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 $\pm$ 369.34 DM/ha), Treatment 2 (7062 kg $\pm$ 319.86 DM/ha), and Treatment 3 (5277 $\pm$ 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

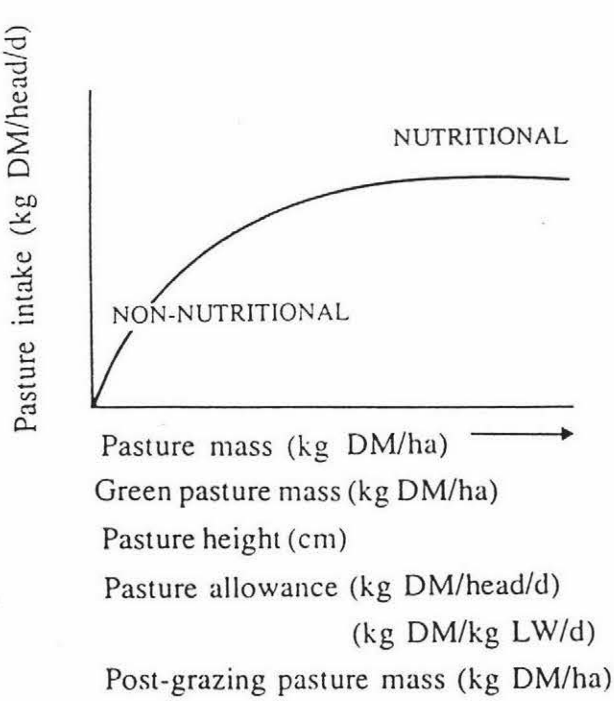
New Zealand farming systems are based almost entirely on pasture grazed *in situ* by the animal. Therefore it is important to understand the interaction between pasture and animal, in order to identify opportunities to improve the farming system.

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.

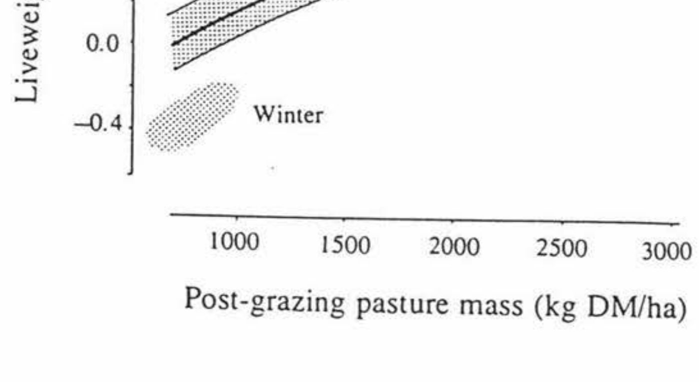
It was shown by several authors that the daily herbage intake of grazing animals increases with the amount of pasture offered (Hodgson, 1977; Marsh, 1977 and 1979; Wade and Le Du, 1981; Stockdale, 1985; Dougherty et al., 1987 and 1992). Marsh (1977 and 1979) worked with Friesian steers at several pasture 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).

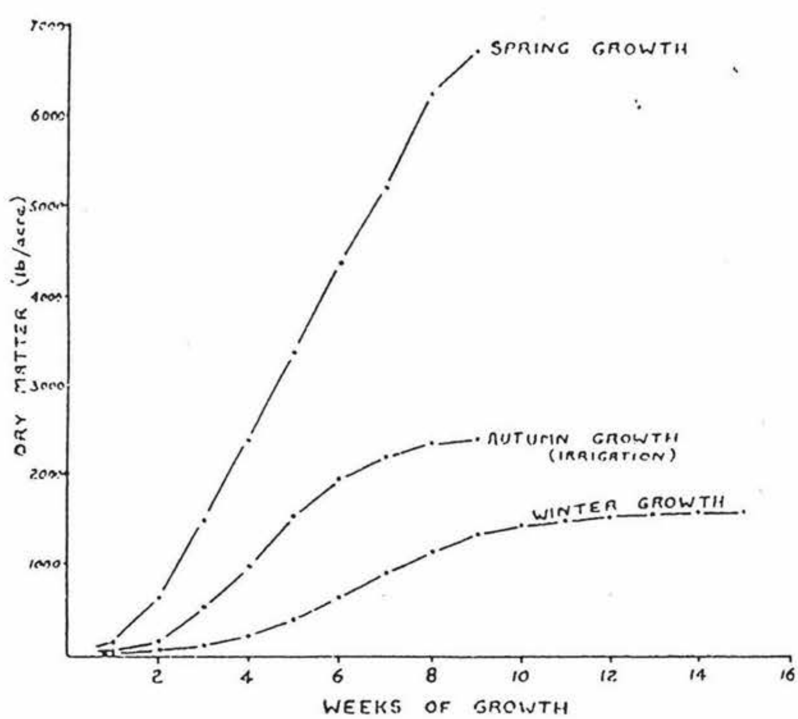
However, increasing the number of cattle per hectare will increase the production per hectare, but will reduce the performance per head. The production per hectare increases up to a point where the forage intake per animal is not enough to support reasonable liveweight gains, reducing the production 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

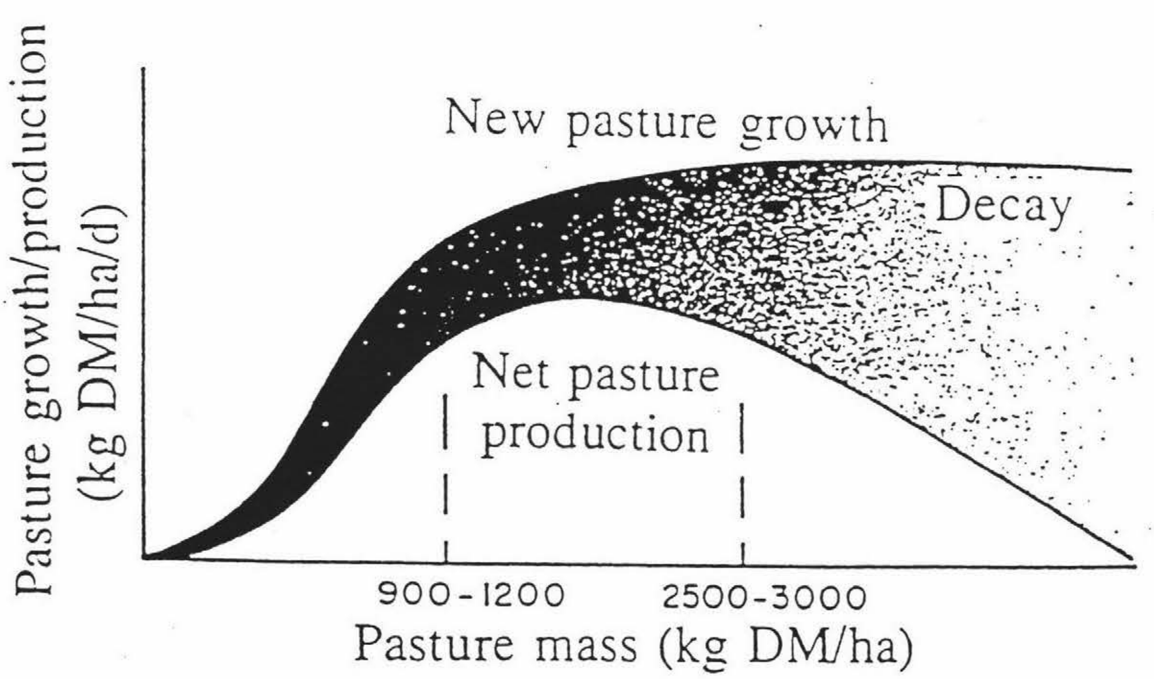
The affect of grazing management on pasture production was initially shown by Brougham (1955, 1956a, 1956b, 1957, and 1960). He studied the effect of intensity of grazing on pasture growth after grazing. It was shown that the pattern of growth rate followed a sigmoid or "S" shaped curve, having a phase 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.