha during winter and 200 to 260 kg DM/ha during spring (Table 3).

Discussion

The general treatment effects are consistent with expectations, in that managements involving heavier cattle and/or lower grazing residuals resulted in greater treading damage. More significant to this discussion are the implications of these damage levels for forage availability and resource status.

The immediate effect of treading is reduced herbage utilisation. In these experiments, treatments which mimic a slow rotation and aim to maintain cattle live-weight, resulted in visual damage to 45–65% of the soil surface during winter (R2 cattle). At the upper level, this would represent a loss of 350 kg DM/ha of pre-graze allocation. With targets of pre- and post-graze combinations of

Figure 3 Treading damage (% soil surface), soil moisture (%) and rainfall (mm over 3.5 days) during winter 1995 in Experiment 2.



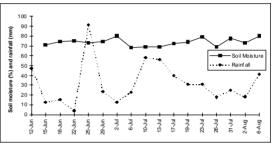
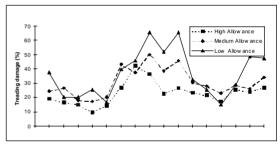
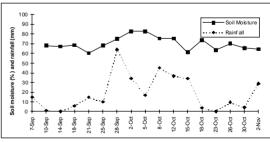


Figure 4 Treading damage (% soil surface), soil moisture (%) and rainfall (mm over 3.5 days) during spring 1995 in Experiment 2.





2500 and 700 kg DM/ha herbage mass respectively, this would represent a 20% wastage of available feed. The consequence would be underfeeding relative to budgeted targets. From a feed allocation perspective, it is also worth noting that even under high feeding regimes

(i.e., high residuals, fast rotations) herbage losses owing to treading are in the vicinity of 150–200 kg DM/ha for heavier R2 cattle, and 100–150 kg DM/ha for lighter R1 cattle.

It could be argued that by reducing grazing intensity (i.e., faster stock rotation) the impact of treading will be lessened. However, there are several important consequences arising from reducing grazing duration and/or stock density. Feed rationing power is reduced and, therefore, the probability of a late winter-early spring feed deficit is higher. Further, if more rapid movement of herds lead to paddocks being grazed 2+times during the winter, then:

- feed levels will be lower for the second time around and animals will be more mobile as they search for feed:
- the accumulated forage losses and damage levels from two grazings is just as likely to be the same or higher than from a single grazing.

Single treading events during winter can also have carry-over effects for spring pasture growth rate. The results of Sheath & Carlson (1997) would suggest that at least during the early spring period of August-September, pasture growth rates would be reduced by 10 kg DM/ha/day where damage was 60% of the soil surface area. This is a particularly significant reduction for mixed livestock pastures where average growth rates for these months may be only 25–30 kg DM/ha/day. Even more important, it is occurring at a time when both sheep and cattle enterprises are most sensitive to nutritional changes (Sheath *et al.* 1987).

The data from these experiments can give only an indication of likely effects arising from single grazing events. However, it is known that a predominance of cattle grazing over several (3+) years can lead to changes in pasture composition and reductions in total annual herbage production (Lambert *et al.* 1985). Such a grazing system can also lead to high soil losses and sedimentation of wetlands and waterways (Lambert *et al.* 1985). Extrapolating the results of Sheath & Carlson (1997) for easy-contoured ash soils, a range of soil surface damage levels of 30-60% would lead to sediment losses of 4–20 g/m² if rainfall and soil moisture conditions were such that surface runoff of water occurred.

In farming cattle through a winter, the reality is that some treading damage will occur. The challenge is to minimise this damage. For instance, heavier cattle certainly create greater levels of damage; therefore a general objective of the cattle finishing enterprise would be to design and achieve growth paths which ensure animals are marketed before their second winter, i.e., as

rising 2-year-old cattle. In addition, a knowledge of the soil's robustness to treading would be of great assistance. This is indicated by the soil moisture plastic limits which tend to be greater on volcanic ash-derived soils than sedimentary- and alluvial-based soils. Heavier cattle can be concentrated on these more robust soils when moisture levels approach their plastic limits. This of course highlights the benefits of monitoring soil moisture levels. The current work of AgResearch at Ballantrae (Betteridge *et al.* 1997) will lead to good management guidelines in this respect.

Given the above, it would seem sensible to manage cattle in a way that damage is concentrated on a small area so that remedial action can follow. This may involve reseeding at the end of a break, and then continuous grazing by sheep over the spring. More rapid recovery of pasture cover is encouraged by this type of spring management (Sheath & Carlson 1997). With this approach, it would be prudent to separate heavily damaged areas from waterways by a grazed riparian strip; and ensure that no surface water channels flow through the damaged area and directly into a waterway. The objective should be to confine any negative effects to the farm itself.

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