THE EFFECTS OF GRAZING MANAGEMENT ON PASTURE AND BULL PRODUCTION OVER THE LATE-AUTUMN TO EARLY-SPRING PERIOD

by

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Abstract

The Massey University Tuapaka farm has been operating a bull beef enterprise for 15 years. During this period, late autumn grazing management has been based on a rotation length of 50 days in order to save pasture for the winter. However this intent is seldom achieved, leading to low pasture cover at the end of the winter and low liveweight gain in early-spring, which in turn compromised final bull slaughter weights. The objective of this research was to design and evaluate winter grazing management systems based on pasture condition targets and to compare the outcome with the normal Tuapaka management. The aim was to maximise pasture growth rate and animal liveweight gains in late-autumn in order to winter heavier bulls at higher pasture covers than the traditional Tuapaka grazing system. Wintering heavier bulls at the target pasture cover (1800-2000 kg DM/ha) the winter grazing management would focus on maintaining pasture cover around 2000 kg DM/ha throughout the winter in order to reach early-spring with an average pasture cover around 1700-1800 kg DM/ha. This way the grazing management in this period would again target sward conditions for high net pasture accumulation and liveweight gains. The trial was conducted at the Tuapaka bull unit, Massey University, from 1 April to 30 September 1997. It compared three contrasting managements, involving a total of 165 bulls stocked at 2.6 bull/ha. Treatment 1 followed a predetermined grazing plan based on a predicted the average pasture growth rate, the animal requirements needed to achieve performance targets, and on pre- and post-grazing pasture mass targets (2700-2800 kg DM/ha and 1500-1600 kg DM/ha for late-autumn and early-spring, and 3000-3200 kg DM/ha and 1100-1200 kg DM/ha for winter). Treatment 2 was managed according to the same pre- and post-grazing targets, except in this case post-grazing covers were monitored daily, and the bulls shifted when the post-grazing targets were achieved. No supplement was considered for Treatments 1 and 2. Treatment 3 followed traditional Tuapaka management, based on 50 day rotation over the autumn and winter, and 30 day rotation in August and bulls set stocked in September. Hay was fed as required in winter at the rate of 120.6 kg DM (pasture equivalent) per hectare. The initial pasture cover and bulls liveweight did not differ between treatments. Results showed a significant difference in average pasture cover ($P < 0.1$) over the autumn, although no difference was found in pre and post-grazing cover, apparent daily dry matter intake, and net herbage accumulation. Over the winter, Treatments 1 and 2 pasture cover did not differ, and both were significantly ($P < 0.001$) higher than Treatment 3. Pre-grazing cover was significantly ($P < 0.01$) different between all treatments, while there was no difference between Treatments 1 and 3 in post-grazing cover and apparent daily dry matter intake, and both were lower ($P < 0.001$) than Treatment 2. Net pasture accumulation of Treatment 1 did not differ from Treatments 2 and 3, however there was a significant difference ($P < 0.05$) between these two last ones. In early-spring, Treatments 1 and 2 pasture cover and post grazing cover did not differ and were higher ($P < 0.001$) than Treatment 3. Pre-grazing pasture cover was different ($P < 0.01$) between all treatments. Net pasture accumulation of Treatments 1 and 2 did not differ and both were higher ($P < 0.05$) than Treatment 3, while the average apparent dry matter intake of Treatments 1 and 3 were similar and both were different ($P < 0.05$) from Treatment 2. The overall liveweight gain (0.84 ± 0.02, 0.87 ± 0.02, 0.74 ± 0.01 kg LW/head/day for Treatments 1, 2, 3 respectively) and liveweight (354.7 ± 3.54, 359.8 ± 3.65, 335.6 ± 3.27 kg LW) did not differ between Treatments 1 and 2 but both were significantly ($P < 0.001$) different from Treatment 3. Total pasture production was significantly different ($P < 0.10$) between Treatment 1 (6147 kg ± 369.34 DM/ha), Treatment 2 (7062 kg ± 319.86 DM/ha), and Treatment 3 (5277 ± 334.08 kg DM/ha). The total pasture production of Treatments 1 and 2 were 16 and 30% higher than Treatment 3. The extra pasture production per 100 kg DM/ha of increase in pasture cover was 1.64 and 3.38 kg DM/ha/day for Treatments 1 and 2 respectively. It was concluded that it is possible to improve both pasture production and bull beef performance when grazing management is based on pre and post-grazing pasture targets, and the practical implications of this were discussed.

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1. Literature Review

1.1 Introduction

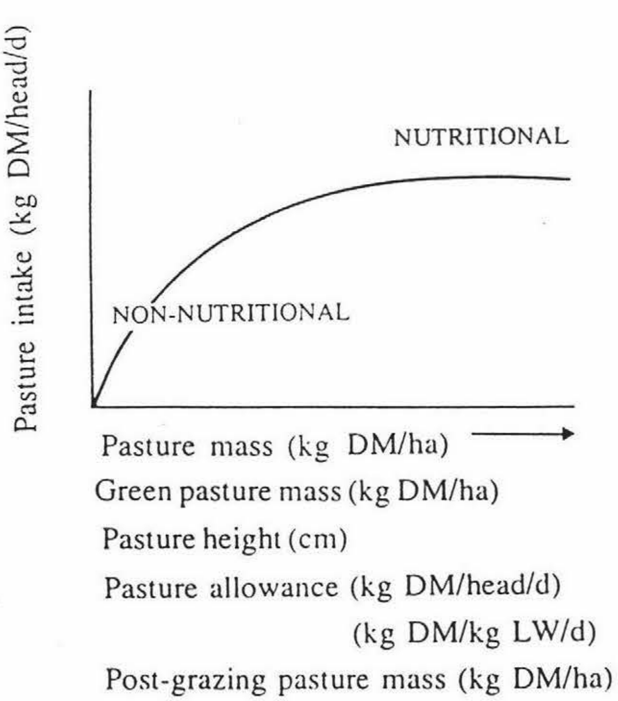
New Zealand farming systems are based almost entirely on pasture grazed *in situ* by the animal. Therefore it is important to understand the interaction between pasture and animal, in order to identify opportunities to improve the farming system.

In this review the affects of pasture quality and structure on animal performance will be outlined together with the effects of the grazing animal upon pasture production. In addition, the grazing management system on the Tuapaka Bull Beef unit at Massey University will be reviewed, as this unit in recent years has failed to meet the original animal performance targets. Hence, a grazing management will be suggested for the farm in order to maximise both pasture and animal production and, at the same time, minimising supplement inputs. This management will be tested on a large scale farmlet form 1 April to 30 September 1997.

1.2 Pasture Factors Affecting Intake of Grazing Ruminant

The pasture intake by the ruminant is represented by a curvilinear function which is influenced by both non-nutritional and nutritional factors. Pasture intake increases in a diminishing proportion as pasture allowance increases until it reaches a constant (Trigg and Marsh, 1979; Forbes and Hodgson, 1985). Pasture allowance is expressed in several ways: pasture mass, green pasture mass, pasture height, and post-grazing pasture mass (Figure 1.1). The first ascending part of the curve is affected by the ability of grazing animal in harvesting the grass. It is more related to pasture structure, and grazing behaviour which includes intake per bite, diet selection, bite size and grazing time (non-nutritional factors) (Hodgson et al., 1994). Therefore, at lower levels animal intake is more affected by pasture availability (quantitative factors) (Marsh, 1979; Stockdale, 1985; Reid, 1986; Morris et al., 1993) than its quality (qualitative factors). The second part of the curve or the plateau is more affected by the quality of pasture available, as pasture allowance is at its maximum. The amount of pasture eaten will depend on pasture digestibility, and the higher the forage digestibility the higher the plateau, and steeper the slope. It means that with pasture of high digestibility intake levels will increase even at lower allowances. (Poppi et al., 1987).

Figure 1.1. The relationship of pasture intake to various pasture characteristics and methods of pasture allocation.



1.2.1 Grazing Behaviour

The amount of herbage eaten by a ruminant is the ultimate factor affecting their production level. The more they eat the higher the production of milk by dairy cows, wool by sheep or meat by cattle and sheep (Hodgson, 1990). Therefore, it is important to study the factors which effect their intake levels.

The amount of herbage eaten by ruminants depends on the forage availability, its accessibility and the grazing preference by the grazing animal, the time spent on grazing, and the quality of forage ingested. The first three items are directly affected by grazing behaviour which is a function of intake per bite, number of bites per period of time grazed, and the grazing time (Hodgson, 1984). The influence of each variable in the ruminant grazing behaviour on animal performance will be discussed in the following sections.

1.2.2 Intake per Bite

Intake per bite can be divided into three variables: Bite depth, bite area, and bulk density of the sward. In early studies, it was believed that intake per bite increased linearly with sward height (Milne et al., 1982; Burlison et al., 1991). More recent studies (Laca et al., 1992a; 1992b; 1992c) under more controlled sward conditions showed that this relationship is asymptotic, and it has a positive relationship with sward height and an inverse relationship with density. Further, the influence of sward height on intake per bite is considerably higher than the pasture density (Hodgson, 1981). Thus, bite depth has a greater influence on intake per bite than bite area and bulk density (Milne et al., 1982; Hughes et al., 1991; Mitchell, et al. 1991; Mursan et al., 1989).

1.2.3 Grazing Time and Biting Rate

There are some variations in grazing time, but on average it takes between 6 and 12 hours per day grazing, depending on sward conditions. The remaining hours will be used for ruminating (6-8 hours), and resting (Phillips, 1989; Hodgson, 1990). Almost all of grazing happens between sunrise and sunset, while most of ruminating activity occurs after sunset. There is also a ruminating period in the afternoon and a small period of grazing at night. In warmer climates this period of night grazing will be increased (Chacon and Stobbs, 1976).

Biting rate is defined as the number of bites per minutes. The average biting rate for a dairy cow in order to achieve its daily intake varies form 20,000 to 40,000 bites over the grazing period. The rate of biting is highly affected by sward height. It is inversely proportional to the intake per bite, and it increases with reduction in sward height together with the grazing time (Jameison and Hodgson, 1979; Forbes and Hodgson, 1985). However, this compensation in grazing time and biting rate seldom offset the intake reduction due to reduced intake per bite (Jameison and Hodgson, 1979; Hodgson et al., 1994).

1.2.4 Selective Grazing

Herbage eaten is generally of higher quality than the whole sward. Sheep and cattle, both show preference for green leaf than for stem and dead material (Hughes et al., 1984; L'Hullier and Poppi, 1984; Clark et al., 1982.). In mixed swards, the grazing animal shows preference for clover rather than grass (Hughes et al., 1984; Clark and Harris, 1985; Torres-Rodrigues et al., 1997).

However, some contrasting results have been published in this area. For example, Milne et al., (1982) found a strong relationship between the clover content in sward and in the diet. Some recent papers have found that clover preference might be influenced by the way it is offered. When grass and clover are distributed in strips, selection for clover was higher than on swards where both were intimately mixed (Clark and Harris, 1985; Torres-Rodrigues, 1997).

The preference of green leaf over stem and dead matter by grazing cattle or sheep is more clear (Dougherty, 1989; Hodgson, 1990). For example, It was shown by several authors (Gardner, 1980; Laidlaw, 1983; L'Huiller et al., 1984) that sheep are able to graze lower layers in order to select higher quality feed, and that they are more selective than cattle. This factor explains why sheep's dry matter intake drops faster than cattle's as pasture quality drops (Collins and Nicoll, 1986).

This selection means, the grazing ruminant is able to select a higher quality diet than that of the whole sward. This difference is greatest in swards with high levels of dead material of low digestibility. Lambs and calves, in this situation, tend to select green leaves which have higher digestibility. However, the higher quality of the diet than the total sward does not always reflect that the animal is selecting better quality food. Sometimes it reflects the difference of digestibility from the top (higher quality) to the bottom (lower quality) of the sward (Hodgson, 1990).

1.2.5 Forage Nutritive Value

Nutritive value is normally expressed in terms of digestibility. Plants with higher digestibility have higher concentrations of digestible nutrients and result in faster rumen out flow rates in the grazing animal (Waghorn and Barry, 1987; Thorton and Minson, 1973). The higher rumen out flow leads to higher forage intakes by the grazing animal, therefore, improving digestibility will give a double advantage to the grazing animal, since it increases the nutrient concentration in the diet, and increases the amount of forage ingested (Hodgson, 1977; 1990).

Forage nutritive value is influenced by pasture species, maturity, grass physiological state and season. Pasture species digestibility is influenced by the proportion of structural and soluble carbohydrates. The higher the proportion of soluble carbohydrates the faster the digestion since structural carbohydrates an more slowly digested. Legumes have a higher proportion of soluble carbohydrates than grasses. Legumes, therefore, are digested faster than grass at any level of digestibility (Ulyatt, 1981; Minson, 1981; Waghorn and Barry, 1987).

Plant maturity highly influences herbage digestibility and intake by grazing ruminants. As a pasture matures, the highly digestible leaf becomes a small proportion of the sward and its digestibility decreases with the increase in less digestible sward components. Also, the proportion of the less digestible stem increases in the sward together with the dry matter content in pasture. The proportion of structural carbohydrates increases and reducing the levels of ready digestible carbohydrates (Waghorn and Barry, 1987). In addition, with maturity structural carbohydrates become more lignified reducing it digestibility, since lignin is not digested by ruminants (Minson, 1981; Waghorn and Barry, 1987).

In New Zealand, white clover/perennial ryegrass swards at the reproductive stage in late-spring/early-summer have a higher dry matter content than winter and spring pastures. This reduces the rate of digestion and the rumen out flow (Geenty and Rattray, 1987). In addition, different species have different reproduction periods, and during this period, the dry matter content increases due to the production of seed heads and not due to elongation of leaves. Although seed heads have high digestibility when young, as they mature digestibility drops very rapidly reducing pasture quality (Geenty and Rattray, 1987).

1.2.6 Pasture Allowance

Pasture allowance is the total amount of herbage offered per head per day (e.g. kg DM/head/day or kg DM/kg LW/day). It may be expressed in several ways, such as: intake (or production) relative to allowance, pasture height, green pasture dry matter mass, and post-grazing pasture mass.

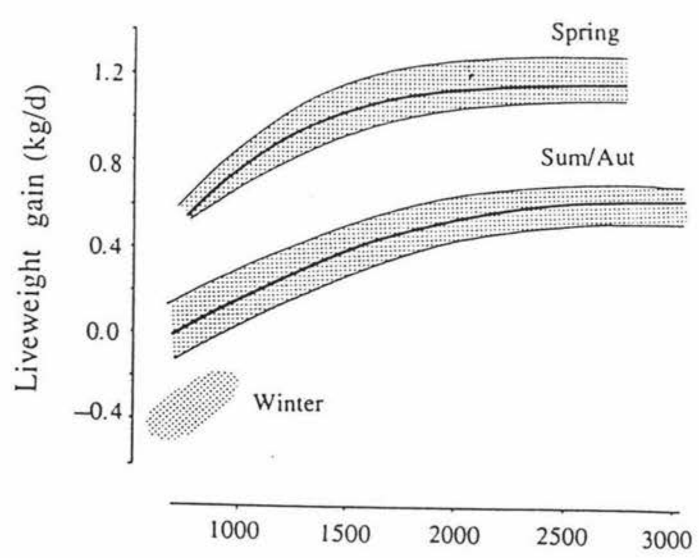
It was shown by several authors that the daily herbage intake of grazing animals increases with the amount of pasture offered (Hodgson, 1977; Marsh, 1977 and 1979; Wade and Le Du, 1981; Stockdale, 1985; Dougherty et al., 1987 and 1992). Marsh (1977 and 1979) worked with Friesian steers at several pasture allowances, with the highest 2-3 times the animal requirements, and found a linear response to liveweight gain to increasing dry matter allowance. He suggested that animal intake was still being restricted at this level of allowance. Rattray and Clark (1984) suggested that intake reaches a maximum at pasture allowance 3-5 times that of intake. However, the level of pasture utilisation will decrease as pasture allowances increase (Marsh, 1979; Smeaton, 1983; Hodgson, 1984).

The relationship between pasture height and forage intake by ruminants was studied by Hodgson et al. (1979); Hodgson, 1985; Reid (1986); Swift et al., (1989); Wright and Whyte (1989); and Morris et al., (1993). High liveweight gains demands high pasture allowances, and at the same allowances animal performance will vary according to the season. For example, maximum liveweight gains are normally higher in spring than in autumn at the same pasture allowances (Reid, 1986; Morris et al., 1993). It was suggested that over the autumn pasture intake is maximised at pasture height of 12-15 cm, whereas over the spring maximum liveweight gains were achieved at values between 8-10 cm. The reasons for that performance variation are not very clear, but some authors relate the lower performance over the autumn to pasture quality (Clark and Brougham, 1979).

From the practical point of view, pasture allowance is very difficult concept for farmers to grasp. Therefore, it is important to express allowance in terms of either residual height or mass which is normally visual assessed. Liveweight gain was reported to be maximised at grazing residuals herbage mass of 1500-2000 kg DM/ha in spring and between 2000-2500 kg DM/ha in autumn (Marsh, 1979; Reardon, 1977; Reid, 1986; Nicol and Nicoll, 1987) (Figure 1.2). Similar relationship has been presented for dairy cattle (Holmes and Wilson, 1987; Holmes, 1987).

Conversely, the effect of pre-grazing herbage mass on daily intake is not as high as the post-grazing levels provided it is within the range of 1500-4000 kg DM/ha and a similar pasture allowance is maintained. Pasture digestibility reduced at a pasture mass of 2900 kg DM/ha in spring-autumn, and 3200 kg DM/ha in winter (Hoogendoorn et al., 1992; Holmes et al., 1993).

Figure 1.2. Relationship between liveweight gain of growing cattle and post-grazing pasture mass (Nicol and Nicoll, 1987).



1.2.6.1 Stocking Rate Effect

Another way to control pasture allowance is through stocking rate. Increasing the number of animals per hectare will reduce the amount of pasture available per animal per hectare. Therefore, the amount of herbage eaten per animal is reduced, and individual animal performance progressively declines as stocking rate increases (Everitt and Ward, 1974; Holmes and Wilson, 1987; Holmes, 1987; Hodgson, 1990; Clark, 1992).

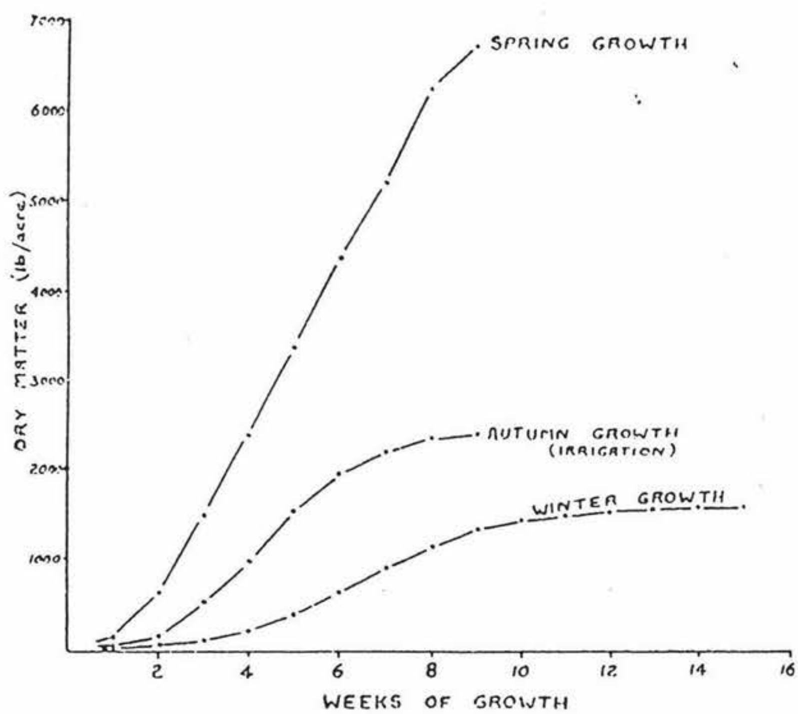
However, increasing the number of cattle per hectare will increase the production per hectare, but will reduce the performance per head. The production per hectare increases up to a point where the forage intake per animal is not enough to support reasonable liveweight gains, reducing the production per hectare (Everitt and Ward, 1974; Clark, 1992). However, particularly for beef production, carcass weight highly influences the final product price, almost always the biological optimum point is not close to the economical optimum point, and lower stocking rates will be more suitable for the beef farming systems (Everitt and Ward, 1974; Clark, 1992).

The decrease in performance at higher stocking rates can be explained not only by the intake per animal, but also by the lower digestibility of the pasture ingested. As stocking rate increased, the proportion of leaf increases the stem and dead material decreases in the sward but the digestibility of the intake is reduced due to a reduction in the opportunity of the animal to select live plant material (Hodgson, 1990).

1.3 Sward Dynamics

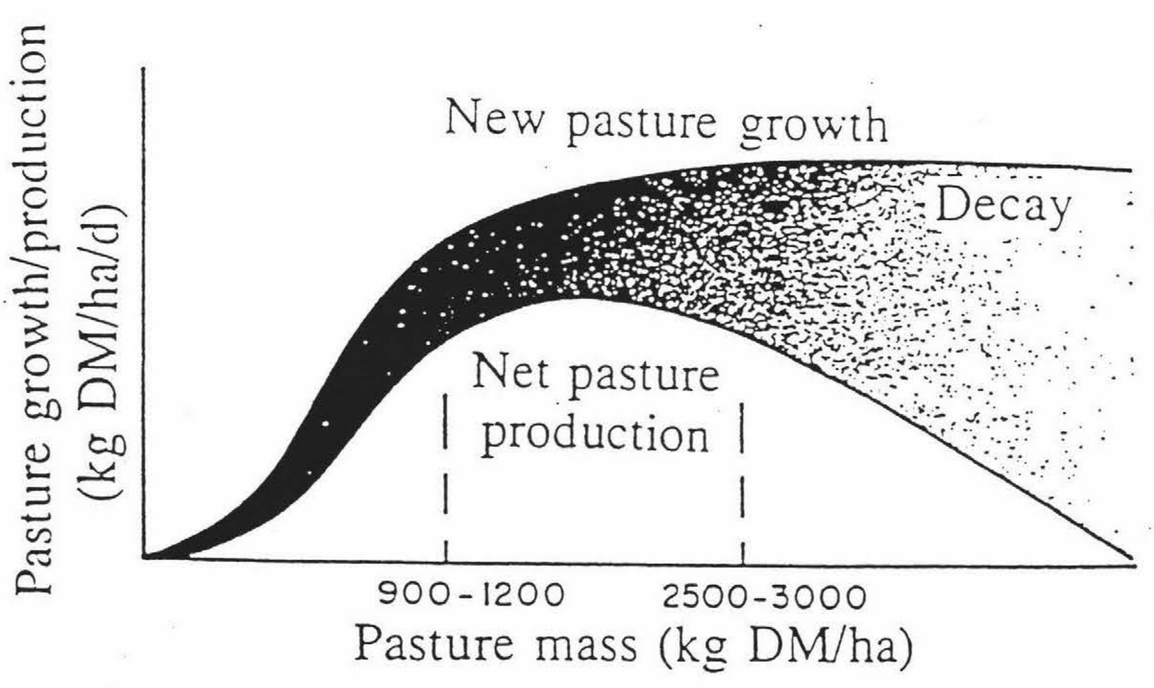
The affect of grazing management on pasture production was initially shown by Brougham (1955, 1956a, 1956b, 1957, and 1960). He studied the effect of intensity of grazing on pasture growth after grazing. It was shown that the pattern of growth rate followed a sigmoid or "S" shaped curve, having a phase of slow growth after grazing, followed by a period where growth was maximised and then a period where pasture growth rate reduces until it becomes negligible (Figure 1.3). He also found that the initial period of slow growth and pasture production was highly dependent on the amount of pasture left after grazing. This shows the influence of residual leaf area and leaf area on the rate of pasture production. However, in his studies Brougham could not explain the reason for the ceiling pasture production. He suggested that it was mainly caused by the lack of nutrients to support further growth.

Figure 1.3. Fitted logistic curve for total herbage and ryegrass yields (lb. DM/ac) for four dates of spelling (Brougham, 1957).



It was almost 30 years before the ceiling pasture was understood. For British swards, Bircham and Hodgson (1983) suggested that net pasture growth rate is maximised between 1250 and 1550 kg DM/ha with net herbage production falling rapidly outside the range of 1000-2500 kg DM/ha. At a lower pasture cover leaf area was too low to intercept available sunlight to maximise pasture growth, while at a higher pasture cover senescence will increase reducing net pasture production. (Net pasture production is defined as the difference between pasture grown and what is lost by decay) (Figure 1.4). However, Matthew et al., (1995) suggested that for the less dense New Zealand swards, maximum accumulation is achieved at a pasture cover between 2000-3000 kg DM/ha. In fact he concluded that pasture growth rate increased by 2 kg DM/ha/day for every 100 kg DM/ha increase in pasture cover over the range of 1000- 2000 kg DM/ha.

Figure 1.4. Relationship between herbage growth, herbage production and decay versus pasture mass (Bircham and Hodgson, 1983).



These factors led Matthews (1994 and 1995) to suggest that pastures should ideally be managed within the range of 1200-3000 kg DM/ha. This in turn would lead to an average pasture cover of 2100 kg DM/ha throughout the year. Further, he suggested that in rotational grazing cattle systems the potential range of pasture cover variation over which pasture production and animal production is not restricted could be between 1700-2500 kg DM/ha. Suggesting an optimum pasture cover for the winter would be between 1700-2100 kg DM/ha, while for the spring it would be around 2000-2400 kg DM/ha.

In order to make this system work, pre and post-grazing targets should be set, monitored, and managed. Post-grazing levels work as a trigger in the system, and whenever residuals drop below target supplements are offered to the herd, or herd numbers reduced, in order to maintain intake levels and optimum residual for pasture re-growth. Conversely, pre-grazing mass control is important to maintain quality and growth rates of the pasture. Above 3000 kg DM/ha, pasture quality is reduced and senescence increased, leading to lower intakes and growth rates (Hoogendoorn et al., 1992; Holmes et. al., 1993).

1.4 The Tuapaka Case

Bull beef farming is a relative new enterprise in New Zealand, and therefore less research has been done in this area. The Tuapaka farm, at Massey University, was run as a sheep and beef farm until 1983, when it was divided in bull unit (the flats) and sheep and beef unit (hill country unit). Due to the lack of information in this area, McRae and Morris (1984) carried out a study in order to define the most profitable bull beef farming system to establish. They tested different stocking rates, selling and purchase time, and developed a financial analysis for each farming system studied.

The best farming system was based on the spring purchase of weaners. This policy would be run at a stocking rate between 3 and 4 bull/ha, with a final carcass weight target between 220 and 240 kg per bull. Weaned Friesian bulls purchased in mid-November would be sold by the end of March of the following season. Therefore, the first two seasons that followed this study started in November 1982 at the planned stocking rate of 3.7 weaners/ha. However, the high stocking rate showed to be very ineffective over the winter, and high supplement inputs had to be used. This led to low final carcass weights (McRae, 1988). In 1988 the stocking rate was reduced to 2.75 bull/ha with the objective of improving performance over the winter and achieving higher final carcass weight per bull.

1.4.1 Tuapaka Targets

Since 1988 the Tuapaka bull beef unit has been farming at a stocking rate of 2.6-2.8 bull/ha in order to reach a minimum average liveweight of 470kg at mid-January at 18-20 months of age, with 275 bull per year finished on the 99 ha farm. Production is mainly pasture based. However, a regrassing and cropping policy has been adapted which allows the renewal 1/15 of the farm every year, and at the same time provide supplement forage in the summer and winter. The predominant crops planted have been radish or turnips for the summer, and black oats for the winter. These forage crops ensure feed supply in the two seasons of expected low pasture growth rate. The extra supply in these two season was on average 240 kg DM/ha/year. In addition, approximately 50 kg DM (pasture equivalent) per ha of hay are supplemented during the winter.

Liveweight targets and the average liveweights achieved are presented in Table 1.1. It shows that weaners have been purchased in mid-November at an average liveweight of 100kg, and the six-year average final liveweight is 468 kg. The targets were obtained by simply adding 10% to the six-year average. The final target weight is 515 kg by the end of December. Therefore, the aim is to gain 415kg in approximately the 410 days the bulls are on the farm, giving a average daily gain of 1.0 kg/head/day. The actual achieved has been 0.89 kg/head/day of gain.

Table 1.1. Tuapaka average bull liveweights (kg) and monthly targets (kg).

Weights are End of Month figures
Figures in italics are average of previous and following months

Birth Dt	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
	Target: 5yr avg + 10%	127	147	178	202	226	256	287	309	316	344	371	433	468	515	530
Spr88	1988/89	117	142	172	188	206	214	229	236							
Spr89	1989/90	110	128	145	181	187	221	250	260	262	278	310	378	418	458	
Spr90	1990/91	114	128	157	171	210	234	262		285	306	343	421	420	461	
Spr91	1991/92	113	132	174		210	230	262	305	296	315	330	407	451	491	
Spr92	1992/93		128	165	189	214	243	265	277	288	335	364	392	436	487	504
Spr93	1993/94	123	139	160	190	210	225	252	274	287	314	339	404	430	460	
Sp94	1994/95	119	150	172	*188*	204	243	274	290	306	326	335	360	400	450	460
Spr95	1995/96	110	147	161	*177*	187	219	245	267	287						
	Avg 89/90 - 94/95	116	134	162	184	206	233	261	281	287	312	337	394	426	468	482

1.4.2 Tuapaka Grazing Management

The Tuapaka grazing management can be divided in 5 different periods: late-spring, early-summer, late-summer/autumn, late-autumn, winter, and early-spring. Starting from late-spring, when there are two stock classes on the farm (the weaners and rising two years bulls from the previous year). From January to March, all the R2ys bulls will be marketed and again there will be only one stock class on the farm until mid-November, when new weaners will be purchased.

Table 1.2.Tuapaka bull beef unit monthly pasture cover (kg DM/ha) and six year average (kg DM/ha).

YEAR	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	MEAN
1988/89	1483	1423	1332	1273	1400	1601	1519	1675	1546	1545	1640	1565	1500
1989/90	1214	1062	1402	2202	2488	2164	1739	1668	1693	1839	2152	1625	1771
1990/91	1257	1270	1075	1286	2072	2104	2151	1802			1576	1614	1621
1991/92	1388	1442	1194	1194	1203	1247	1225	1323	1391	1696	1717	1557	1381
1992/93	1240	1249	1029	804	1114	1935	1837	1552	1766	1767	1600	1740	1469
1993/94	1439	1166	1221	1415	1607	1462	1468	1377	1132	1189	1264	1600	1362
1994/95	1350	1276	1285	1282	1271	1200	935	910	1578	1868	1727	1244	1327
1995/96	1079	1022	996	1380	1750	2100	1600	*1600*	1900	2200	*1800*	1595	1585
1996/97	*1254*	809	1177	1224	1738	2243	2299	2390					1642
6 yr ave	1315	1244	1201	1364	1626	1685	1559	1439	1512	1672	1673	1563	1488

1.4.2.1 Late-spring

During this period bulls are set stocked and the weaners for the next season are purchased. The weaners averaging 100 kg LW are grouped in one mob and rotated through the paddocks with higher pasture cover. The target liveweight gains in this period are 1 kg LW/day and 1.3 kg LW/day for the weaners and R2ys bulls respectively. The average pasture cover for the period is 1672 kg DM/ha (Table 1.2).

1.4.2.2 Early-Summer

This is the period when the bulls from the previous season will start to be marketed, as they reach the minimum liveweight targeted of 470 kg/bull. Because the number of R2ys bulls starts to reduce the weaner calves are set stocked together with the R2ys bulls according to the pasture cover of each paddock. It is expected that all the R2ys bull will be sold by the end of March. The weaners liveweight gain for this period is 0.88 kg LW/day, while the big bulls are expected to gain enough weight to be marketed. The average pasture cover for this period is just above 1550 kg DM/ha (Table 1.2), and the paddock (normally around of 4 ha) of forage crop is grazed.

1.4.2.3 Late-Summer/Autumn

At this stage all bulls from the previous season are expected to be sold. The weaners are managed on a 30-day rotation until 1 April. Rotation length increases to 50 days, in order to save pasture for the winter. Paddocks larger than 3 ha are split in two and they are grazed for 4 or 5 days, depending on size. The average pasture cover on 1 April is 1500 kg DM/ha, and it reaches 1700 kg DM/ha by the end of May (Table 1.2). The liveweight gain target for the period is 1.0 kg LW/head/day.

1.4.2.4 Winter

This season starts with the same grazing management of the autumn. However, 6 kg of hay per head is supplied to each mob in the last grazing day, if it is a 4-day grazing period, or in the last two days if it is a 5-day grazing period. In August, an area around 4 ha of winter crop is supplied for the mob with the lowest pasture cover, while the other mobs will go to a rotation of 30 days including the paddocks of the mob on the crop. The total supplement input is around 30000 kg DM for the period or around 300 kg DM/ha. The target liveweight gain for the period is 0.62 kg LW/head/day. The average pasture cover starts at 1700 kg DM/ha in 1 June and drops to 1200 kg DM/ha by the end of August (Table 1.2).

1.4.2.5 Early-Spring

At this stage, all the bulls are normally set stocked. The pasture cover by the end of the winter is around 1200 kg DM/ha (Table 1.2), and therefore there is no other option but to spread out the bulls in order to maximise their intake during the pasture spring flush. This management aims to take advantage of the compensatory growth in this season caused by the intake restriction over the winter. During this period target liveweight gain is 1.4 kg LW/day (Table 1.1).

1.5 The Dairy Farming Example

New Zealand dairy farming has been based on high pasture utilisation and production per hectare. Until recently, production per hectare was achieved by increasing stocking rate. This led to under fed cows and low production per cow. Matthews (1994) argued that such systems were likely to reduce net herbage production as a result of the high stocking rates and low grazing residuals used. He presented an alternative farming system, which was designed to improve production per hectare, but also trying to take advantage of the high production potential of both the pastures and the individual cow. The main objectives of this pasture based dairy system were to:

1. Maximise pasture production
2. Develop a system based on the efficient utilisation of pasture grown
3. Exploit the productive potential of the herd
4. Achieve high per hectare production through high per animal performance.

The system should be managed so that prescribed pre and post-grazing sward conditions are achieved to allow a) maximum net pasture production and b) allow sufficient high quality pasture to enable high levels of pasture intake and production per cow. The sward targets for each season for this system as it operated on a seasonal production dairy farm are outlined in Table 1.3.

Although these targets were set for a dairy farming, the principle will apply to any pasture based farming system. However, some problems need to be solved. In order to exploit productive potential of the herd, and achieve high performance per animal, high residuals levels need to be left after grazing (Hodgson, 1990, Morris et al., 1993).

Table 1.3. Seasonal herbage mass targets for a dairy farm (Phillips and Matthews, 1994).

Season	Average Cover (kg DM/ha)	Pre-grazing (kg DM/ha)	Post-grazing (kg DM/ha)
Late-Autumn	1750-2000	2400-2700	1200-1400
Winter	1900-2100	2500-2700	800-1000
Early-Spring	1900-2000	2500-2700	1300-1400
Late-Spring	2000-2200	2500-2700	1500-1600

Can a similar approach, based on appropriate sward conditions, be operated at Tuapaka to help achieve liveweight targets? Since each unit of liveweight gained adds to the maintenance cost until the end of the finishing season a bull beef finishing system must achieve maximum gains through out the season in order to reduce this maintenance cost. It is the reason why Tuapaka bulls are not wintered for a second year to achieve higher slaughter weights. This requires offering high allowances of high quality pasture through out the season. However it is very difficult, since it will lead to an increased amount of dead matter in the sward, reducing feed quality (Sheath and Clark, 1996). Matthews (1995) argues that it is the relationship between pre and post-grazing conditions that is important. Pre-grazing level must be reduced to maintain sward quality and therefore obtain higher levels of intake at lower post-grazing residuals. For bull beef farming, the average pasture utilisation for high animal performance is around 65% (Cassells and Matthews, 1988). This suggests that for bull production the control of herbage quality through the control of the pre-grazing sward conditions is likely to be implemented if high grazing residuals are required.

Therefore, in a beef cattle system pasture residuals should be defined basically for two periods: 1) from spring to autumn (when liveweight gain should be as high as possible), and 2) for the winter (when pasture growth rate will never be high enough to support high levels of liveweight gain). In this season, attention must be focused on pasture cover targets for early-spring rather than on the animal production itself. In addition, if pasture is managed all year round in order to optimise cattle performance, then the restriction over the winter will not jeopardise final targets.

Hence, in order to maximise bull liveweight gain in the beef cattle enterprise, more attention should be paid to sward conditions. Bircham and Hodgson (1983) and Parsons et al. (1983) showed that it is impossible to maximise photosynthesis and net pasture production. Also, Bryant and Holmes (1985) showed that it is impossible to maximise intake per animal and production per hectare at the same time. Therefore, pasture management must focus on maintaining sward conditions for maximum net pasture growth rate, maintaining the pasture cover between 2000 and 3000 kg DM/ha (Matthew et al., 1995; Sheath and Clark, 1996). Approaching the bottom level pasture quality increases, while at the top level growth is enhanced. Further, over the pasture cover range of 1000-2000 kg DM/ha, each increase of 100 kg DM/ha in pasture cover generates an extra pasture production of 2 kg DM/ha/day (Matthew et al., 1995).

In winter, sward targets will fall below the optimum level for high animal production, since pasture production will never be enough to support high levels of productivity. Thus, the aim of this period should be to prepare the sward conditions for maximum production in early-spring. The feed restriction implemented over the winter will probably show some negative effects early in the season. However, it might be compensated by the end of the winter and early-spring when animals will be able to be better fed (Bryant, 1980). Further, if the correct grazing management is applied before the winter, bulls will be wintered at heavier liveweights than normal, minimising the effect of feed restriction in the period. Besides, some compensatory growth might be expected over the spring due to the feed restriction in winter (Hogg, 1991).

1.6 Recommendations and Conclusions

In this section, the information reviewed previously in this chapter will be used in an attempt to define the sward conditions required for a profitable bull beef system. The positive relationships between animal performance and pasture allowance, and the pasture allowance with pasture residual, suggest that high residuals are fundamental for high performance of beef cattle. The minimum pasture residual for maximum animal performance is around 2000 kg DM/ha (Hodgson, 1990; Morris et al., 1993). Although this pasture mass is feasible on the short term, on the longer term it will lead to low pasture utilisation and consequently high senescence and lower pasture digestibility (Smeaton, 1983). Consequently, both pasture and animal productivity will be jeopardised. At the same time it is important to maintain pasture residuals long enough to maximise pasture accumulation. The optimum range for New Zealand swards is between 2000-3000 kg DM/ha (Matthew et al., 1995). It could be argued that if the average pasture cover through the year at the Tuapaka bull beef unit of 1450 kg DM/ha was increased to 2000 kg DM/ha then the net pasture growth rate could be increased by 10 kg DM/ha/day (Matthew et al., 1995).

Although pasture accumulation is maximised above 1200 kg DM/ha, animal production will be limited before this level is reached due to intake restriction. In order to find the balance between pasture mass for optimum pasture production and animal intake it is important to set the minimum mass for maximum pasture production. If the pasture mass is maintained at 1500-1600 kg DM/ha both the pasture net accumulation and pasture quality will be maintained all year round. Residuals below 1500 kg DM/ha will reduce animal intake to a level that will neither be compensated by higher pasture quality nor by an extended grazing time (Hodgson et al., 1994).

Generally, more attention is given to post-grazing pasture mass and pasture allowance than it is to pre-grazing herbage mass. This fact leads to poor animal performance since pasture quality drops very quickly when it is kept at high masses for long periods due to structural changes and to increase in proportion of dead material in sward (Marsh, 1979). Although 3000 kg DM/ha is suggested as the top limit for pre-grazing (Matthew et al., 1995), it seems that pasture quality and beef cattle liveweight gain are jeopardised before this value is reached. Consequently, it is important to maintain pre-grazing levels below 3000 kg DM/ha, aiming at around 2800 kg DM/ha (Matthews, 1995). On the other hand, pre-grazing bottom limit is not as important as the top limit, considering it will only interfere in animal production if it is too close to post-grazing limits. Hence, a reasonable and secure range for pre-grazing pasture cover should be targeted at 2500-2800 kg DM/ha (Matthews, 1995). Provided pre-grazing mass is controlled it will be possible to expect to maintain high pasture intakes per animal at high level due to the higher digestibility of the diet.

1.6.1 Proposed Sward Targets for The Tuapaka Bull Beef Unit

Based on the previous discussion the following sward targets have been formulated for the Tuapaka farm. Pre-grazing and post-grazing limits were defined between 2500-2800 kg DM/ha and 1500-1900 kg DM/ha respectively. This means that the average pasture cover will vary between 2000-2350 kg DM/ha. This range will maximise net pasture accumulation from spring to autumn, enhancing animal production in the same period (Matthew et al., 1995; Sheath and Clark, 1996). Over the winter when intakes are restricted due to lower rates of pasture growth, pre-grazing targets will be reduced below this level to 1100 to 1200 kg DM/ha to control animal intake (Table 2.4).

These sward residual targets are slightly higher than the values suggested by Philips and Matthews (1994) (Table 2.3) especially over the winter. Since wintered dairy cows (450 kg at maintenance) have higher feed requirements than wintered bulls (300 kg LW bulls gaining 0.5 kg LW/day) at the same stocking rate, bulls can be better fed and at the same time leave higher residuals. Post-grazing pasture cover over the winter, of between 1100-1200 kg DM /ha are targeted. This fact will also reduce sward damage by treading during the wet winter, improving both animal and pasture performances. At the same time, pasture cover can be maintained at 1900-2000 kg DM/ha if it starts at around 2000 kg DM/ha on 1 June. Bulls at 300kgLW have a daily requirement of 5.7kgDM/day to gain 0.5 kg LW/day (Journeoux, 1987), what gives a total daily intake of 15.5 kg DM/ha (at the current stocking rate of 2.75 bull/ha). Considering an average pasture growth rate of 13 kg DM/ha/day, there will be a deficit of 2.5 kg DM/ha/day or 150 kg DM/ha in June and July (61 days). Therefore, pasture cover in 1 August will be around 1850 kg DM/ha. If pasture growth rate increases, as it was suggested by Matthews (1995) and Clark et al. (1994), pasture supply can be increased enhancing animal performance over the period. Nevertheless, it is important to be totally committed to sward targets, so rotation length will be a consequence of pasture growth rate. In addition, pre-grazing mass around 3200 kg DM/ha is acceptable during the winter, since both pasture growth and decay are not high in this season (Bryant, 1980).

Table 1.4. Pre and post-grazing targets for the proposed grazing management for Tuapaka bull unit.

Period	Pre-grazing (kg DM/ha)	Post-grazing (kg DM/ha)	Average Pasture Cover (kg DM/ha)
Summer/Autumn	2700-2800	1500-1600	1900-2100
Winter	3000-3200	1100-1200	1800-2000
Spring	2700-2800	1500-1600	1800-2000
Late-spring/Early-summer	2700-2800	1500-1600	2000-2200

Another benefit of this farming system is the reduced supplement inputs (compare Appendix C Table C.1 and Table C.2), which makes the actual farming system (dependent on summer and winter supplements) into a 100%, all grass, grazing system. However, supplements (hay) should be available to be put into the system when pasture growth rates drop to unexpected levels. If this happens, supplement should be fed in order to maintain pasture cover and residuals on target. Conversely, the current Tuapaka grazing management relies on supplementation for winter and summer in order to achieve liveweight gain targets, rather than maintaining specified sward conditions.

Since beef has been facing very tough competition from white meats, there is an increasing need for farms to meet the market demand for high quality, at a low cost. Therefore, it is crucial to develop a beef farming system totally dependent on pasture production. To do so, the seasonally pattern of pasture production and factors determining net pasture production must be taken into account. These will help the farm manager set sward targets for each season, to enable maximum net pasture production and pasture intakes, thus avoiding unnecessary supplementation which is normally expensive and not always cost effective.

2. Introduction and Objectives

Since bull beef farming is a relative new enterprise in New Zealand, little research has been carried out in this area. However, the new grazing management strategies applied to dairy farming also suits the aims of bull beef farmers of maximising pasture production and production per hectare through higher individual animal performance.

Traditionally bull beef grazing management is based on animal intakes required to reach the targeted liveweight gains rather than specific sward targets. During late-autumn, the herd intake has been restricted to save pasture for the winter. This low procedure leads to low animal performance and high supplement inputs over a long period which starts in late-autumn, extends throughout the winter, with the pasture cover reaching a critical point in late-winter/early-spring (September). This pasture cover leads to an animal performance in early-spring below potential which will generally compromise beef farming outcomes. This period comprises a total of 180 days, and when farming for high levels of production and profit it is not acceptable to have such a long period of low animal performance. Therefore, a profitable farming system 100 % dependent on pasture production should be developed in order to maximise pasture production, increase animal performance, and reduce supplement inputs.

Grazing management trials suggested that pasture accumulation is limited by the levels of herbage remaining after grazing (Brougham, 1955, 1956a, 1956b, 1957, and 1960). Grazing residuals of around 1200 kg DM/ha were then proposed as the minimum for maximum pasture accumulation. Later, it was suggested by Bircham and Hodgson (1983) that there was little change in net pasture accumulation provided swards were managed between 1000-2500 kg DM/ha (Bircham and Hodgson, 1983). Below this limit pasture accumulation was restricted by reduced leaf area which was not enough to intercept sufficient sun light for photosynthesis, and above this limit pasture decay increased to a level that impaired pasture accumulation. The suggested limit for British swards may not be applicable to the more open sward types found in New Zealand.

Matthew et al., (1995) concluded that the optimum range for New Zealand swards was 2000-3000 kg DM/ha. In addition, he advised that over the pasture cover range of 1000-2000 kg DM/ha the net pasture accumulation would increase by 2 kg DM/ha each 100 kg DM/ha of increase in the average pasture cover.

Based on this theory, dairy farmers have changed their traditional grazing management in order to maximise pasture production and consequently milk solids production (Phillips and Matthews, 1994). The latest approach in dairy farming grazing suggests a tendency for improving production per hectare through improvement of individual cow production rather than increasing stocking rate. A recent grazing trial with bull beef suggested that pasture height between 10 and 12.5 cm is the minimum pasture residual for maximum liveweight gain in spring and autumn respectively (Morris et al., 1993).

Based on the previous information the following hypothesis is proposed:

- If appropriate sward conditions can be established over the autumn/winter period on the Tuapaka bull beef unit, increased net pasture growth will enable either increased pasture cover to be carried into the spring, increased bull growth rates or a combination of the two.

It was estimated that net pasture accumulation would increase by 538 kg DM/ha/year (Appendix C, Table C.2) if appropriate sward targets were established. Accordingly, the following were proposed for the management at the Tuapaka farm from April to September:

(i) To establish pre and post-grazing pasture targets (Table 3.1) to enhance net pasture accumulation in the autumn, and maximise stock liveweight gains to winter heavier bulls.

(ii)To establish sward conditions over the winter (Table 3.1) in order to maximise net pasture accumulation, enabling spring pasture cover targets to be reached rather than maximising animal performance over this season.

(iii)To establish sward conditions to enhance the rate of net herbage accumulation and bull liveweight gains in early-spring (Table 3.1).

3. Materials and Methods

3.1 Introduction

In order to test the effect of grazing management on net pasture accumulation and animal performance, and to identify appropriate management strategies for the period from late-autumn to early-spring, a grazing experiment was carried out at the Massey University Tuapaka bull unit during a 180 day period starting from 3 April to 30 September 1997.

3.2 Site

The Tuapaka bull beef unit (99 ha of effective pasture) is a Massey University farm located on Highway 57 A, south of the Manawatu Gorge. The predominant soil type is Yellow-Grey Earth (Tokomaru silt loam and Ohakea silt loam). These soils are derived from wind blown dust (loess) from riverbeds with a natural fertility from medium to high. In spite of being tile and mole drained, the compacted subsoil causes the soil to be very slow-draining, leading to very winter wet soils subject to pugging. Fertiliser is applied once a year in order to maintain phosphorus level above 20 μg/g (Olsen P test). Current soil nutrient levels are presented in Appendix A, and all paddocks pH and P levels are within the optimum values.

The climate is very typical of the Manawatu region. Soil and air temperatures are shown in Figures 3.1 and 3.2, respectively. The summers are normally warm and subject to drought due to evapotranspiration exceeding rainfall. The winters are mild with normally not more than 7 frosts. The average rainfall of 1100 mm is well distributed over the year (Figure 3.3).

Tuapaka's pastures are perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). They are on average 15 years old, and follow a pasture renewal policy of one paddock per year (4 ha/year). This area is taken out of the rotation and put into crop each spring (Turnips or Radish), followed by a winter crop of black oats (*Avena strigosa*). After one year of cropping the paddock is replanted in the spring with perennial ryegrass and white clover pastures.

Figure 3.1. Tuapaka soil temperature data recorded over a 6-year period and during 1996/97 (Source: Massey University, Tuapaka).

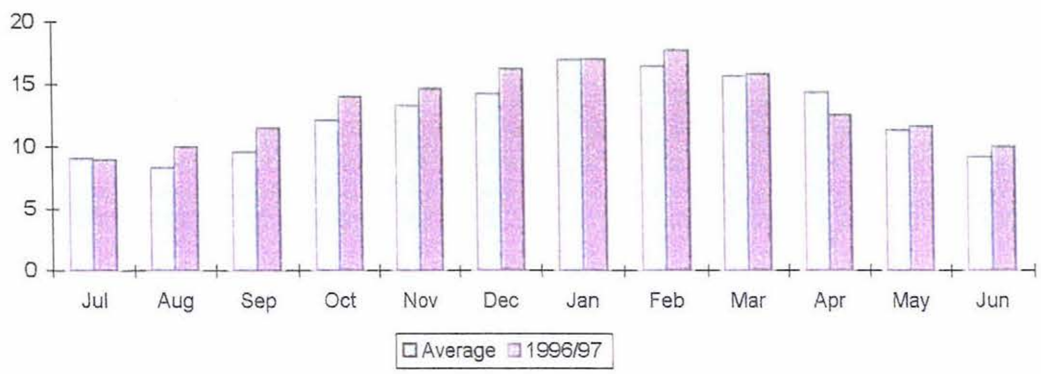


Figure 3.2. Manawatu 60-year average air temperature and 1997 (° C) (Source: AgResearch, Palmerston North)

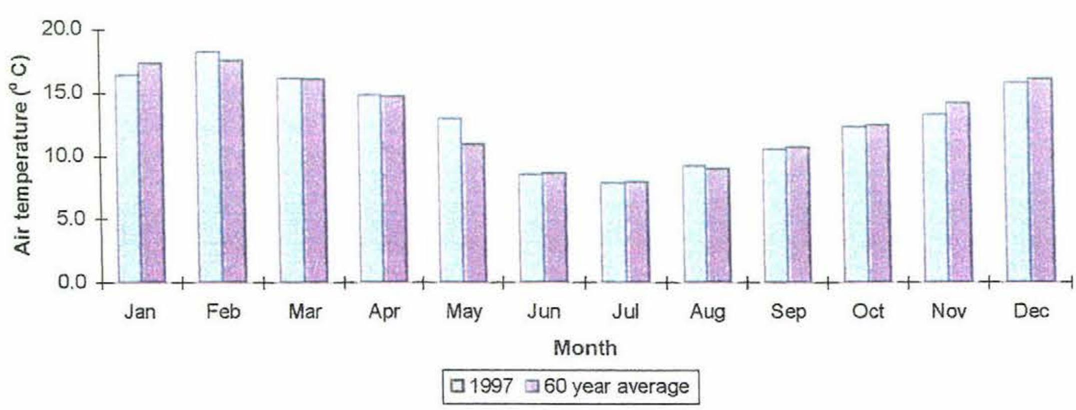
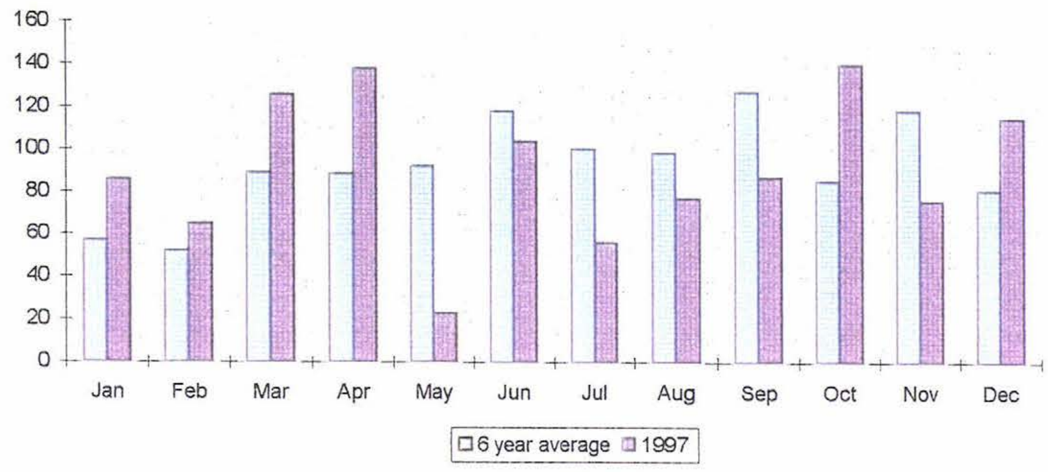


Figure 3.3. **Tuapaka 10-year average and 1997 monthly rainfall (Source: Massey University Tuapaka).**



3.3 Experimental Treatments

Three experimental treatments were established:

(i) Treatment 1 - Based on the targets presented in Table 3.1. The treatment was conducted strictly according to the grazing plans which were based on the targeted sward conditions, average pasture growth rate (Appendix C, Table C.3), and animal requirements (Appendix B). The grazing plans were prepared in the beginning of each period and reassessed once a month. The changes in grazing plan were carried out according to the current bull liveweight and average pasture cover.

(ii) Treatment 2 - This treatment was based on the same sward targets as Treatment 1 (Table 3.1), but shifts were done when post-grazing or pre-grazing pasture limits were reached. Rotation length, in this case, was dependent on current pasture growth rate, and supplementation was to be considered when sward conditions were not being achieved.

(iii)Treatment 3 - Based on Tuapaka traditional grazing plan, which is based on animal weight targets and not on pasture targets. This grazing management is basically implemented by dividing each paddock (bigger than 3 ha) into two, and giving 4 or 5 grazing days for each break (depending on the area). In addition, 6 kg of hay per head is offered in the last grazing day (4 day break) or in the last two grazing days (5 day break) (Chapter 1, Section 1.4.2.3). This management gives a rotation length of 50 days, which is normally applied from the beginning of April until when bull were set stocked due to low pasture cover in August.

Table 3.1. Suggested sward condition and liveweight targets for each season

	Pre-grazing (kg DM/ha)	Post-grazing (kg DM/ha)	Pasture Cover (kg DM/ha)	ADG (kg LW/day)	Final Weight (kg LW)
Autumn (3 Apr/ 30 Jun)	2700-2800	1500-1600	1800-2000 (1Jun)	1.2	280
Winter (1 Jul/31 Aug)	2800-3000	1100-1200	1700-1800 (1 Sept)	0.5	325
Early-Spring (1 Sept/1 Oct)	2700-2800	1500-1600		1.5	370

3.3.1 Grazing Plans

In order to calculate the grazing plan for Treatment 1, a computerised spreadsheet was developed (Table 3.2) using Microsoft Excel. The grazing plan for each month was carried out in the beginning of each season, and reassessed every month, taking into account the current bull liveweight and average pasture cover on Farmlet 1. The pasture growth rate was based on published MAF data (Anon, 1992), but for the autumn and spring the average figures were increased by 15%, since Matthew et al., (1995) suggested that net pasture accumulation increases by 2kgDM/ha for every 100 kg DM/ha increment of pasture cover in the farm. Feed requirements were based on the metabolic energy (ME) requirements presented by Journeoux (1987) (Appendix B). The pasture requirements were then calculated by dividing these metabolic energy values by the ME (MJ/kgDM) content in the forage, which was assumed to be 10.8 MJ/kg DM (McRae and Morris, 1984).

The grazing period within each paddock was then changed until the target post-grazing cover was achieved. According to the grazing period, the pre-grazing of the next paddock was calculated. The same procedure was done for all paddocks until the rotation was completed. During the grazing period, pasture accumulation was taken into account while calculating pasture residuals. It was assumed that pasture produced at the average rate of pasture growth over this period.

According to the model, the rotation length for each period or season for Treatment 1 was:

(i) Two rotations of 30 days for the months of April and May (late-autumn) (Table 3.2).
(ii)One rotation of 100 days over the winter, starting on 1 June and finishing on 10 September (Appendix E; Table E.2).
(iii)One rotation at the rate of 30 days from 10 September until 10 October (Appendix E; Table E.3).

Table 3.2. Treatment 1 Simulation model of autumn grazing plan (On 1 hectare basis).

Farming Area (ha)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Number of Paddocks	12	12	12	12	12	12	12	12	12	12	12	12
Date	1-Apr	4-Apr	7-Apr	10-Apr	13-Apr	16-Apr	19-Apr	22-Apr	25-Apr	28-Apr	1-May	4-May
Breaks	1	2	3	4	5	6	7	8	9	10	11	12
Paddock Area (ha)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Pasture growth (kg DM/ha/day)	24.4	25.2	25.9	26.7	27.5	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Pre-grazing (kg DM/ha)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Supplement (kg DM/ha)	0	0	0	0	0	0	0	0	0	0	0	0
Stoking rate	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Animal intake (kg DM/head/day)	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.15	8.15
Grazing period (days)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Post-grazing (kg DM/ha)	1579	1579	1579	1580	1580	1580	1580	1580	1580	1580	1444	1444
Pasture change (kg DM/ha/grazing period)	-207	-207	-207	-207	-207	-207	-207	-207	-207	-207	-252	-252
Average Pasture Cover (kg DM/ha)	1800	1815	1833	1852	1874	1898	1923	1949	1974	1999	2025	2039

3.4 Experimental Design

The experiment was a modified randomised block design. Since the Tuapaka bull unit is divided in three blocks by natural barriers (Appendix D), the distribution of paddocks had to be carefully monitored in order to have all treatments evenly distributed around the farm. From the 99 ha of Tuapaka flats, 35.5 ha (including the crop paddock) were assigned to the steers mob, while the remaining area available for the trial was divided into three farmlets. Paddocks were allocated avoiding assigning adjacent paddocks to the same treatment, as well as balancing treatments across the natural blocks (Appendix D).

Three treatment areas at 19.9, 20.1, and 23.5 ha were established. These were assigned 51, 53, and 61 bulls respectively in order to have the initial stocking rate as close as possible to 2.6 bulls/ha. The 165 bulls were weighed (fasted for 12 hours), grouped into liveweight strata and then randomly allocated to each treatment from each strata in order to have the initial weight of all mobs as similar as possible. Although each bull had a numbered tag in their left ear, two mobs were tagged on the right ear with blue and yellow tags respectively. Afterwards, the treatments were randomly designated to each mob:

(i) Treatment 1 - 20.1 ha and 53 bulls (2.63 bulls/ha)
(ii)Treatment 2 - 19.9 ha and 51 bulls (2.56 bull/ha)
(iii)Treatment 3 - 23.5 ha and 61 bulls (2.59 bull/ha)

Because of potential behavioural problems and the lack of a spare bull mob, any bulls lost by death or injury in any mob were not replaced during the experimental period.

Table 3.3. Treatment Details: Paddock area and pasture cover distribution (1 April 1997).

TREATMENT 1			
Paddock Number	Area (ha)	Average RPM Reading	Average Cover (kg DM/ha)
6	5	14.8	2856
23	5.2	12.2	2414
28	2.1	9	1870
20	3.9	8.6	1802
32	1.7	13.8	2686
35	2.2	11.2	2244
Area Total	20.1	Weighted Average	2353

TREATMENT 2			
Paddock Number	Area (ha)	Average RPM Reading	Average Cover (kg DM/ha)
7	4.3	13	2550
16	3.4	9.2	1904
19	2.9	10.4	2108
24	2.8	11.4	2278
26	2.7	11.6	2312
30	2.1	14.6	2822
34	1.7	13	2550
Total Area	19.9	Weighted Average	2333

TREATMENT 3			
Paddock Number	Area (ha)	Average RPM Reading	Average Cover (kg DM/ha)
5	5.2	18.2	3434
29	3.3	7.6	1632
21	4.8	8.8	1836
27	1.8	7	1530
31	1.8	14.2	2754
33	2.9	16.2	3094
15	3.7	7.4	1598
Total Area	23.5	Weighted Average	2326

3.5 Management

All paddocks larger than 2.5 ha were split, and each half was then considered to be a treatment paddock, giving, Treatment 1, 2, and 3 a total of 9, 12, and 11 paddocks respectively (Table 3.3). This procedure was carried out in order to avoid grazing periods longer than 3 days per paddock, and to increase the number of the pasture measurements and consequently the degrees of freedom in the statistical analysis.

During the winter when on longer rotations, Treatments 1 and 2 were grazed in two-day breaks. To do so, temporary electric fences were used in front and behind each mob and they were shifted every two days. Because the winter is very wet in this region, all the mobs had the option to be taken out of the paddock for a day or two in days of heavy rain, avoiding serious sward damage. The pasture covers of the run off areas were maintained at low levels of herbage mass by a group of rising two years bull.

No supplement was required for Treatment 1 (based on the grazing plans presented in Table 3.1 and in Appendix E). In Treatment 2, supplement (hay) would be fed if the treatment was not achieving the targeted sward conditions.

3.6 Measurements

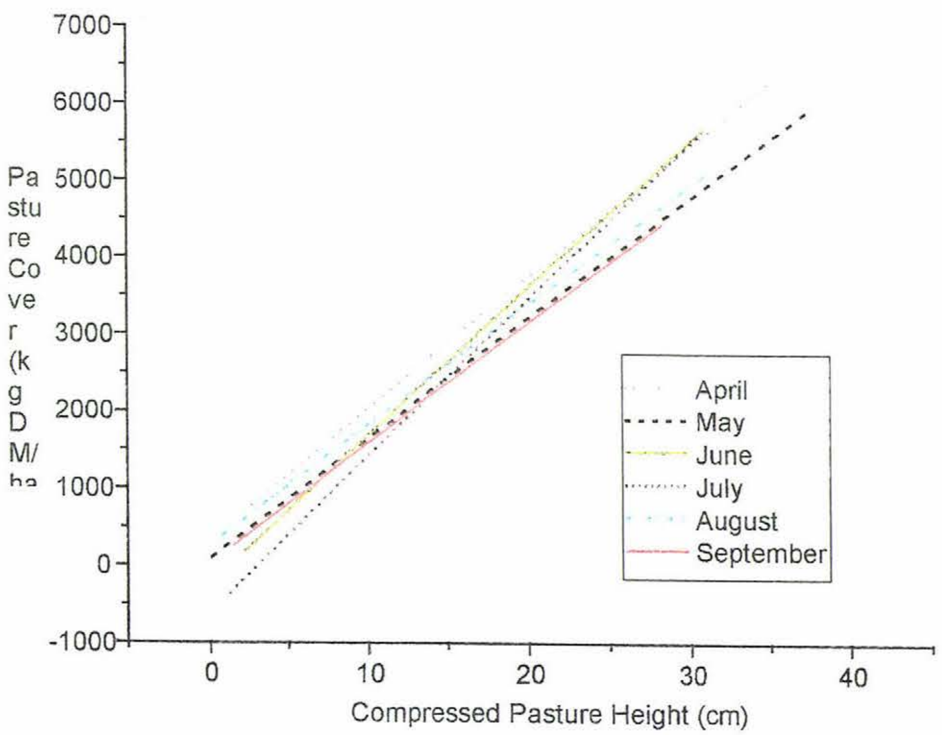
3.6.1 Pasture measurements

The herbage mass of all paddocks was measured on the same day at weekly intervals. It was carried out by using a rising plate meter, with the average of 100 readings per paddock recorded (Earle and McGowan, 1979). Individual paddock data was then used to calculate the average farmlet pasture cover and the average daily net pasture accumulation. This procedure allowed the calculation of monthly average net pasture accumulation for each treatment.

Daily pre and post-grazing pasture covers were measured for all treatments with the average of 100 readings per paddock recorded. These measurements were used to estimate daily apparent dry matter intake per bull, and to monitor management in Treatment 2. They were calculated by dividing the product of the difference of pre and post-grazing pasture mass and the paddock area by the product of the grazing period and the number of bulls in the treatment.

For Treatment 2 this measurement was also the base of grazing management decisions. The mob was shifted whenever the target post-grazing mass was achieved, or when pre-grazing cover reached the upper target limits. Conversely, the rotation length was slowed in the winter when the average pasture cover on this treatment reached its minimum target for the winter.

Figure 3.4. Rising plate meter calibration equation for each month



A calibration equation was established for the rising plate meter at the start of each month (Figure 3.4). In each case a total of 50 quadrats of 0.01 m^2 in area were selected from 3 or 4 paddocks per treatment, in order to cover the range of pasture height present. The compressed pasture height was taken on each quadrat with the rising plate meter. Quadrat samples were then cut to ground level with an electric shearing hand-piece to determine herbage mass. Cut herbage was washed and oven dried at 80 °C for 24 hours. Dry samples were weighted and multiplied by 100 in order to determine its mass per hectare. The compressed pasture height and the pasture mass per hectare data were entered in a spreadsheet, a scatter graph was plotted, and a linear regression calibration equation established for the farm. In total six calibration equations were established (Appendix F).

3.6.2 Liveweight Measurements

Individual bull fasted (16 hours) weights were recorded at the beginning (3 April) and end of the experiment (1 October). Bulls were weighed monthly, in order to evaluate the grazing management. The final average liveweight was compared between treatments at the end of every season (late-autumn, winter, and early-spring). Dividing the difference between the average initial and final weights by the number of days in the period, the average daily gain for each treatment was also calculated and statistically analysed. The initial average fasted liveweight of Treatments 1, 2, and 3 were 201.8 ± 2.2, 201.0 ± 2.2, and 200.4 ± 2.0 kg respectively.

3.6.3 Supplement Inputs

The number of 25 kg bales of hay offered to Treatment 3 and Treatment 2 was recorded daily. Each bale was considered to weigh 15 kg of pasture equivalent DM.

3.7 Statistical Analysis

All data was analysed using the ANOVA analysis (SAS, 1988) within the SAS computing package in accordance with the modified randomised block design. Average pasture cover, pre-grazing, and post-grazing data were analysed using time as replication. For pasture growth rates, paddocks were used as replicates, and liveweight data analysis was carried out using individual bulls as replicates. Since treatments had different numbers of paddocks and bulls, all the ANOVA analysis was based on unbalanced treatments. The monthly calibration equations were analysed using a linear regression also within the SAS programme.

4. Results

4.1 Introduction

As the trial was divided into three periods (autumn, winter, and early-spring) the results are presented on a per season basis. Average pasture cover, average pre-grazing, average post-grazing, average net pasture accumulation rate and average apparent daily pasture intake are presented for each season.

4.2 Liveweight And Liveweight Gain

4.2.1 Autumn

This period started on 3 April and finished on 31 May, however the final weighing was on 28 May. Initially, only the fasted liveweights were recorded, and these were increased by 6.8 % (which was the mean difference between the full and fasted weight at the end of the experiment), in order to calculate the initial full weight. The liveweight for Treatment 1 was significantly heavier ($P < 0.05$) than the other two treatments (Table 4.1) by the end of autumn. On a liveweight gain basis, there was no significant difference between Treatments 2 and 3, but both were significantly lower ($P < 0.001$) than Treatment 1 (Table 4.1).

4.2.2 Winter

This was a period of 92 days between 1 June and 31 August. By the end of August, Treatments 1 and 2, were 12.2 and 11 kg respectively heavier than Treatment 3 ($P < 0.001$) (Table 4.1). Liveweight gain results showed that Treatment 2 (0.86 kg LW/head/day) was significantly higher ($P < 0.001$) than both Treatments 1 (0.76 kg LW/head/day) and 3 (0.73 kg LW/head/day) (Table 4.1).

4.2.3 Early-spring

This period was from 1 September to 1 October (31 days). The final liveweight showed that Treatments 1 and 2 were significantly heavier than Treatment 3 ($P < 0.001$) (Table 4.1). The liveweight gains in spring were significantly different between all Treatments ($P < 0.001$) (Table 4.1).

Table 4.1. Seasonal liveweight (kg) and liveweight gain (kg LW/head/day).

	Treatment 1	SEM	Treatment 2	SEM	Treatment 3	SEM
Apr-03 (kg LW)	216.9 ^{a}	2.2	215.6 ^{a}	2.2	215 ^{a}	2.03
May-28 (kg LW)	265.8 ^{b} *	3.08	253.6 ^{a}	3.11	255.5 ^{a}	2.84
ADG (kg LW/head/day)	0.88 ^{b} ***	0.03	0.69 ^{a}	0.03	0.73 ^{a}	0.02
Aug-31(kg LW)	337.7 ^{a}	3.56	336.5 ^{a}	3.67	325.5 ^{b} *	3.28
ADG (kg LW/head/day)	0.76 ^{a}	0.01	0.87 ^{b} ***	0.02	0.73 ^{a}	0.01
Sep-30 (kg LW)	380.4 ^{b}	3.81	388 ^{b}	3.93	361 ^{a} ***	3.52
ADG (kg LW/head/day)	1.41 ^{c} ***	0.04	1.71 ^{b} ***	0.04	1.18 ^{a} ***	0.04

1. Items with the same letter are non-significant

2. *** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; + = $P < 0.1$ (In this and the following Tables)

4.2.4 Fasted Liveweight

It can be seen in Table 4.2, that there was no difference in initial average fasted liveweight between Treatments 1 (201.75 ± 2.2 kg), 2 (200.97 ± 2.2 kg), and 3 (200.4 ± 2.2 kg). Final fasted liveweight for Treatments 1 and 2, were 24 and 19 kg heavier than Treatment 3 ($P < 0.001$). There was no significant difference between Treatments 1 and 2.

Overall liveweight gain for Treatment 1 (0.84 kg ± 0.02 LW/head/day) and Treatment 2 (0.87 ± 0.02 kg LW/head/day) were significantly different ($P < 0.001$) to Treatment 3 (0.74 ± 0.01 kg LW/head/day), as presented in Table 4.2.

Table 4.2. Bulls' initial and final fasted liveweight (kg) and liveweight gain (kg LW/head/day).

	Treatment 1	SEM	Treatment 2	SEM	Treatment 3	SEM
Apr-03 (kg LW)	201.7 ^{a}	2.2	200.9 ^{a}	2.2	200.4 ^{a}	2.03
Oct-01(kg LW)	359.8 ^{b}	3.54	354.7 ^{b}	3.64	335.6 ^{a} ***	3.27
ADG (kg LW/head/day)	0.84 ^{b}	0.02	0.87 ^{b}	0.02	0.74 ^{a} ***	0.01

4.3 Pasture Results

The initial pasture covers on 3 April were 2353, 2333, 2326 kg DM/ha for Treatments 1, 2, and 3 respectively (Figure 5.1). There was no significant difference between treatments.

4.3.1 Autumn

During this period the average pasture cover for Treatments 1, 2, and 3 were 2289 ± 68, 2366 ± 68, 2235 ± 68 kg DM/ha respectively. Treatment 2 pasture cover was higher ($P < 0.1$) than the other two treatments (Table 4.3).

The average pre-grazing pasture cover for this period was 2717 ± 74.4, 2832 ± 59.9, and 2746 ± 70.0 kg DM/ha for Treatments 1, 2, and 3 respectively, and the difference between treatments was not significant. The average post-grazing pasture cover for Treatment 1 (1729 ± 91.7 kg DM/ha), 2 (1930 ± 73.9 kg DM/ha), and 3 (1564 ± 86.3 kg DM/ha) were also not significantly different. Further, there was no difference in apparent dry matter intake between Treatments 1(12 ± 0.9 kg DM/head/day) and 2 (13.8 ± 0.7 kg DM/head/day), but they were significantly higher ($P < 0.05$) than Treatment 3 (8.9 ± 0.9 kg DM/head/day) (Table 4.3).

The average net pasture accumulation rate recorded over the autumn was 41.4 kg DM/ha/day. Although there was a difference of almost 9 kg DM/ha/day between Treatments 1 and 3, this difference was not significant.

Table 4.3. Autumn pasture measurements.

	Treatment 1	SEM	Treatment 2	SEM	Treatment 3	SEM
Pasture Cover (kg	2289 [a]	68.1	2366 [b] +	68.1	2235 [a]	68.1
Pre-grazing (kg DM/ha)	2717 [a]	74.4	2833 [a]	59.9	2746 [a]	70.0
Post-grazing (kg	1729 [a]	91.7	1930 [a]	73.9	1564 [a]	86.3
Intake (kg	12.0 [b]	0.95	13.8 [b]	0.77	8.9 [b] *	0.89
PGR (kg DM/ha/day)	41.2 [a]	3.96	45.8 [a]	3.24	37.1 [a]	3.55

4.3.2 Winter

The average pasture cover over the winter for Treatments 1 and 2 was significantly higher ($P < 0.001$) than Treatment 3 (Table 4.4). The average pre-grazing pasture covers for all Treatments were significantly different ($P < 0.01$) (Table 4.4).

The average post-grazing pasture cover of Treatment 1 (1291 ± 67 kg DM/ha) and 3 (1208 ± 41 kg DM/ha) were significantly lower than Treatment 2 (1536 ± 33.5 kg DM/ha) ($P < 0.001$). A similar result was recorded for the average apparent daily pasture intake. Treatments 1 (8.7 ± 1.00 kg DM/head/day) and 3 (10.2 ± 0.62 kg DM/head/day) being significantly lower ($P < 0.01$) than Treatment 2 (13.1 ± 0.60 kg DM/head/day) (Table 4.4).

Table 4.4. Winter pasture measurements.

	Treatment 1	SEM	Treatment 2	SEM	Treatment 3	SEM
Pasture Cover (kg	2168 [b]	43.06	2139 [b]	43.0	1806 [a] ***	43.0
Pre-grazing (kg DM/ha)	3294 [a] **	125.0	2796 [b] **	62.9	2471 [c] **	76.4
Post-grazing (kg	1291 [a]	66.67	1536 [b] ***	33.5	1208 [a]	40.7
Intake (kg	8.7 [a]	1.00	13.1 [b] ***	0.60	10.2 [a]	0.62
PGR (kg DM/ha/day)	28.9 [ab]	1.99	34.2 [a]	1.63	25.2 [b] *	1.78

The average pasture growth rate throughout the winter was significantly higher ($P < 0.05$) for Treatment 2 (34.2 ± 1.63 kg DM/ha/day) than Treatment 3 (25.2 kg ± 1.78 DM/ha/day). Treatment 1 (28.9 ± 1.99 kg DM/ha/day) did not differ from either Treatment 1 or 3 (Table 4.4).

During this period, Treatment 3 was supplemented with 4804 kg of hay or 120.6 kg DM (pasture equivalent)/ha. This amount of hay was not included in the calculation of daily pasture intake. Hence, including the supplementation, the daily mean dry matter intake of this treatment increased by 0.5 kg DM/day.

4.3.3 Early-Spring

During this period the average pasture cover of Treatments 1, 2, and 3 were 1938 ± 46, 1893 ± 46, 1387 ± 46 kg DM/ha respectively. Analysis showed no difference between Treatments 1 and 2, but both Treatments were significantly higher than Treatment 3 (Table 4.5).

Average post-grazing pasture cover of Treatments 1 and 2 followed the same pattern as average pasture cover. According to the statistical analysis, there was no significant difference between Treatments 1 and 2, but both were significantly higher ($P < 0.001$) than Treatment 3 (Table 4.5).

On the other hand, the average pre-grazing pasture cover of Treatment1 (2394 ± 66 kg DM/ha), Treatment 2 (2174 ± 49 kg DM/ha), and Treatment 3 (1649 ± 53 kg DM/ha) were all significantly different ($P < 0.01$) (Table 4.5).

The average apparent pasture intake for early-spring was similar for Treatments 1 (12.2 kg ± 0.88 DM/head/day) and 2 (13.5 ± 0.59 kg DM/head/day). Both were significantly higher ($P < 0.01$) than Treatment 3 (8.6 ± 0.73kg DM/head/day) (Table 4.5). Finally, the average pasture growth rate of Treatments 1, and 2 were similar, and both were significantly higher ($P < 0.05$) than Treatment 3 (Table 4.5).

Table 4.5. Spring pasture measurements.

	Treatment 1	SEM	Treatment 2	SEM	Treatment 3	SEM
Pasture Cover (kg DM/ha)	1938 ^{a}	46.58	1893 ^{a}	46.58	1387 ^{b***}	46.5
Pre-grazing (kg DM/ha)	2394 ^{a**}	65.71	2174 ^{b**}	49.04	1649 ^{c**}	53.3
Post-grazing (kg DM/ha)	1633 ^{a}	56.03	1607 ^{a}	41.81	1113 ^{b***}	45.4
Intake (kg DM/head/day)	12.2 ^{a}	0.88	13.5 ^{a}	0.59	8.6 ^{b**}	0.73
PGR (kg DM/ha/day)	34.2 ^{a}	3.08	37.2 ^{a}	2.52	23.9 ^{b*}	2.76

4.4 Overall sward dynamics

The total net pasture accumulation over the experimental period was calculated in order to analyse whether there was a difference or not in pasture growth rate according to the grazing management. The overall pasture accumulations of Treatments 1, 2, and 3 were 6147 ± 369, 7062 ± 320, and 5277 ± 334 kg DM/ha respectively. These values were significantly different ($P < 0.1$) from each other, and gave an advantage in pasture production to Treatments 1 and 2 over Treatment 3 of 870 and 1785 kg DM/ha respectively. Also, the pasture balance (Table 4.6) shows that the pasture consumption of Treatments 1 and 3 were similar, however, Treatment 3 had to sacrifice pasture cover and introduce supplement into the system in order to reach this level. This fact induced poor performance of the bulls especially in early-spring.

Table 4.6. Pasture balance throughout the grazing trial.

	Treatment 1	Treatment 2	Treatment 3
Pasture produced (kg DM/ha)	6147 ^{b} +	7062 ^{b} +	5277 ^{a} +
Supplement (kg DM/ha)	0	0	120.6
Cover difference (kg DM/ha)	281	348	844
Total dry matter consumed (kg DM/ha)	6428	7410	6241

5. Discussion

5.1 Calibration Equations

During the trial six calibration equations were established (Appendix F), however only four of them were applied. The June and July calibrations increased the average pasture cover of these periods, which would have required a change in the grazing management. Visual assessment of pasture cover showed that the average pasture cover was closer to the value from May calibration equation than from June and July equations, which appeared to over estimate the pre-grazing and under estimate the post-grazing herbage mass. Therefore, the May rising plate meter equation was maintained over the winter, and it was only changed in August. At this time, the change was necessary, as the sward conditions were different from the late-autumn/early-winter. New calibration equations were used in both August and September. Obviously over a larger time period pooled equations (across months/years) would enable large differences between months as measured in this experiment to be taken into account.

5.2 Grazing Management And Experimental Design

The average pasture cover at the start of the experiment was 2350 kg DM/ha for all Farmlets (Figure 5.1). This was 800 kg DM/ha higher than the average pasture cover at the same time in the previous six years (Table 5.1). This extra pasture cover together with the poor grazing management over summer and early-autumn led to clumpy and poor quality swards (Figure 5.2). As a result, the initial pasture targets of Treatments 1 and 2 had to be changed. It was not possible to maintain target post-grazing pasture covers (Table 3.1) without leading to longer rotation lengths and consequently to higher pre-grazing cover and lower pasture quality as well as restricting intake levels due to the low quality pasture on offer. Controlling the pre-grazing cover became more important than the post-grazing, although the original grazing plan of a 30 day rotation was maintained (Table 3.2). This procedure led to higher post-grazing residuals (Table 4.3; Figure 5.3) but it enabled the pre-grazing target levels to be met (Table 4.3; Figure 5.4) and improved sward conditions (Marsh, 1979; Bircham and Hodgson, 1983; Holmes et al., 1993; Matthews, 1994; Matthew et al., 1995).

Figure 5.1. Average Pasture Cover (kg DM/ha): All treatments.

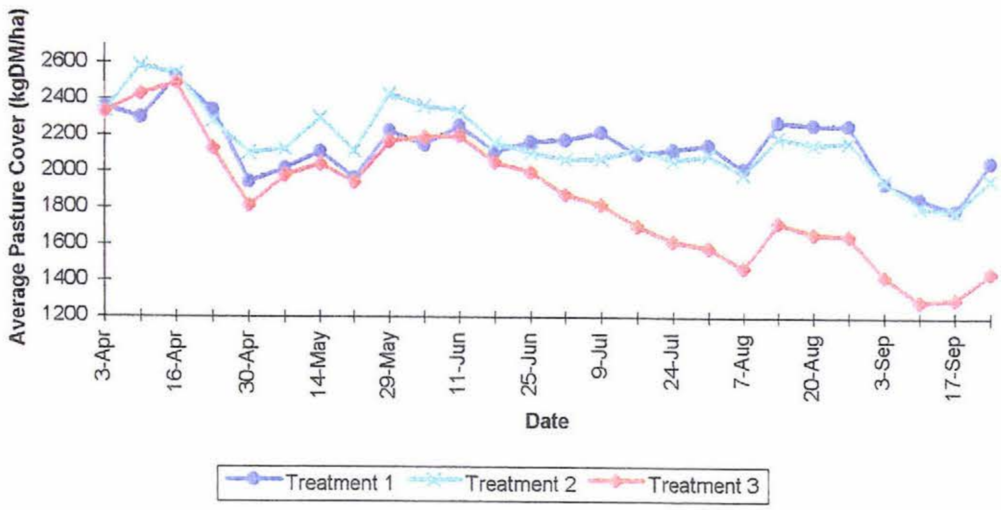


Table 5.1. Average pasture cover (kg DM/ha): Tuapaka 6 years average and Treatment 3 (March to September 1997).

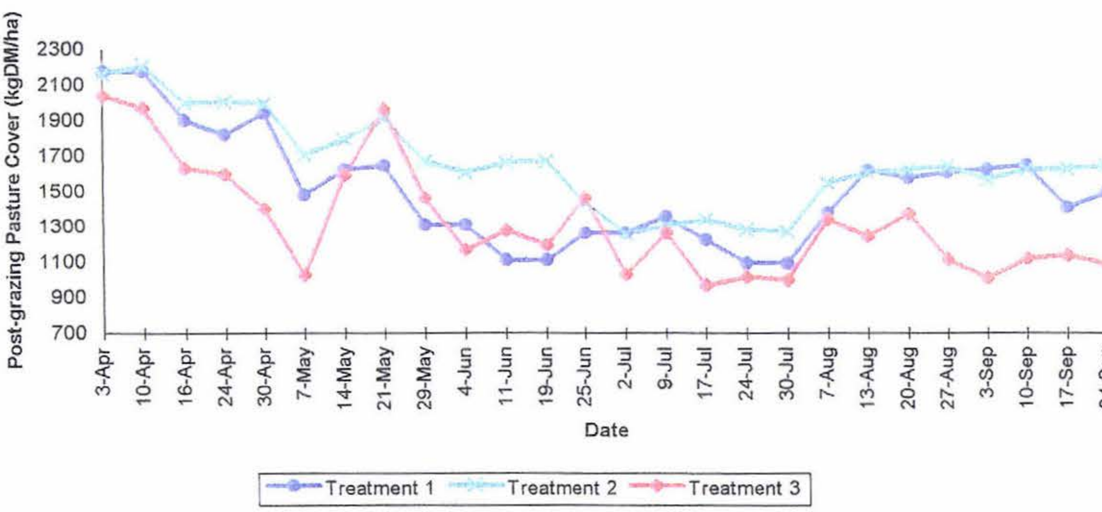
	6 Years Average (kg DM/ha)	Treatment 3 1997 Average Pasture Cover (kg DM/ha)
March	1512	2326
April	1672	1812
May	1673	2162
June	1563	1995
July	1315	1579
August	1244	1645
September	1201	1482

To avoid changing the grazing plan in Treatment 1 pre-grazing pasture covers in autumn were controlled by the rising two-year bulls. Whenever the pasture cover of a paddock reached 2700-2800 kg DM/ha before its time to be grazed, the two-year bulls were brought in to avoid high covers. This management was applied to overcome the higher than expected initial pasture cover and the low pasture quality at the start of the trial. Five out of 10 paddocks of Treatment 1 were grazed by two-year bulls. This was also the reason why Treatment 1 pre-grazing pasture cover (Figure 5.4) and average pasture cover were lower than Treatment 2 by the end of autumn (Figure 5.1; Table 5.2).

Figure 5.2. Sward conditions (Treatment 1 - 13 April).

In Treatment 2 animal shifts were to be carried out when average post-grazing cover target levels were reached. Some grazing management changes had to be made due to the clumpy conditions of the sward in autumn (Figure 5.2). Maintaining the original post-grazing targets would lead to a longer rotation and pre-grazing pasture cover would reach values above the maximum target limit. Besides, in order to achieve residual targets the bulls would need to graze the poor quality clumps, resulting in low animal performance (Matthews, 1994). Therefore, the shifts were based on the target post-grazing level (1500-1600 kg DM/ha) being achieved between clumps. It has been observed in dairy herds, grazing poor quality pastures, that the residual herbage mass between clumps controls animal intake better than the average pasture cover of the whole paddock (Matthews, pers. communication). This new grazing strategy led to a rotation length of 25 days, to improved sward conditions, and to a pasture cover higher than the other two treatments by the end of this season (Figure 5.1; Table 5.2). Despite the higher average pasture cover, the average pre-grazing cover was maintained close to the target value of 2800 kg DM/ha (Figure 5.4).

Figure 5.3. Average post-grazing pasture cover (kg DM/ha) (All treatments: April to September).



As planned, the Treatment 3 autumn grazing management followed Tuapaka traditional 50-day rotation. This management allowed pasture cover to be transferred through this season due to the high initial pasture cover (Figure 5.1) and higher than average pasture accumulation rate achieved (Table 4.3). Initially, this treatment resulted in the lowest post-grazing pasture covers (Figure 5.3) but these post-grazing covers increased during the second month as a result of the higher pre-grazing pasture cover (Figure 5.4), and the longer autumn grazing rotation.

The winter grazing plan (Appendix E; Table E.2) for Treatment 1, which started on 1 June, was based on a single rotation of 100 days over the winter without any supplementation. In order to achieve this, each paddock was divided into two-day breaks with each break fenced in front and behind by temporary electric fences (Figure 5.7). This management was expected to lead to a liveweight gain of 0.5 kg/head/day (Table 3.1) if net pasture accumulation was close to the average of the region, and the spring grazing management would start at the end of this rotation on 10 September.

Figure 5.4. Average pre-grazing pasture cover (kg DM/ha) (All treatments: April to September).

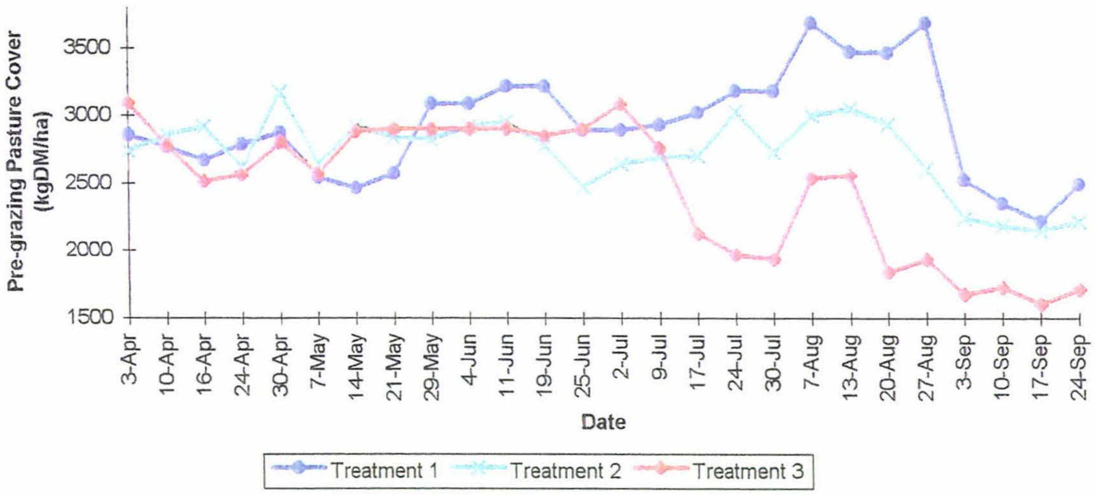


Table 5.2. Weekly average pasture cover (kg DM/ha).

Date	Treatment 1	Treatment 2	Treatment 3
03-Apr	2353	2333	2326
10-Apr	2294	2585	2424
16-Apr	2521	2535	2486
24-Apr	2337	2275	2125
30-Apr	1942	2101	1812
07-May	2014	2120	1978
14-May	2107	2294	2037
21-May	1963	2109	1937
29-May	2219	2425	2162
04-Jun	2143	2357	2187
11-Jun	2247	2329	2193
19-Jun	2108	2158	2048
25-Jun	2160	2100	1995
02-Jul	2169	2065	1872
09-Jul	2213	2069	1815
17-Jul	2093	2119	1696
24-Jul	2118	2058	1614
30-Jul	2143	2087	1579
07-Aug	2013	1983	1468
13-Aug	2268	2186	1714
20-Aug	2256	2146	1655
27-Aug	2251	2159	1645
03-Sep	1935	1948	1424
10-Sep	1848	1803	1286
17-Sep	1786	1777	1300
24-Sep	2051	1954	1445
01-Oct	2072	1985	1482
Mean	2134	2150	1840

Figure 5.5. Treatment 2: Autumn post-grazing level.

Figure 5.6. Treatment 3: Autumn post-grazing levels.

Figure 5.7. Treatment 1: Winter break feeding.

Implementing this winter grazing plan for Treatment 1 resulted in a pasture residual of around 1200 kg DM/ha (Figure 5.3). However, the continued higher pasture growth rates led to both pre-grazing (3600 kg DM/ha, in Figure 5.4) and average pasture cover (2268 kg DM/ha, in Table 5.2) being higher than the targets for the season (Table 3.2). A new transitional grazing plan between winter and spring management was, therefore, implemented on 10 August (Appendix E, Table E.3) in order to consume the extra pasture accumulated over the winter before the spring. This was considered necessary as pasture decay would likely increase during the spring, leading to low pasture quality (Bircham and Hodgson, 1983; Holmes et al., 1993). Consequently, the residuals were lifted to 1500-1600 kg DM/ha associated with an increase in daily animal intake levels. The spring grazing management for Treatment 1 started 10 days earlier than planned on 1 September. Although Treatment 1 showed that management does not need to be monitored on a daily basis, it was also shown that the period (time) of each plan was a) too long and b) did not allow for transitional periods between plans.

Due to the higher pasture cover on 1 June (Table 5.2) and to the higher net pasture accumulation over the winter (Table 4.4), Treatment 2 had a more flexible grazing management over the winter. Grazing management started with a rotation similar to late-autumn (25 days) resulting in pasture residuals at 1700 kg DM/ha (Figures 5.3; 5.8), and consequently high liveweight gains (Geenty and Rattray, 1987). The rotation length was slowed, on 1 July, when the average pasture cover approached the target of 2000 kg DM/ha (Figure 5.1). At this stage strip grazing, similar to Treatment 1, was applied, but again the grazing period varied according to pre-planned post-grazing cover. Thus, whenever the winter post-grazing cover target (Table 3.1) was reached (Figure 5.9), the bulls were shifted, leading to an average rotation rate of 70 days. This led to the average pre-grazing pasture cover becoming very even, at 2600 kg DM/ha (Figure 5.4). As net pasture accumulation rates increased, the grazing rotation was shortened in order to maintain bull intakes and control post-grazing cover to the targeted levels.

Figure 5.8. Treatment 2: Pre and post-grazing herbage mass (June).

Figure 5.9. Treatment 2: Pre and post-grazing herbage mass (mid-winter).

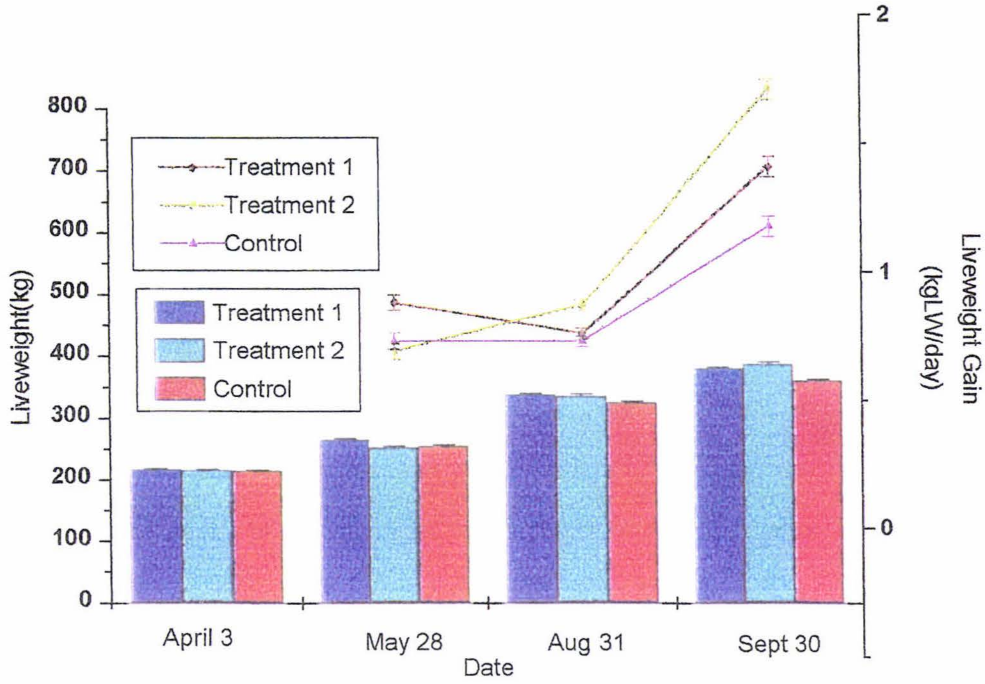
Throughout the winter Treatment 3 was managed on the traditional grazing management of a 50 day rotation, and supplementation of 6 kg of hay/head in the last day or last two days, for 4 or 5 day grazing periods respectively. Due to the high pasture cover over the winter (Table 5.1), supplementation (which normally starts by the end of autumn) only occurred in July, and August with total supplements fed of 120.6 kg DM (pasture equivalent) per hectare. The pasture cover which was 2187 kg DM/ha on 1 June dropped to 1424 kg DM/ha by the end of the winter (Table 5.2).

Over the early-spring, Treatments 1 and 2 had very similar grazing management, as they were based on the same sward targets. Treatment 2 averaged a 25-day rotation compared to the planned 30-day rotation for Treatment 1 (Appendix E, Table E.3). While Treatments 1 and 2 rotations were based on optimising sward conditions to improve pasture accumulation and liveweight gain, Treatment 3 had to speed up the rotation due to the lower average pasture cover in this treatment (Figure 5.1). The traditional grazing management, therefore, relies on the spring flush of pasture growth to build up pasture cover as well as to increase animal intakes and liveweight gains. The Treatment 3 average pasture cover of 1424 kg DM/ha by 3 September (Table 5.2) led to an average pre-grazing and post-grazing pasture cover of 1649 and 1113 kg DM/ha respectively (Table 4.5). In fact, the Treatment 3 spring average pre-grazing cover was similar to the post-grazing levels in both Treatments 1 and 2 (Table 4.5). This factor restricted daily pasture intake per bull (Geenty and Rattray, 1987), and consequently resulted in significantly lower liveweight gains in this treatment (Table 4.1; Figure 5.10).

5.3 Animal Performance: Animal Intake, Liveweight And Liveweight Gain

The Treatments 1 and 2 average post-grazing cover levels were considerably higher than Treatment 3 over the autumn (Figure 5.3). Therefore, apparent daily dry matter intakes and liveweight gains were both expected to be higher than for Treatment 3 (Holmes, 1987; Geenty and Rattray, 1987) at the end of this season. Although, Treatments 1 and 2 had higher apparent dry matter intake than Treatment 3 (Table 4.3; Figure 5.11), this advantage was not transferred into bull weight, and Treatment 2 was the lightest among all treatments (Table 4.1; Figure 5.10). The reason for this is not very clear, but it probably reflects the difference in gut fill of each treatment at weighing on 28 May. Treatment 2 was weighed while being shifted (post-grazing), whereas the other two had been shifted the previous day and weighed after the first day in a new paddock. The gut fill could account to up to 6.8% of the full body weight, (as was measured by the difference of full and fasted weight by the end of this trial). This suggests there probably was little difference in liveweight between Treatment 1 and Treatment 2. This argument is supported by the relative weight gains of Treatment 1 and Treatment 2 between weightings on 28 May and 30 June (Figure 5.10).

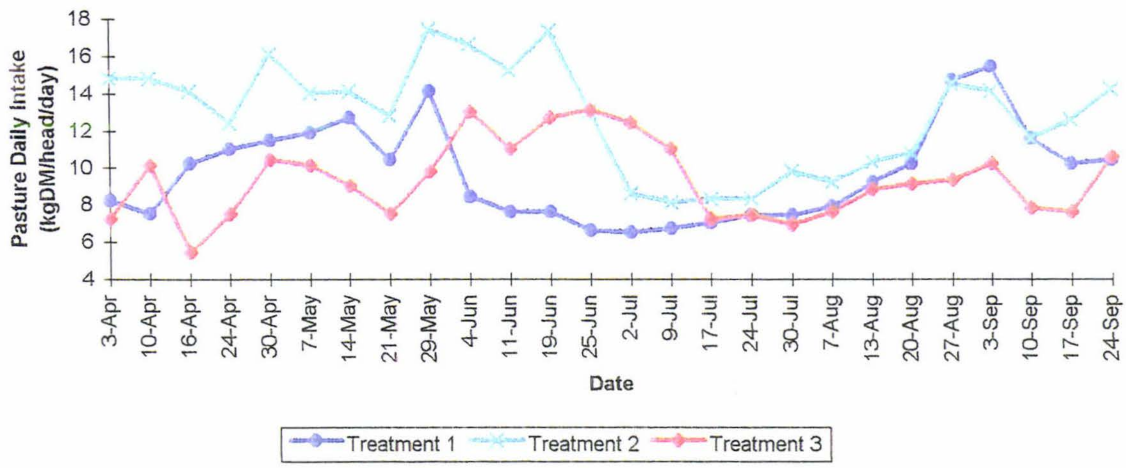
Figure 5.10. Liveweight (kg) and liveweight gain (kg/head/day) (April to September).



During the set up period (autumn) some bull behavioural problems were observed in Treatments 1 and 2, and were considered to be a consequence of the mobs redistribution and feeding levels. Surprisingly, there were no such problems in Treatment 3, in spite of this being the biggest mob (61 bulls), and with bull intakes below those in other Treatments. One bull death occurred in each of Treatments 1 and 2 and none in Treatment 3.

During the winter, Treatment 1 liveweight gain was targeted at 0.5 kg/head/day (Table 3.1). On the other hand, an above target pasture cover on 1 June (Table 5.2) and the higher net pasture accumulation (Figure 5.12) led to a faster rotation and residuals slightly higher (1289 kg DM/ha) than targeted. Average liveweight gain, over the winter was therefore 0.76 kg/head/day without supplementation (Table 4.1; Figure 5.10).

Figure 5.11. Average daily pasture intake (kg DM/head/day).



Treatment 3 liveweight gain target for the winter was 0.7 kg/head/day. This value was considerably higher than the 0.55 kg DM/head/day average achieved in the previous 8 years (Table 5.3). The pasture cover of 2162 kg DM/ha by 29 May was 489 kg DM/ha higher than the average of the previous 6 years (Table 5.1). A difference of 445 kg DM/ha was maintained on average throughout the winter. This fact, together with the higher pasture accumulation in the period and the supplementation of 120.6 kg DM (pasture equivalent) per hectare of hay allowed Tuapaka traditional management to approach the farm liveweight target over this period (Table 5.3).

The higher liveweight gain in Treatment 2 in winter (Table 4.1; Figure 5.10) was due to the faster rotation under which this group was managed, leading to higher post-grazing cover (Table 4.4; Figure 5.3), higher pasture allowance and consequently higher pasture intakes (Figure 5.11) (Holmes, 1987; Geenty and Rattray, 1987). The net pasture accumulation was also higher than expected (Anon, 1992). This resulted in a pasture cover of 2357 kg DM/ha on 4 June (Table 5.2), which was 200 kg DM/ha higher than the target minimum limit. Therefore, if the rotation length had been increased on 1 June, pre-grazing pasture cover would have reached values above target, therefore, jeopardising sward quality. As a result, the rotation length in the first month of the winter remained at 25 days, and pasture residuals higher than 1600 kg DM/ha. Finally, bulls in Treatment 2 ended the winter at a similar weight to Treatment 1 (Table 4.1; Figure 5.10), thus overcoming the big difference measured at the end of autumn.

Table 5.3. Bull liveweights (kg) (8-year average, Tuapaka targets and Treatment 3).

	8 year Average Liveweight (kg) +	Target Liveweight (kg)	Treatment 3 1997 Average Liveweight (kg)
March	206	226	200.4
April	233	256	229.2
May	261	287	255.5
June	281	309	291.8
July	287	316	299.5
August	312	344	325.5
September	337	371	361

+ End of the month values

Although the average pasture residuals of Treatment 2 and Treatment 1 were similar over the spring (Table 4.5; Figure 5.3), the first had the highest apparent daily pasture intake (Table 4.5; Figure 5.11), due to the faster rotation length reducing grazing intensity from 77.6 to 61.5 bulls/ha/day. This resulted in Treatment 2 having the highest final liveweight and liveweight gain (Table 4.1; Figure 5.10). Once again, the gut fill effect in this type of experiment was shown with Treatment 1 being the heaviest mob, although Treatment 2 had the highest overall liveweight gain (Table 4.2). In spite of being lighter than Treatments 1 and 2, Treatment 3 performed 7.1 % better in the 1997 season than Tuapaka average results (Table 5.3). This suggests that 1997 was an above average year.

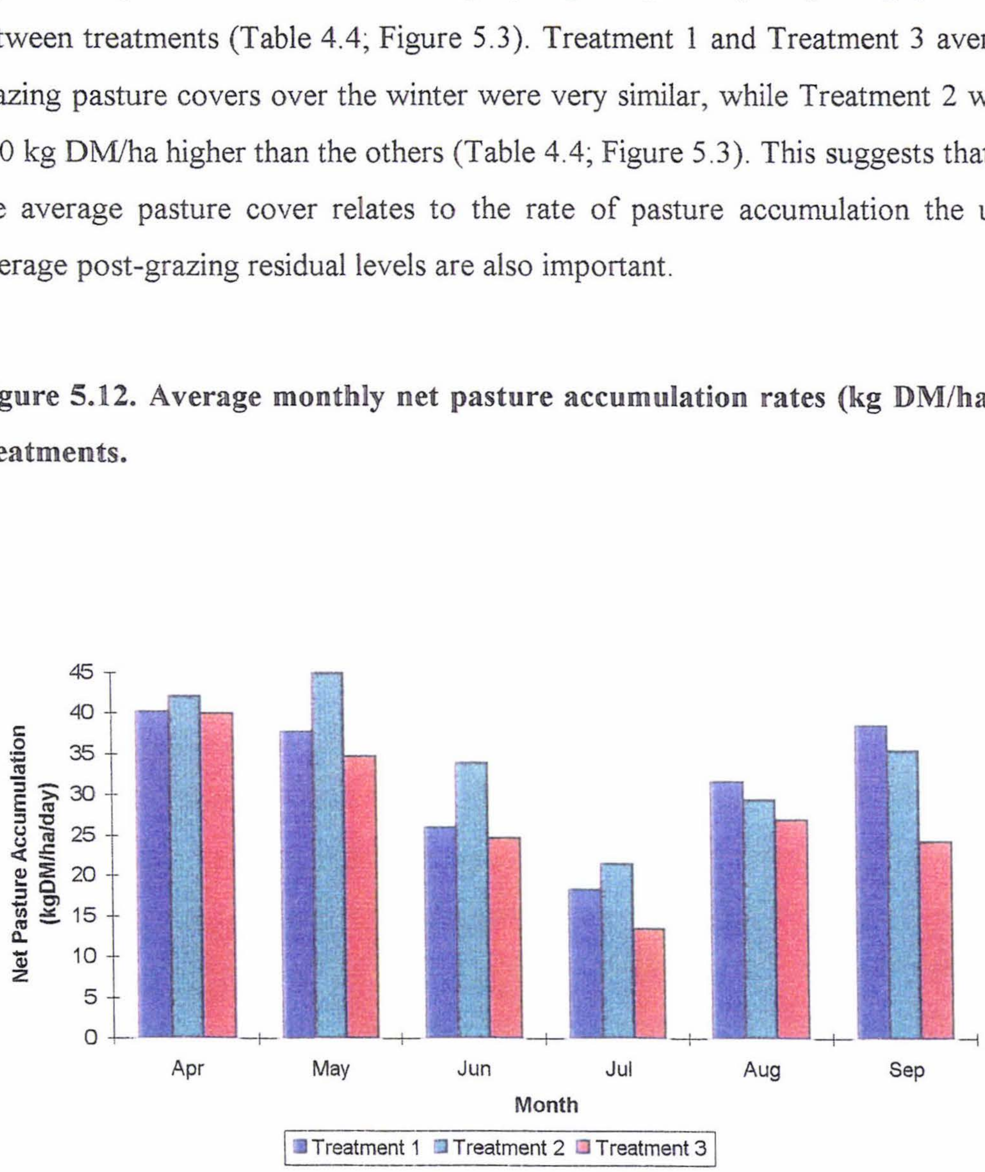
It was also possible to confirm that at the same pasture residuals daily average liveweight gain is higher in spring than in autumn (Morris et al., 1993). For example, Treatment 3 average residual cover over early-spring (Table 4.5) averaged 450 kg DM/ha lower than in autumn (Table 4.3), even though, liveweight gain almost doubled in spring. Similarly, Treatments 1 and 2 average residuals were higher in autumn (Table 4.3) than in early-spring (Table 4.5), however their liveweight gains in this last period were almost the double of the ones in autumn. This difference was also evident between winter and early-spring. Even though average post-grazing mass was higher in the winter (1208 kg DM/ha) than in the early-spring (1113 kg DM/ha) liveweight gains were higher in the early-spring.

5.4 Sward Conditions

During the autumn the average pasture cover for all Treatments was maintained above 2000 kg DM/ha (Figure 5.1). This was due to the high initial pasture cover and to the high pasture growth rate over this period. The historical average net pasture accumulation in the Manawatu area for late-autumn was around 25 kg DM/ha (Appendix C, Table C.3), whereas the lowest average registered during the trial was 37.1 kg DM/ha/day. The highest difference measured was between Treatment 2 and Treatment 3 (8.7 kg DM/ha/day) (Table 4.3; Figure 5.12), although this difference was not significant. Treatment 2 average pasture cover was higher than the other two treatments over the autumn, and also by the end of the season (Figure 5.1). This, together with the higher average apparent daily pasture intake in autumn (Table 4.3; Figure 5.11), suggest some influence of the grazing management on the average net pasture accumulation rates between treatments.

Over the winter, the average pasture accumulation in Treatment 2 was higher than the other two treatments (Table 4.4; Figure 5.12). This happened, despite the fact that the average pasture covers of Treatments 1 and 2 for this period were similar (Table 4.4). Both treatments pasture covers were on average 300 kg DM/ha higher than Treatment 3, and it was expected that these treatments would have an average pasture accumulation over this period around 6 kg DM/ha/day higher than Treatment 3 (Matthew et al., 1995). However, this advantage was only detected on Treatment 2, where net pasture accumulation rate was increased by 2.7 kg DM/ha/day for every extra 100 kg DM/ha in pasture cover. Treatment 1 extra pasture accumulation over this period was only 1.03 kg DM/ha per extra 100kg DM/ha higher than the average of Treatment 3. This could be explained by the difference in average pre-grazing and post-grazing pasture covers between treatments (Table 4.4; Figure 5.3). Treatment 1 and Treatment 3 average post-grazing pasture covers over the winter were very similar, while Treatment 2 was almost 300 kg DM/ha higher than the others (Table 4.4; Figure 5.3). This suggests that although the average pasture cover relates to the rate of pasture accumulation the underlying average post-grazing residual levels are also important.

Figure 5.12. Average monthly net pasture accumulation rates (kg DM/ha/day): all treatments.



During the winter the rotation length reflected the average pasture cover and the pre-grazing cover of each treatment. Treatment 1 had the highest average pasture cover and pre-grazing herbage mass as a result of the longer winter (100 days) and early-spring (30 days) rotations. On the other hand, Treatment 2 had lower pasture cover (Figure 5.1) and pre-grazing herbage mass (Figure 5.4), but similar post-grazing cover to Treatment 1 (Table 4.5; Figures 5.3, 5.13) resulting from a faster winter and spring rotations (25 days). Further, the short rotation length, on Treatment 3, was due to the lower pasture cover and reduced grazing residuals to 1113 kg DM/ha (Table 4.5; Figure 5.14). The lower residuals together with the lower pasture cover are likely to be the reason for this treatment having the lowest level of net pasture accumulation (Bircham and Hodgson, 1983), animal intake levels and animal production.

Throughout the spring, the higher net pasture accumulation rates for Treatments 1 and 2 (35.7 kg DM/ha/day) than for Treatment 3 (23.9 kg DM/ha/day) amounted to an extra 2.36 kg DM/ha/day DM grown for each 100 kg DM/ha increase in average pasture cover. This supports the finding of Matthew et al., (1995). It also shows a significant increase in net pasture accumulation rate between the systems managed on pasture targets compared to the traditional Tuapaka management (a 49 % increase). This was much higher than the 15 % budgeted at start of the experiment.

Although the Treatment 3 average pasture cover was lower than Treatments 1 and 2 at the end of the winter grazing management (31 August) (Table 5.2), this value was 401 kg DM/ha higher than Tuapaka average for the previous 6 years (Table 5.1). This increase in values was also noticed by the end of the trial (1 October), however the average pasture cover was only 281 kg DM/ha higher than Tuapaka previous 6 years average (Table 5.1).

Figure 5.13. Treatment 2: Example of post-grazing pasture cover of in spring.

Figure 5.14. Treatment 3: Post-grazing residuals in spring.

5.5 Overall Pasture Accumulation and Pasture Balance

During the whole trial there were months when the differences in pasture accumulation between treatments were not detected. For example, in the first three months of the trial there was no difference in net pasture accumulation between treatments (Table 4.3; Figure 5.12). As the winter grazing management progressed, the average pasture cover on Treatment 3 reduced until it reached a low point of 1286 kg DM/ha (Table 5.2). Similarly, from July onwards, when Treatment 3 pasture cover started to drop, Treatments 1 and 2 had higher net pasture accumulation than Treatment 3 (Figure 5.12). Therefore, the treatment effect on the total pasture accumulation over the experimental period needs to be compared.

The total pasture accumulation during the trial is presented in Table 4.6. It can be seen that the average difference between Treatments 1 and 3, and Treatments 2 and 3 were 870 and 1785 kg DM/ha respectively. Based on this data, the extra average net pasture accumulation of Treatments 1 and 2 over Treatment 3 were calculated at 4.83 and 9.91 kg DM/ha/day respectively. As a result, the average pasture cover over the trial of Treatments 1 and 2 was 293 kg DM/ha higher than Treatment 3 (Table 5.2). Therefore, the increase in pasture growth rate per extra 100 kg DM/ha of pasture cover was 1.64 kg DM/ha/day (Treatment 1) and 3.38 kg DM/ha/day (Treatment 2). These values are very close to the one suggested by Matthew et al., (1995) of 2 kg DM/ha/day per 100 kg DM/ha pasture cover increase. It can be concluded from this result that the net pasture accumulation rate is directly influenced by sward conditions established by the different grazing management strategies.

In addition, the extra pasture produced by Treatments 1 and 2 (Table 4.6) over the winter resulted in higher pasture covers (Figure 5.1) rather than higher liveweight gains. The higher pasture cover in early-spring allowed pre and post-grazing targets to be achieved, increasing pasture allowance, dry matter intake, and consequently average daily gain in both Treatments 1 and 2 over this period (Table 4.5). It can be seen in Table 4.6 that the extra pasture produced in Treatment 1 reflected in higher pasture cover than Treatment 3, since both treatments had very similar total pasture consumption and the difference in pasture production between them was 870 kg DM/ha. This value was similar to the difference in pasture cover between Treatments 1and 3 by the end of the trial.

Finally it is important to note that despite the apparent success of the Treatment 1 grazing plans they did not adequately take into account the initial situation and the planning periods were too long. This fact together with the lower post-grazing and higher pre-grazing pasture covers over the winter (Table 4.4) may be the reason for lower net pasture accumulation in Treatment 1 than in Treatment 2. The adjustments made to the transition between winter and spring and the earlier start of the spring plan, probably contributed to this successful outcome of Treatment 1. Treatment 2 had a very flexible grazing management, which allowed management to respond much quicker to changes in sward conditions. This fact was also the reason for the best animal performance, especially over the winter when the temperatures and net pasture accumulations were much higher than predicted by previous experience.

6. Conclusions And Practical Implications

6.1 Conclusions

The present trial aimed to study the effect of grazing management on net pasture accumulation and on animal performance from late-autumn to early-spring at the Tuapaka bull unit. It tested the hypothesis that increased net pasture accumulation can be achieved when grazing management is based on sward targets rather than on animal intakes and animal performances. Management targets (Table 3.1) were established to maximise net pasture accumulation over the autumn in order to start the winter with higher pasture cover, heavier bulls or a combination of both factors. With heavier bulls, the grazing management in winter could then focus on establishing the sward conditions over the winter to achieve early-spring pasture targets, rather than increase animal intakes. If the early-spring pasture targets were achieved then the grazing management could again focus on managing swards for maximum net pasture accumulation and bull liveweight gain.

This trial showed that the grazing management based on sward target conditions increased the net pasture production over the late-autumn to early-spring period. It resulted in improved animal performance, and reduced supplement input during the winter, therefore, reducing farming cost. It also confirmed the assumptions made by Phillips and Matthews (1994) and Matthews (1997) that maintaining target pre and post-grazing sward conditions enhanced net herbage accumulation. The managed farmlet (Treatment 2) produced 33 % more pasture DM per hectare than the traditional grazing management (Treatment 3). The average increase was 3.38 kg DM/ha/day for each 100 kg DM/ha increase in average pasture cover (Treatment 2 vs. Treatment 3), which is higher than the value quoted by Matthew et al., (1995). The lower response in Treatment 1 (1.64 kg DM/ha/day for each 100 kg DM/ha increase in average pasture cover) was due to the differences in pre and post-grazing sward conditions rather than to differences in average pasture cover. This emphasis the need not only for management to focus on average pasture cover, animal intakes, but also on pre and post-grazing sward conditions if maximum net herbage accumulation and bull liveweight gains are to be achieved.

Although the implementation of a fixed plan for Treatment 1 was successful the initial plan did not adequately take into account the start situation and the transition between fixed plans. This meant that Treatment 2 adjusted better to the current situation of sward conditions due to its flexible grazing plan, which led to better performance over the trial. If this grazing management is to be tested again then grazing plans should be calculated per season and re-evaluated on a weekly basis, according to the actual average pasture cover and net pasture accumulation to maintain management targets.

6.2 Practical Implications In The New Zealand Farming System

The grazing managements tested in this trial were very efficient and presented higher net pasture accumulation than the traditional management systems during the whole period. It proved that applying better grazing management from late-autumn to early-spring period, not only pasture production but also animal performance can be improved, and at reduced cost due to reduced supplement inputs. The early-spring is always a critical period for beef farmers with low levels of liveweight gain, due to the low pasture cover. The extra pasture produced over the winter will allow higher pasture covers at the start of spring enabling improved feeding of the bulls and ultimately increased liveweight gain. Final target liveweight might be reached sooner, allowing bulls to be sold earlier or final target liveweights increased.

In addition, average pasture cover alone is not an adequate basis for grazing management decisions, and target pre and post-grazing pasture covers should also be used. It is important to set targets for average pasture cover, pre-grazing cover, and post-grazing cover for each season. The monitoring of pre and post-grazing pasture cover appears to be more important for daily grazing management decisions, than the monitoring the whole farm pasture cover. Hence, it can be proposed that in spring and autumn, when the rotation length will be normally faster than 30 days and several paddocks are grazed every week, measuring pre and post-grazing covers alone will be as efficient as measuring the average pasture cover and will demand less time. In this case, net pasture accumulation can be estimated from the difference of the pasture cover between grazings. Pre and post-grazing measurement will also give a reasonable idea of the average pasture cover if it is calculated from their average. However it is also important that the grazing manager visually assesses the non grazed paddocks to ensure that all of them are within the target cover.

Grazing management over the autumn should focus on sward conditions to improve net herbage production rather than set sward conditions for improved animal performance over the winter. Conversely, during winter liveweight gain should not be the first target but a consequence of pasture availability, and grazing management should focus on setting up pasture conditions for early-spring. During the spring, grazing management should again focus on sward conditions for high pasture production in order to maximise bulls liveweight gain before replacements are purchase. Finally, rotation length will always be a function of the current sward condition and net pasture accumulation, and therefore will not be fixed.

7. References

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Appendix A: Tuapaka soil test data

Table A.1. Soil test results from Tuapaka bull unit.

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Facsimile 0-6-350 5632

MASSEY UNIVERSITY

LABORATORY REPORT

Name: Alistair MacDonald

Date: 10/12/97

Address: University Farms
Tuapaka Lower Beef Unit

Type of material: Soil

ANALYSES:

SAMPLE	pH	Olsen P µg/g	SO_4 µg/g	K meq/100g	Ca meq/100g	Mg meq/100g	Na meq/100g	CEC meq/100g	Soil volume correction factor
2	6.1	29.1	9.0	0.32	8.5	1.62	0.11	13	0.91
3	5.9	33.8	6.5	0.28	7.4	1.39	0.14	13	0.92
5	5.9	27.6	7.0	0.29	8.2	1.61	0.03	14	0.91
6	6.0	27.1	7.0	0.21	10.4	1.52	0.05	16	0.93
7	6.0	20.0	5.5	0.19	7.8	0.88	0.01	11	1.02
13	5.7	23.8	6.5	0.18	5.6	0.97	0.01	12	0.99
15	5.9	30.5	6.5	0.16	7.2	0.98	0.02	11	0.96
16	5.9	24.3	6.5	0.15	8.1	1.00	0.17	12	0.95
20	6.0	22.4	5.8	0.26	8.9	1.18	0.02	14	0.90
21	5.9	24.2	6.5	0.20	8.7	1.29	0.31	15	0.87
23	6.0	25.7	5.0	0.12	11.5	1.14	0.03	18	0.96
24	5.9	34.8	8.3	0.37	8.7	1.39	0.41	16	0.81
26	5.9	36.6	6.2	0.27	9.7	1.53	0.03	18	0.89
28	6.0	26.9	6.5	0.23	10.3	1.35	0.01	17	0.86
29	5.9	33.0	7.5	0.32	7.8	1.39	0.08	15	0.90
31	6.0	28.6	7.3	0.31	11.2	1.59	0.15	18	0.86
32	6.1	27.1	6.8	0.40	11.0	1.71	0.13	17	0.74
33	6.0	29.1	8.3	0.37	10.0	1.95	0.09	17	0.83

Phosphate and sulphate values are expressed as µg/g (air-dry). Exchangeable cations and CEC values are expressed as meq/100g (air-dry).

The soil volume correction factor is a measure of the weight of air-dry soil (g) per volume (ml) and can be used to convert results to a volume basis.

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Appendix B: Metabolic Energy Requirements of Bull Beef

Table B.1. Metabolic Energy requirements of bull beef (Journeoux, 1987)

BULL ENERGY REQUIREMENTS (MJME)

Live Weight (kg)

kg/day wt gain	100	150	200	250	300	350	400	450	500	550	600
0	22.6	28.3	33.1	37.4	41.4	45.0	48.5	51.7	54.8	57.7	60.6
0.1	24.2	30.4	35.7	40.5	44.9	48.9	52.5	56.0	59.5	62.9	66.0
0.2	26.0	32.5	38.3	43.6	48.5	52.8	56.7	60.5	64.4	68.1	71.7
0.3	27.7	34.8	41.0	46.8	52.1	56.9	60.9	65.0	69.3	73.5	77.5
0.4	29.6	37.1	43.9	50.1	55.9	61.0	65.3	69.7	74.4	79.0	83.5
0.5	31.4	39.5	46.7	53.5	59.8	65.2	69.8	74.4	79.6	84.6	89.5
0.6	33.3	41.9	49.7	56.9	63.8	69.6	74.4	79.3	84.9	90.4	95.7
0.7	35.3	44.4	52.7	60.4	67.8	74.0	79.0	84.3	90.4	96.3	102.1
0.8	37.4	47.0	55.8	64.0	72.0	78.5	83.8	89.4	95.9	102.3	108.6
0.9	39.4	49.6	58.9	67.7	76.2	83.1	88.7	94.6	101.6	108.5	115.2
1.0	41.6	52.3	62.1	71.5	80.5	87.9	93.7	99.9	107.4	114.7	122.0
1.1	43.8	55.0	65.4	75.4	84.9	92.7	98.8	105.3	113.3	121.1	128.9
1.2	46.0	57.8	68.8	79.3	89.4	97.6	104.0	110.9	119.3	127.7	135.9
1.3	48.3	60.7	72.3	83.3	94.0	102.6	109.2	116.5	125.5	134.4	143.1
1.4	50.7	63.6	75.8	97.4	98.7	107.7	114.6	122.3	131.8	141.2	150.4
1.5	53.1	66.6	79.4	91.6	103.4	112.9	120.1	128.1	138.2	148.1	157.9

Appendix C: Grazing Plans For Tuapaka Bull Unit

Table C.1. Feed Budget of the actual grazing plan applied at Tuapaka bull unit

Feed Budget for the period ending:	October											
Farmer:	Tuapaka Bull Beef Unit											
Address:												
EFFECTIVE AREA:	90	90	95	95	95	95	95	95	99	99	90	90
INITIAL COVER:	1364											
STARTING PERIOD:	11											
MONTH:	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
FEED DEMAND AND SUPPLY												
Net Pasture Accumulation/day	47	45	16	10	16	22	17	12	0	13	20	42
Intake/day	39	43	23	18	13	16	17	16	12	18	21	36
Difference/day	9	2	-7	-8	2	5	0	-5	-12	-6	-1	5
Supplements (enter total)												
Turnips			10000	10000				0	10000	10000		
Silage:								2500	2500	0	0	0
Nitrogen:												
FINAL COVER:	1626	1685	1559	1439	1512	1672	1673	1563	1315	1244	1201	1364
ANIMAL INTAKE;												
R1yrs Bulls:	275	275	275	275	275	275	275	275	275	275	275	275
Intake/head/day	4	3.3	4.3	4.5	4.6	5.6	6	5.6	4.3	6.5	7	11.9
R2yrs Bulls:	275	275	137	70	1							
Intake/head/day	8.6	10.7	7.5	6.75								
TOTAL DEMAND/HA/DAY	39	43	23	18	13	16	17	16	12	18	21	36
DAYS/PERIOD:	30	31	31	28	31	30	31	30	31	31	30	31

Table C.2. Sward dynamics of the suggested grazing plan for Tuapaka bull unit

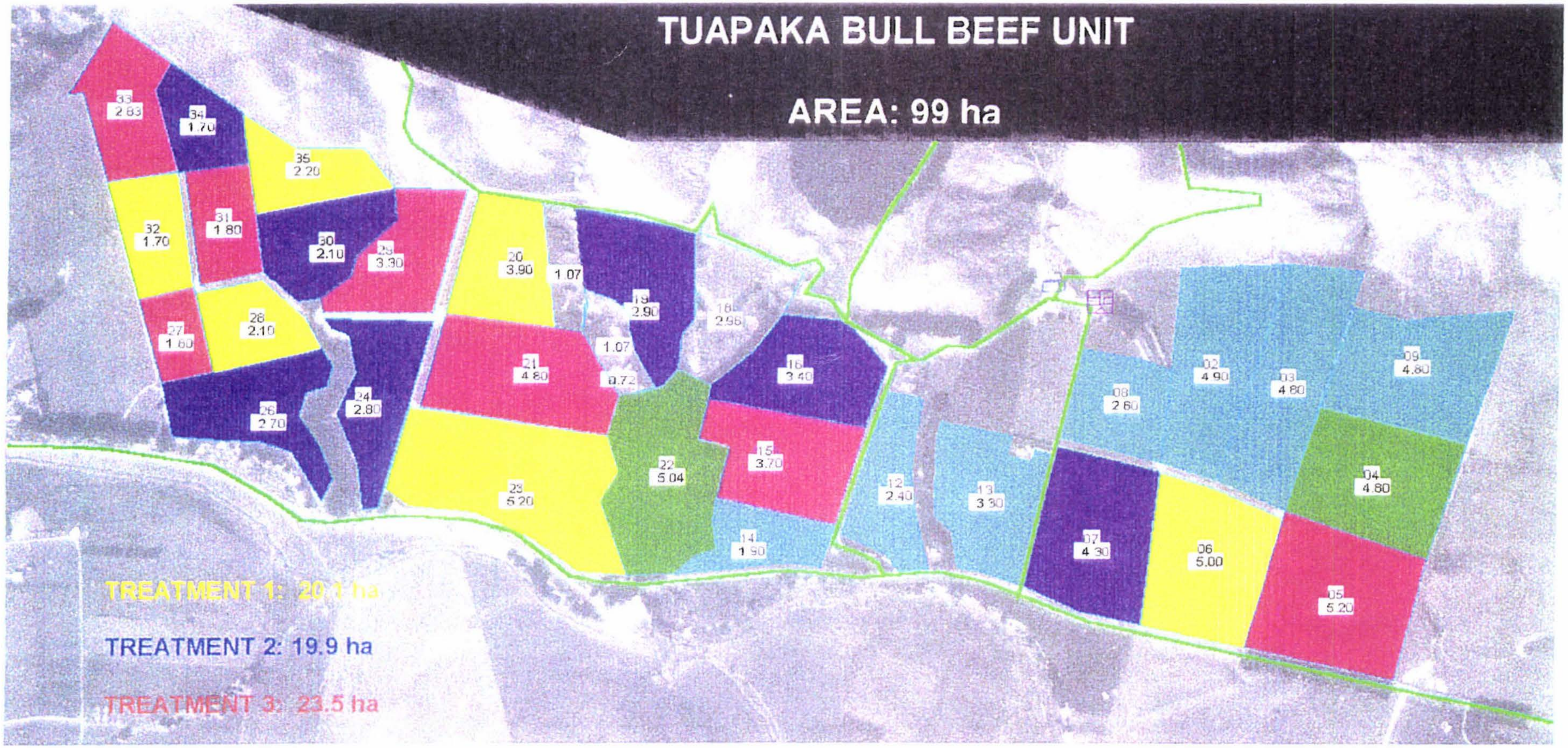
Feed Budget for the period ending:	October											
Farmer:	Tuapaka Bull Beef Unit (Proposed management)											
Address:												
EFFECTIVE AREA:	99	99	99	99	99	99	99	99	99	99	99	99
INITIAL COVER:	2000											
STARTING PERIOD:	11											
MONTH:	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
FEED DEMAND AND SUPPLY												
Pasture Net Accumulation/day	39	40	10	15	19	18	23	16	13	17	33	35
Intake/day	39	40	13	15	16	18	23	16	16	20	30	31
Difference/day	0	0	-3	0	3	0	0	0	-3	-3	3	3
Supplements (enter total)												
Turnips								0	0			
Silage:										0	0	0
Nitrogen:												
FINAL COVER:	2000	2000	1900	1900	2000	2000	2000	2000	1900	1800	1900	2000
ANIMAL INTAKE;												
R1yrs Bulls:	275	275	275	275	275	275	275	275	275	275	275	275
Intake/head/day	3.8	4.2	4.8	5.3	5.8	6.4	8.2	5.7	5.8	7.2	10.7	11.3
R2yrs Bulls:	275	275	0	0	0							
Intake/head/day	10.4	10.3	0	0								
TOTAL DEMAND/HA/DAY	39	40	13	15	16	18	23	16	16	20	30	31
DAYS/PERIOD:	30	31	31	28	31	30	31	30	31	31	30	31

Table C.3. Average monthly (kg DM/ha/day) and annual (kg DM/ha) pasture accumulation for Manawatu (Mean of 11 years, Anon, 1992), and average pasture accumulations according to the actual (Table C.1) and proposed (Table C.2) Tuapaka bull unit grazing management.

Month	Manawatu Average (kg DM/ha/day)	Actual Average (kg DM/ha/day)	Proposed (kg DM/ha/day)
January	41	16	10
February	39	10	15
March	36	16	19
April	25	22	18
May	21	17	23
June	16	12	16
July	16	0	13
August	21	13	17
September	33	20	33
October	46	42	35
November	48	47	39
December	52	45	40
Total Accumulation (kg DM/ha)	11975	7929	8467

Appendix D: Paddock Layout

Table D.1. Tuapaka bull unit layout with paddocks distribution for each treatment



Appendix E: Treatment 1 Grazing Plans

Table E.1. Treatment 1 autumn grazing plan.

Farming Area (ha)	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Number of Paddocks	9	9	9	9	9	9	9	9	9	9	9	9	9
Date	3-Apr	7-Apr	11-Apr	14-Apr	18-Apr	22-Apr	28-Apr	30-Apr	2-May	5-May	9-May	11-May	14-May
Paddock Number	6A	6B	32	35	23A	23B	20A	20B	28	6A	32	28	23A
Paddock Area (ha)	2.50	2.50	1.70	2.20	2.20	3.00	1.95	1.95	2.10	3.00	1.70	2.10	2.20
Pasture growth (kg DM/ha/day)	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3
Pre-grazing (kg DM/ha)	2856	2985	2944	2615	2914	3027	2608	2673	2805	3181	3278	3062	3029
Supplement (kg DM/ha)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Number	53	53	53	53	53	53	53	53	53	52	52	52	52
Animal intake (kg DM/ha/head/day)	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	12.7	12.7	12.7	12.7
Grazing period (days)	4.0	4.0	3.5	4.0	3.5	6.0	2.0	2.0	3.0	4.0	2.5	3.0	3.0
Post-grazing (kg DM/ha)	2245	2374	2158	1921	2307	2264	2217	2282	2260	2397	2090	2086	2129
Pasture change (kg DM/ha/day)	-382	-382	-382	-382	-382	-382	-382	-382	-382	-660	-660	-660	-660
Average Pasture Cover (kg DM/ha)	2353	2349	2345	2345	2342	2340	2331	2330	2329	2328	2314	2310	2304

Table E.2. Treatment 1 winter grazing plan.

Farming Area (ha)	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Number of Paddocks	9	9	9	9	9	9	9	9	9	9	9	9	9
Date	21-May	24-May	27-May	30-May	2-Jun	17-Jun	30-Jun	7-Jul	17-Jul	28-Jul	13-Aug	22-Aug	1-Sep
Paddock Number	23B	20A	28	20B	6A	6B	32	35	23A	23B	20A	28	20B
Paddock Area (ha)	3.00	1.95	2.10	1.95	2.50	2.50	1.70	2.20	2.20	3.00	1.95	2.10	1.95
Pasture growth (kg DM/ha/day)	25.1	23.6	22.2	20.7	19.3	13.0	13.0	13.0	13.1	13.8	14.9	17.3	20.5
Pre-grazing (kg DM/ha)	2090	2257	2264	2047	2731	2586	2374	2472	2593	2656	2570	2517	2877
Supplement (kg DM/ha)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Number	52	52	52	52	52	52	52	52	52	52	52	52	52
Animal intake (kg DM/ha/head/day)	7.1	7.1	7.1	7.1	5.7	5.7	5.7	5.7	5.7	6	6	6	6.2
Grazing period (days)	3.0	3.0	3.0	3.0	15.0	13.0	7.0	10.0	11.0	16.0	9.0	10.0	11.0
Post-grazing (kg DM/ha)	1796	1760	1803	1542	1242	1214	1244	1255	1255	1214	1264	1204	1283
Pasture change (kg DM/ha/day)	-294	-323	-323	-329	-248	-264	-274	-268	-268	-270	-283	-276	-282
Average Pasture Cover (kg DM/ha)	1962	1959	1957	1955	1953	1941	1927	1923	1900	1876	1839	1820	1800

Table E.3. Treatment 1 late-winter/early-spring grazing management

Farming Area (ha)	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Number of Paddocks	9	9	9	9	9	9	9	9	9	9	9	9	9
Date	30-Jul	10-Aug	18-Aug	24-Aug	31-Aug	6-Sep	9-Sep	11-Sep	14-Sep	16-Sep	20-Sep	23-Sep	26-Sep
Paddock Number	23B	20A	20B	28	6A	6B	32	35	23A	23B	20A	20B	28
Paddock Area (ha)	3.00	1.95	1.95	2.10	2.50	2.50	1.70	2.20	2.20	3.00	1.95	1.95	2.10
Pasture growth (kg DM/ha/day)	14.0	14.7	16.0	17.9	20.2	22.1	23.1	23.7	24.7	25.7	28.3	30.3	32.3
Pre-grazing (kg DM/ha)	2621	3372	3060	3020	2745	2224	2247	2375	2087	2394	2342	2316	2288
Supplement (kg DM/ha)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock Number	51	51	51	51	51	51	51	51	51	51	51	51	51
Animal intake (kg DM/ha/head/day)	7	9.1	9.1	9.1	10	10	10	10	10	10	10	10	10
Grazing period (days)	11.0	8.0	6.5	6.5	6.0	3.0	2.0	3.0	2.5	4.0	3.0	3.0	3.5
Post-grazing (kg DM/ha)	1466	1585	1616	1699	1642	1678	1693	1750	1569	1765	1616	1595	1551
Pasture change (kg DM/ha/day)	-315	-435	-433	-427	-460	-455	-471	-458	-456	-433	-455	-451	-442
Average Pasture Cover (kg DM/ha)	2143	2124	2113	2104	2095	2084	2078	2076	2072	2069	2060	2058	2055

Appendix F: Rising Plate Meter Calibrations

Table F.1. Pasture sample on 27 March for rising plate meter calibration equation showing the compressed height, the sample weight and its correspondent cover per hectare.

Sample No.	Rising Plate Meter	Quadrat ($g/0.01m^2$)	Average Pasture Cover (kg DM/ha)
1	18.4	31.2	3467
2	17.6	26.3	2922
3	16	38.8	4311
4	19.6	30.9	3433
5	20.8	31.6	3511
6	12	13.5	1500
7	7.2	9.9	1100
8	5.6	6.8	756
9	11.2	13.1	1456
10	8	10.9	1211
11	6.4	7.8	867
12	4.8	5.5	611
13	6	10.8	1200
14	5.2	7.5	833
15	17.2	30.6	3400
16	7.6	15.9	1767
17	7.6	15.4	1711
18	17.6	29.3	3256
19	26.8	74	8222
20	15.2	23.5	2611
21	19.2	41.2	4578
22	20.4	44.9	4989
23	13.6	23	2556
24	11.1	15.9	1767
25	4.8	10.6	1178
26	20	27.2	3022
27	12	19.9	2211
28	5.2	12.3	1367
29	14	21	2333
30	10.8	16	1778
31	12.4	18.2	2022
32	18	42.6	4733
33	28	29.8	3311
34	29.6	30.2	3356
35	23.9	40.4	4489
36	12.4	28.1	3122
37	7.2	14.1	1567
38	6.8	14.4	1600
39	8.8	16.4	1822
40	7.6	17.7	1967
41	7.6	10.3	1144
42	28	41.4	4600
43	8.4	15.2	1689
44	32.4	53.7	5967
45	31.2	43.6	4844
46	8.4	23.6	2622
47	7.6	23.8	2644
48	14	36.1	4011
49	7.6	15.7	1744
50	17.2	47.1	5233

Table F.2. Pasture sample on 1 May for rising plate meter calibration equation showing the compressed height, the sample weight and its correspondent cover per hectare.

Sample No.	Rising Plate Meter	Quadrat ($g/0.01m^2$)	Average Pasture Cover (kg DM/ha)
1	4.4	5.2	520
2	4.4	5.8	580
3	4.4	6.9	690
4	4.8	9	900
5	5.6	9.1	910
6	8.4	16.2	1620
7	6.8	10.6	1060
8	6.4	8.5	850
9	7.6	12.5	1250
10	8	13	1300
11	3.6	6.8	680
12	5.2	10.5	1050
13	10.4	13.1	1310
14	11.6	20.3	2030
15	10.8	23.3	2330
16	11.2	22.7	2270
17	17.2	27.2	2720
18	11.2	14.9	1490
19	14	25.6	2560
20	5.6	7.1	710
21	8	13	1300
22	7.2	10.7	1070
23	4.8	5.2	520
24	6.8	14.2	1420
25	8	14.5	1450
26	11.6	15.9	1590
27	20.8	42.7	4270
28	16.8	26.5	2650
29	15.2	21.7	2170
30	12.4	26.1	2610
31	24.4	46.1	4610
32	23.6	39.6	3960
33	23.6	48.8	4880
34	19.6	28.8	2880
35	11.6	26.4	2640
36	10.8	24	2400
37	17.2	24.4	2440
38	15.2	29.7	2970
39	24.8	44.7	4470
40	21.2	32.8	3280
41	21.6	29.1	2910
42	15.6	22.9	2290
43	19.6	22.6	2260
44	18	25.9	2590
45	18.8	25	2500
46	16.8	23.2	2320
47	23.6	42.6	4260
48	19.6	27.7	2770
49	28	42	4200
50	33	43.8	4380

Figure F.1. Calibration for Rising Plate Meter (27 March).

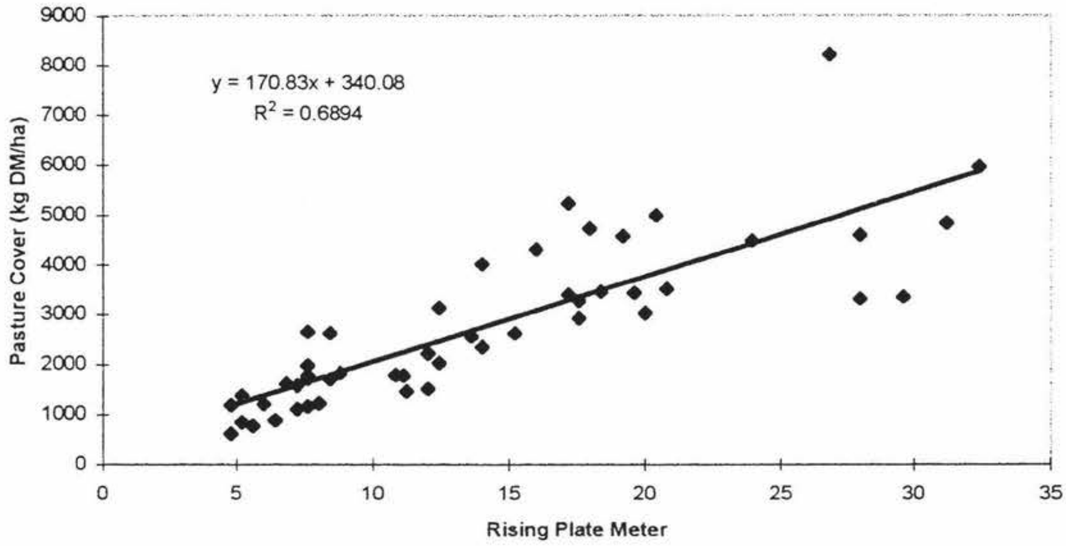


Figure F.2. Calibration for Rising Plate Meter (1 May).

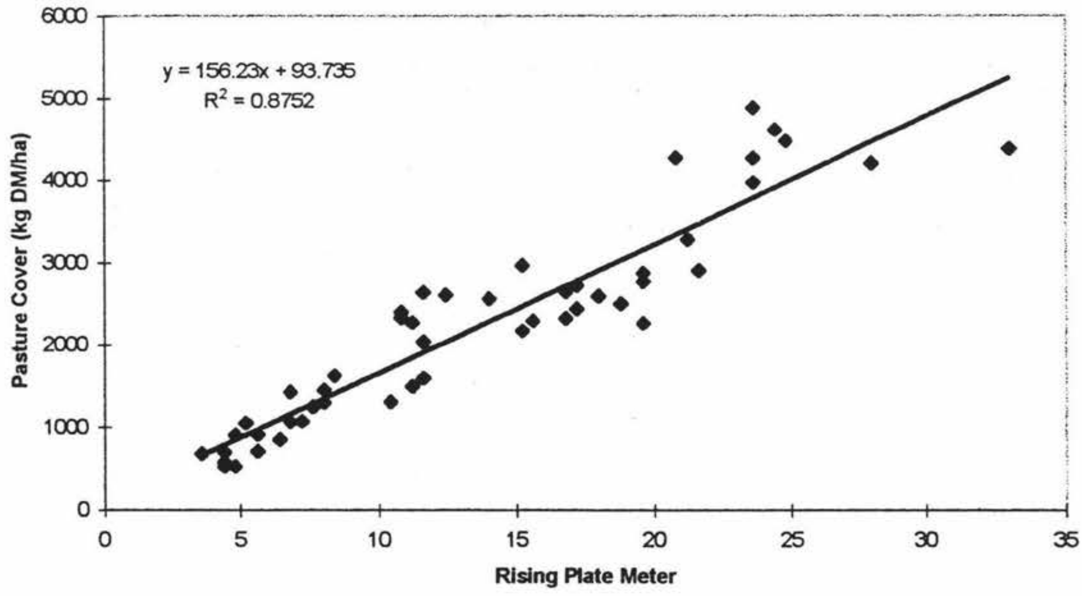


Table F.3 Pasture sample on 5 June for rising plate meter calibration equation showing the compressed height, the sample weight and its correspondent cover per hectare.

Sample No.	Rising Plate Meter	Quadrat ($g/0.01m^2$)	Average Pasture Cover (kg DM/ha)
1	9.6	8.5	850
2	22	28.8	2880
3	10.8	13.7	1370
4	6	6.8	680
5	14	24.9	2490
6	8	7.3	730
7	19.2	43.7	4370
8	15.2	27.1	2710
9	4.4	8.8	880
10	11.2	18.5	1850
11	23.6	34.6	3460
12	9.2	16.2	1620
13	15.6	21.4	2140
14	7.6	11	1100
15	24	42.8	4280
16	4.8	7.2	720
17	8.4	16.7	1670
18	11.6	35.2	3520
19	14	26.9	2690
20	18	37.5	3750
21	20	41.6	4160
22	9.2	18.7	1870
23	12	24.5	2450
24	5.6	11.9	1190
25	28.4	51.4	5140
26	13	21.8	2180
27	18	26.5	2650
28	7.6	8.6	860
29	22.8	36.5	3650
30	10.8	13.6	1360
31	14	23.2	2320
32	20.4	25.2	2520
33	7.6	11.9	1190
34	13.2	18.1	1810
35	25.2	35	3500
36	14.4	24.5	2450
37	4.8	9.9	990
38	20.4	50.9	5090
39	17.2	26.8	2680
40	23.6	50.6	5060
41	7.2	8	800
42	13.6	19	1900
43	21.6	52	5200
44	7.2	11.8	1180
45	17.6	52.7	5270
46	6	9.4	940
47	20.8	41.6	4160
48	14	26.1	2610
49	9.6	14.3	1430
50	11.6	19	1900

Table F.4. Pasture sample on 4 July for rising plate meter calibration equation showing the compressed height, the sample weight and its correspondent cover per hectare.

Sample No.	Rising Plate Meter	Quadrat ($g/0.01m^2$)	Average Pasture Cover (kg DM/ha)
1	8.4	10.5	1050
2	17.6	29	2900
3	10.8	15.2	1520
4	14	16.9	1690
5	18.8	26.9	2690
6	9.6	12	1200
7	15.6	18.3	1830
8	13.6	18.1	1810
9	22	37.1	3710
10	18.4	29.1	2910
11	5.6	7.5	750
12	8.4	11.2	1120
13	9.6	14.2	1420
14	11.6	22.8	2280
15	6.8	6.7	670
16	5.2	4	400
17	6.2	12	1200
18	10.8	18.7	1870
19	14.4	15.7	1570
20	9.6	6.6	660
21	23.2	43.1	4310
22	14.8	28.9	2890
23	17.6	27.6	2760
24	20.4	32.1	3210
25	20	35.1	3510
26	21.6	47.6	4760
27	17.2	29.5	2950
28	28	55	5500
29	24.4	49.3	4930
30	25.2	41.8	4180
31	9.6	8	800
32	12.4	15.7	1570
33	14	31	3100
34	11.2	18.2	1820
35	6.8	9.2	920
36	10.8	12.7	1270
37	4.4	7.3	730
38	8	16.2	1620
39	9.2	9.4	940
40	3.6	7	700
41	7.2	9.4	940
42	4.4	4.1	410
43	6.8	5.3	530
44	10	15	1500
45	7.6	10.4	1040
46	12.8	14.7	1470
47	23.6	48.9	4890
48	15.2	24.8	2480
49	13.6	17.1	1710
50	8.4	14.8	1480

Figure F.3. Calibration for Rising Plate Meter (5 June).

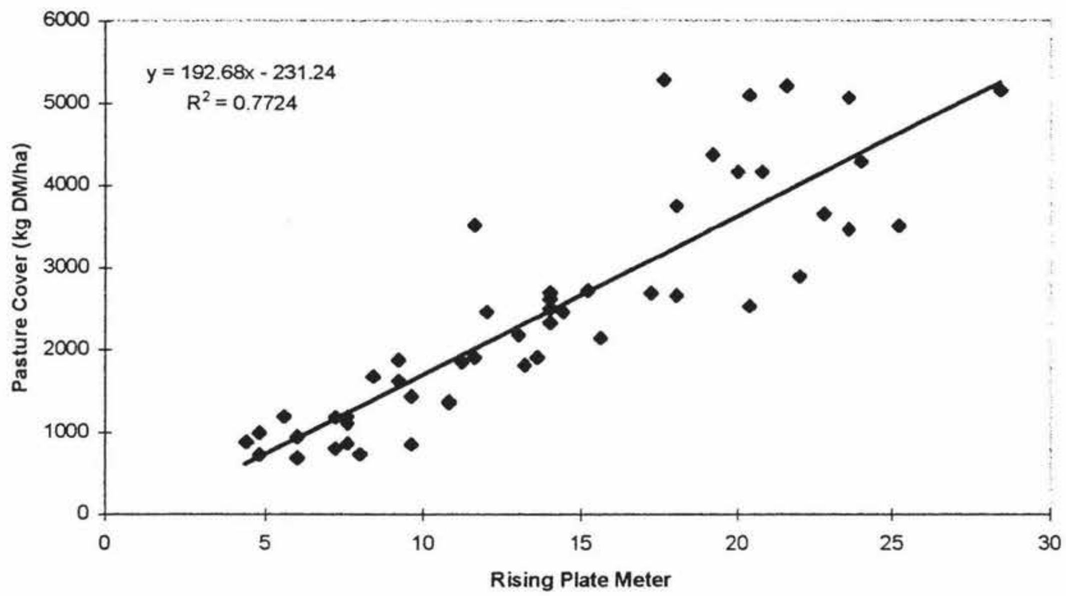


Figure F.4. Calibration for Rising Plate Meter (4 July).

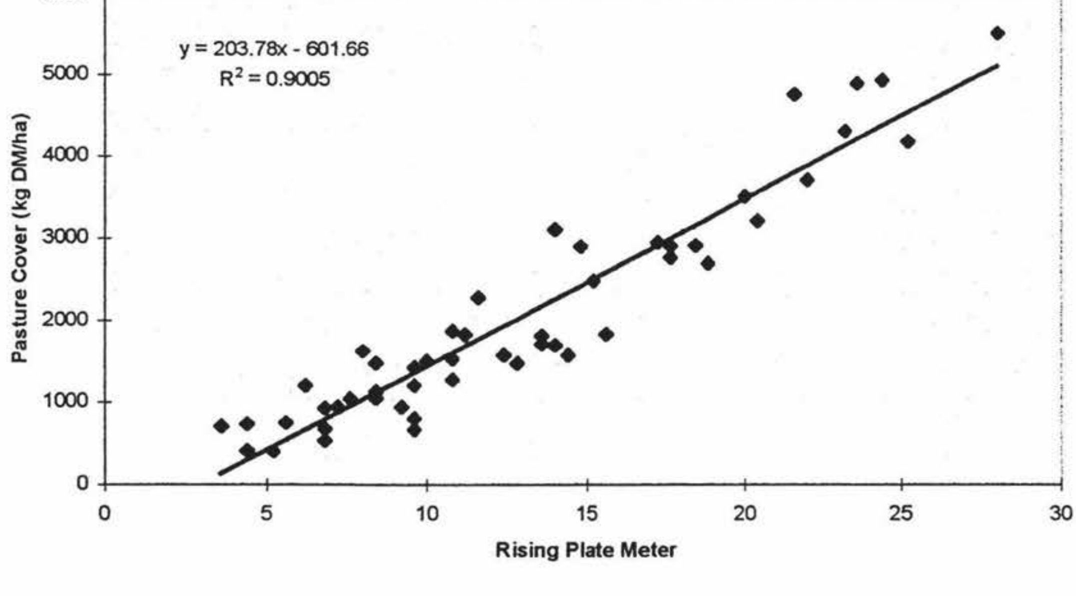


Table F.5. Pasture sample on 5 August for rising plate meter calibration equation showing the compressed height, the sample weight and its correspondent cover per hectare.

Sample No.	Rising Plate Meter	Quadrat ($g/0.01m^2$)	Average Pasture Cover (kg DM/ha)
1	20.8	29.3	2930
2	14	24.1	2410
3	8.4	18.7	1870
4	11.6	19.8	1980
5	24	33.1	3310
6	10.4	16.5	1650
7	15	28.8	2880
8	21.6	34.2	3420
9	7.6	16.1	1610
10	18.4	44.5	4450
11	3.2	7	700
12	14	19.5	1950
13	7.2	10.3	1030
14	5.2	5	500
15	6	12.4	1240
16	4.4	7.9	790
17	8.4	21	2100
18	8.8	13.8	1380
19	12	29.8	2980
20	12.4	27.8	2780
21	11.6	19.5	1950
22	24.4	46.8	4680
23	13.6	26.6	2660
24	17.6	28.7	2870
25	10	19.5	1950
26	5.2	14.2	1420
27	6.8	9.1	910
28	20.8	35.8	3580
29	11.6	24.6	2460
30	10.8	17.3	1730
31	20	28.5	2850
32	16.8	27.1	2710
33	15.6	21.2	2120
34	12	23.2	2320
35	9.2	17.5	1750
36	6.8	12.7	1270
37	17.2	27.6	2760
38	8	16.3	1630
39	15.6	30.3	3030
40	24.8	41.4	4140
41	14.4	26	2600
42	19.6	32.2	3220
43	10.8	20.9	2090
44	21.6	40.1	4010
45	7.2	12.3	1230
46	28.8	45	4500
47	14.8	27.9	2790
48	11.8	19.1	1910
49	17.2	35.6	3560
50	10	16.2	1620

Table F.6. Pasture sample on 2 September for rising plate meter calibration equation showing the compressed height, the sample weight and its correspondent cover per hectare.

Sample No.	Rising Plate Meter	Quadrat ($g/0.01m^2$)	Average Pasture Cover (kg DM/ha)
1	9.6	10.1	1010
2	14	21.8	2180
3	6.8	6.3	630
4	22.8	32.7	3270
5	7.2	10	1000
6	6.8	11.1	1110
7	14.8	19	1900
8	8.8	9	900
9	20.4	31.5	3150
10	12	15.8	1580
11	6	9.3	930
12	17.2	28.2	2820
13	10.8	24.1	2410
14	19.6	27.1	2710
15	5.2	9.8	980
16	7.6	14.3	1430
17	13.2	33.4	3340
18	8.4	11.6	1160
19	20.4	30.4	3040
20	3.6	7.6	760
21	5.2	5.4	540
22	13.6	17.5	1750
23	16.4	32	3200
24	11.2	12	1200
25	23.6	34.8	3480
26	7.6	10.7	1070
27	9.6	15	1500
28	15.6	26.7	2670
29	24	33.5	3350
30	7.2	14.9	1490
31	11.6	10.8	1080
32	15.2	38.5	3850
33	10.4	10.9	1090
34	4.8	8.2	820
35	19.6	40.5	4050
36	12.4	22.8	2280
37	6.4	11.5	1150
38	7.2	10.2	1020
39	22	30.3	3030
40	6.4	11	1100
41	8.4	14.1	1410
42	16	19.3	1930
43	9.2	19.5	1950
44	19.6	34.3	3430
45	10	16.9	1690
46	6	10	1000
47	16.4	29.1	2910
48	6.7	9.2	920
49	9.2	22.6	2260
50	26	42.4	4240

Figure F.5. Calibration for Rising Plate Meter (5 August).

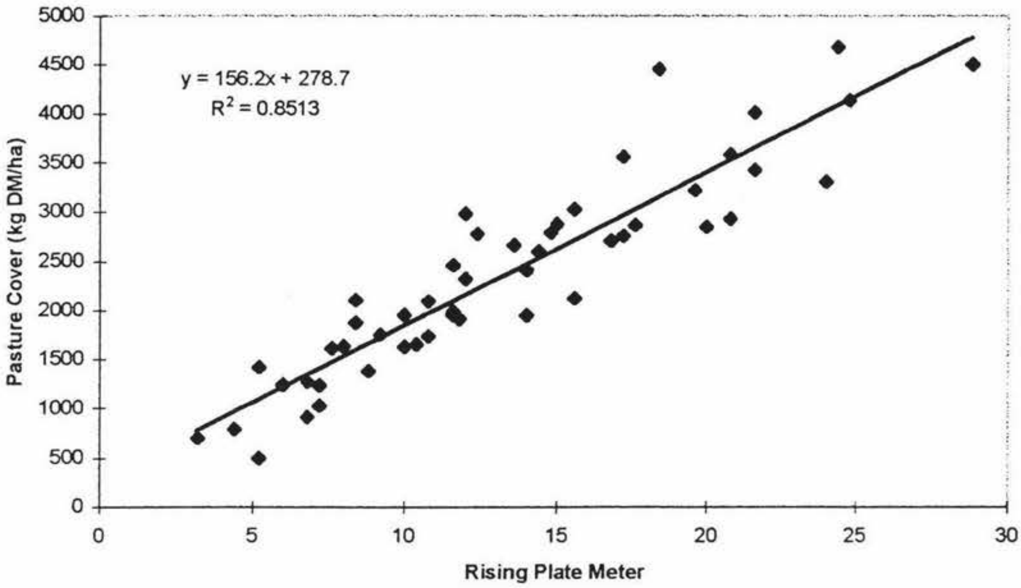


Figure F.6. Calibration for Rising Plate Meter (2 September).