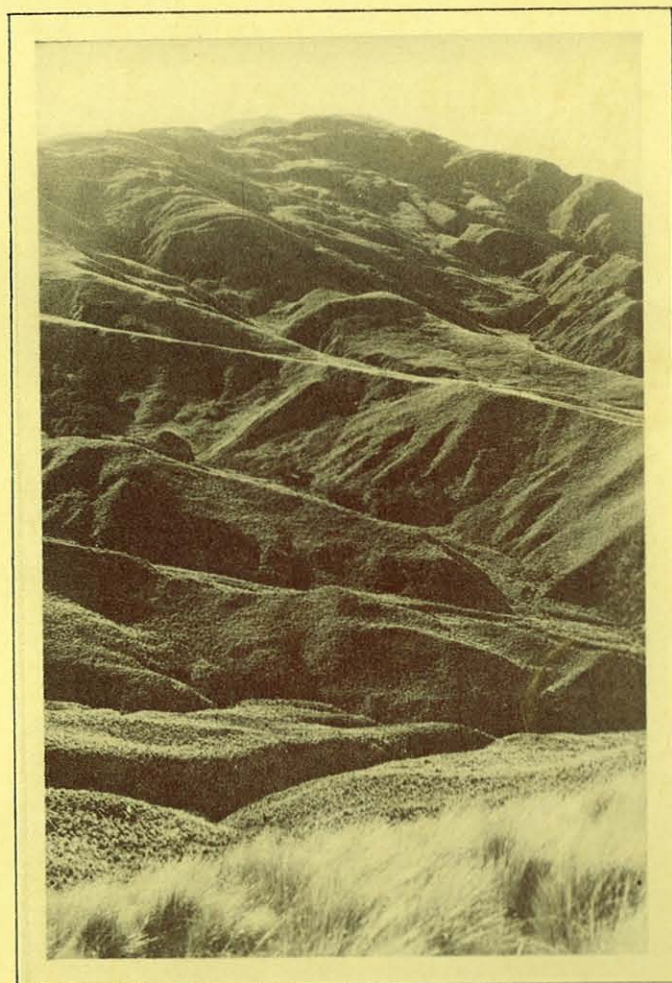


Tussock country management: principles and practice

Michael Abrahamson



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TUSSOCK COUNTRY MANAGEMENT: PRINCIPLES AND PRACTICE

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1. Introduction

This study is a distillation of farmer opinions and practices collected on visits to 91 South Island hill and high country farmers and of the research work and theory related to the management of the tussock country and values of tussocks. The study initially measured sheep and cattle stocking loads on hill and high country runs. Grazing management records were made for some of the high and hill country farms visited. However, there were difficulties in recording stock movements for some properties as the frequency of shifts and uses of each block were often not available. Only those runs where stock movements were easy to record had complete grazing records. The sample of farms with good records were thus mainly high country stations of limited subdivision, and only represented one situation. A list of the runs and some of their characteristics are shown in the appendix. The properties cannot be identified in this table because of the need for confidentiality.

The emphasis of this study shifted from one intended to collect farmers opinions on the value of tussocks to one which incorporated data on tussock country management practices, including the measurement of stocking loads. There appeared to be a need for such a study: Brougham (1970) suggested more work was needed in developing systems and evaluating the research work and what was currently known and applying them in the development of suitable management systems. It was also evident during the farm visits that there were some innovative and successful practices that could be applied elsewhere in similar situations. Knowledge of stocking loads only could not identify the apparently successful practices, as only gross differences could be indicated by those comparisons, and some of those innovative farmers were less likely to be in the sample with reliable stock movement records as they often had more intensive subdivision. The innovative and successful practices could be evaluated on the basis of optimum use of available resources. Any available feedback such as increase in stock numbers since a practice was adopted, condition of stock, pastures and often a well-reasoned and thought-out logic for a certain system or practice could indicate the success of the system. Farmers had often thought through their decisions (or else by hindsight had evolved explanations for the apparent success of a practice). The reasons for adopting a practice can be applied elsewhere to similar situations.

These opinions and practices appeared to offer something in addition to

research work which was often carried out in a single environment because of the costs and practicalities involved. Farmers can give opinions and practices from a wide range of situations that cannot be covered in a single experiment or even a series of experiments. An experiment could sometimes be regarded as an hypothesis that needs to be tested in a wider situation, before adoption; the same approach could be taken to adapting practices from one area to another, e.g. such as North Island hill country management to South Island hill country. Brougham (1970), suggested the vast amount of research work done was of only limited value to the soil-plant-animal complex of grassland farming, since once a result has been obtained, little effort was made to relate it or the feasibility of application, to practical situations, where interaction can frequently modify or negate findings made under more controlled conditions. Spedding (1975) has suggested, in a discussion on the efficiency of mixed grazing (sheep and cattle or one species present), "that it has to be recognised there is no one general answer...it is always necessary to elaborate a general model of the subject, as well as to pose very precisely formulated questions for experimentation. It may be too much to expect of an experiment that it should serve both purposes simultaneously but it is most important in discussion to be sure which we are dealing with." In discussing grazing management he has also suggested "surveys or other observational studies are important in gaining experience, can suggest what the important components of a system are and can be used in assessing the usefulness of systems in practice."

Farmers' opinions and practices can support research work and provide examples of application so that farmers can relate to it, as well as producing new ideas and technology independent of research and advisory work. This study will relate some of the relevant research work to farmers' opinions and practices. A complete bibliography has been avoided; some subjects such as grazing management have had a large amount of work done on them and inclusion of much of the work could have obscured any conclusions. Conclusions from reviews of the work provided a sufficiently authoritative study.

Similarly, there has been a lot of research work on tussocks (mostly tall tussocks) and some of it not directly applicable to the value of tussocks. This study focuses on the management aspects of tussocks, and any research work not relevant to this has been omitted.

The form of presentation is in response to a runholder who asked that more information be presented in a written form, rather than in tables and figures. References are included for those who require verification of conclusions drawn from written material.

The study is in two main parts: the first section is concerned with tussock country management and is divided into topics that appeared to be of concern in tussock country stocked with beef cattle and sheep; the second section is on the value of tussocks in the tussock grasslands as indicated by runholders in the hill and high country and by a review of the relevant literature.

2. Farming in extensive situations and problems of management

The problem of having very large blocks in a high country environment is common - some high country and hill country properties have only a few blocks and this naturally limits the choice of management alternatives available to them.

2.1 Decisions in use of blocks

In the more extensive grazing systems observed on visits to runholders, some of the main criteria for deciding on the use of a certain block where there were only a few blocks available were as follows:

- (1) The warmest block is often used for lambing and can include natural shelter such as bushes, gullies and rocks.
- (2) Warm dry blocks are often used for hogget rearing.
- (3) Wethers are usually used to graze the roughest areas.
- (4) Shady blocks may not provide much feed in the winter, and sunny blocks are usually used then.
- (5) Snow risk is greater on some blocks than others. Higher and darker blocks may not be used in winter.
- (6) Cattle are best on some blocks in winter, as they can survive deep snow better than sheep, and are less likely to get trapped in snowdrifts.
- (7) Sizeable feed supplies are needed when mobs of sheep are brought in for shearing etc. Stock may be near the yards for up to two months of the year at any one time, and these blocks nearby are often kept for this purpose.

Climatic factors dominate decision making for the management of large blocks. A common pattern is to move stock slowly out to the higher altitude from spring to early summer. Then stock are gradually brought back in off the colder and snow risk areas as growth on these areas decreases, and snow falls become imminent. This practice (transhumance) is common in other countries.

Some blocks can be so large the snow risk affects only a part of a block. Here the main activity, when snow falls are due, is to move sheep down until the snowline is established. There can be problems in these situations if sheep become stranded by early falls of snow and are above the snowline. Blocks can be so large that stock can take days to shift

from one side to the other. More frequent stock movements that could be advocated with closer subdivision are just not practical with large blocks.

One major problem with very large blocks is poor pasture management. Better quality feed can be wasted if fed during periods when only maintenance quality is required. Sunniest aspects can be overgrazed. Usually stock are left several months on each block, as stocking rate is low, and are able to select at will. Some large blocks have difficult access, and the only management alternative is to run wethers or cattle, as wethers do not require the same level of stockmanship that breeding ewes require. Cattle can survive if access is not possible.

2.2 Choice of class of stock

Some properties may be only suited to dry stock, such as Merino wethers. These can be left on a block all year round. It is too difficult to shift them. On these farms the main labour cost involved is in mustering (shearing and fall), shearing, and stock handling whenever the stock are brought in. Breeding stock require a certain quality (digestibility) of feed to maintain performance - feed needs to be of a good energy content and digestibility. Some properties with low breeding stock performance may be more suited to dry stock, which can get by on maintenance quality feed, while still producing some of the best quality fine wool or store cattle.

Dry sheep can be left on blocks longer where there is an accumulation of roughage, as they are more tolerant of lower quality feed than breeding ewes, but adequate subdivision is needed for some control of pastures - low stocking rates all year can lead to problems even with dry sheep. Mature wethers can sometimes be used to control those areas which tend to revert to scrub or fern as the wethers can be "hit" harder without suffering too much loss in performance. Dry sheep or cattle are a valuable class of stock on some more developed farms to prepare "safe" pastures for young stock, as they can clean up internal parasitic larvae ahead of the susceptible stock. Lower body weights in wethers causes them to produce less wool - in ewes, death, poor milking performance and low lamb weaning weights.

The choice of running an all wether-flock also depends on economic factors - relative profitability of ewes or wethers, current price for finer wools, replacement costs and demand for two-tooth wethers. If these economic

factors are favourable, then wethers may even be run on some of the better country. Saunders (1983) found little difference in gross margins per stock unit for ewes and wethers on high country runs, but about \$5 per stock unit in favour of ewes on hill country. Management of a wether flock is a lot simpler than a breeding flock, and are often preferred on colder, sour country where ewes are susceptible to high lambing losses. In the more extensive situation, wethers can be left on a block for long periods, and while they may have good nutrition for some of the year, at other times there may be only roughage. A ewe flock requires an increased feed requirement over the growing season, particularly where the lambing percentage is high, and this can lead to better utilisation of pastures. A wether flock does not show the same seasonal feed demand.

Usually in an extensive grazing situation, and particularly with an all-wether flock there is a lack of flexibility as stock cannot be bought for replacements easily because sheep are thought to always perform better on the country they are born on. Several farmers suggest that until sheep become used to a terrain, losses can occur as sheep fall off bluffs, or eat poisonous plants such as tutu (Coriaria spp.). A poor performance could be expected for the first few years when stocking a property with bought-in sheep until they get used to the property (especially breeds based on Merino). A common practice is to put two-tooths with older sheep so they can learn from the others. One farmer in a very extensive situation suggested that two-tooths need to be taken out and introduced to an area, and that the same number of sheep will return each year after that. Introduction of sheep to an area, and development of home-range-behaviour could be a learned response: a North Canterbury high country farmer has noticed different behavioural patterns of sheep that had become used to more intensive management compared to sheep allowed to choose their own areas. When they were introduced to an extensive situation, the sheep not accustomed to extensive grazing for a few years stayed at lower altitudes and did not spread out as they had done a few years before. Culling of older sheep is also practised to reduce grazing pressure at higher altitudes.

One farmer interviewed, buys in five year old wethers from the same source each year and keeps them until eight or nine years old. He maintains that the older sheep are able to withstand the snow better and produce more wool than two toothes in rough country. Since the sheep have been bought from the same source each year and stay on the new owner's property for several

years there would possibly be minimum disturbance to social groups, which could affect the ability of bought-in-sheep to settle. Some flexibility in this situation can be introduced (see section on the use of cattle) by buying and selling store cattle. Apart from sheep behavioural problems, farmers in more extensive situations are reluctant to buy in sheep to eat extra feed in good years as they can buy in footrot problems, and are often stuck with a situation where feed is going to waste in a good season without enough stock to use it. Uneven or steep terrain in most situations rules out conservation of hay or silage.

In winter all-wether flocks are best confined to as few mobs as possible. One high country farmer had heavy losses in the big snow of 1973 when his sheep were spread over several blocks. With snow-raking it was almost impossible to find the sheep as they were spread over large areas and "huddled in hollows or under knobs". Since then he has kept the wethers together in one or two blocks to make snowraking easier. On this same property it took six men six days to muster class VII and VIII country grazing only a few hundred wethers for a few weeks. The economics of this could be examined more closely, and it would well be better to divert the money usually used for mustering high altitude areas to improving lower country, thus avoiding the recurring cost of mustering each year.

2.3 Problems of pasture control

Low winter carrying capacity is usually the major problem in the high country. Some runholders with extensive management systems in an extensive situation suggested that carrying capacities could be increased four or five fold if the extra stock could be wintered. There is often a high peak of feed produced in the spring, summer and early autumn, and not much the rest of the year. One major effect of this is that farmers are not able to control pastures. Stock are not there in sufficient numbers to eat the feed when it is growing rapidly, and being largely uneaten, it goes to seed or dries off, and becomes little more than poor quality standing hay for late summer and autumn. Once the leaf content falls and stem and reproductive tiller content of a pasture increases, there is a rapid fall-off in quality (see discussion of set stocking) with serious effects on stock performance.

Selective grazing over this period allows the favoured species to be eaten, with an increase of less-favoured species, such as weeds and woody plants.

Selective grazing also allows good quality feed to be eaten out, leaving only poor quality feed for other periods. Hoggets require high quality feed after weaning, but on pastures that have "got out of control" feed quality is inadequate, despite selection.

Rank pasture not only affects herbage quality in the summer season, but lasts throughout the whole year. Accumulation of unused feed grown past the vegetative stage into a reproductive stage adversely affects the quality of pasture for flushing ewes in autumn. The carry-over of poor quality feed even affects the period before and during lambing: one farmer noted a ten percent increase in survival in twins from sheep fed on pastures established by cultivation (i.e. intensively used), compared with those from sheep grazed on rough uncontrolled pastures. The quality of the extensively grazed pastures was not sufficient to adequately provide for twin lambs. Blocks grazed at low stocking rates over summer, (e.g. for hoggets), will need cleaning up if the carry-over of feed is to be avoided. This calls for pasture control when extra stock are not usually available. Accumulation of unused feed, and selective grazing appears to have serious effects on persistence of clover (section 2.5).

2.4 Balancing feed supply and demand - management options

The problem in these extensive situations is to fit the feed supply curve in with the feed demand curve. How to feed extra stock in the periods of low feed production, and or better match the requirements of the present stocking level is the key management problem. One method is to lamb later to allow better nutrition in the few weeks before and during lambing. Later lambing could also increase the lambing percentage. Coop and Clark (1966) found that mating in May and June cycles eliminated the need for supplementary saved feed before lambing, with only a small increase needed in the first week or so after lambing. However body weight and nutrition usually decline in May, June and July. Where it is possible to lamb later, and feed supplies are available for fattening lambs, then this could be considered. Another method of transferring feed is by conserving it in some form, whether it is by "all grass wintering", hay, wilted silage, or some other means. Despite the losses in these systems (see Chapter 9) there appears to be no alternative in some situations to cutting and storing feed, especially in those areas affected by snow or frost for long periods. The available area of hill or steepland, shady or sunny aspects will determine the options possible for conservation of feed. The last

choice in these systems would be the large reserves of standing hay as are common at present. Where there is no other alternative, i.e. where winter stock numbers cannot be increased, little or no area suitable for cutting hay and silage, and severe climatic limitations for grass wintering, then at least there is a reserve of low quality roughage that could provide some feed in the winter. The all-wether run is an example of this where feed quality may not be sufficient to justify the use of breeding ewes. As discussed under subdivision, where more pasture development has occurred, the area of standing roughage has declined.

Where areas of excess feed do occur during each season in extensive grazing systems, then alternate spelling of blocks can be a useful method of maintaining or increasing a vegetative cover, especially where there are bare areas with little vegetative cover in a block. These blocks can be used every few years when there is a feed shortage. The improved areas on the farm should be carefully grazed to maintain oversown species and keep grasses in a vegetative state; the unimproved areas could be sacrificed in seasons of plenty before the improved areas, and would be allowed to reseed. Sometimes only a few hundred stock units can be supported on an unimproved block whereas a capacity 5-10 times that can be supported on an improved area. Occasional spelling of the unimproved blocks would not be much of an economic loss compared with the major effect poor utilisation would have on feed quality and pasture composition of improved areas.

Early weaning of lambs is practised on some high country farms, e.g. weaning at 10 weeks so that ewes can be mob stocked by late December to gain control of pasture that had been set-stocked at low to moderate stocking rates over lambing and lactation. Mobs of ewes can either be used to gain control over some of the previously partially grazed pastures or for some other purpose such as grazing some higher altitude areas so that lower altitude blocks can be spelled to save feed for autumn flushing or for all grass wintering. Cattle play an essential role in the management of these more extensive systems, as will be discussed later.

Finally, in these more extensive situations there appears to be no alternative to easy care lambing. Blocks can be too large to cover once or twice a day to assist sheep with lambing. However, Halfbred, Corriedale or Merino sheep seem often suited to minimum interference during lambing, as they can be disturbed by too much attention.

2.5 Clover persistence in extensive management

Some opinions and practices concerning clover survival were recorded on the 91 farms visited. Where there was a problem of clover persistence, either large blocks were being improved without subdivision, or the farmers themselves suggested that the problem was caused by the lack of subdivision and sufficient maintenance fertiliser.

Twelve farmers expressed concern at the low persistence of clovers on their improved country. Five of these suggested that the reason for low persistence was caused by lack of grazing, and suggested there was shading of clovers in long pastures and over grazing of clovers in dry periods. The seven other farmers had oversown large blocks and had low levels of subdivision.

Some examples of levels of sub-division were; a Mackenzie country station in five blocks with the better areas oversown and unfenced; Canterbury gorge high country runs with only 9-13 blocks on the run; a North Canterbury farm that had oversown a block of 400 hectares without subdivision; a Central Otago property where two-thirds of the property was oversown without subdivision.

Some stocking rates on the improved blocks were low. On one farm, with blocks of 460 ha, there could be at most only 13 sheep/ha at any one time even if there had been 6,000 ewes in a mob.

Farmers' comments and practices suggest much higher stocking loads are needed to get an even utilisation over a block, thus avoiding overshadowing of clovers and preventing the favoured areas being eaten out.

Another example where clover did not persist was managed with a stocking rate of 800 hoggets from December to April on 143 ha; only 4 s.u./ha during grazing. Clover could also have been overgrazed during dry spells in this period.

Research work in New Zealand and overseas shows how grazing affects clover persistence. Bedell (1974) in Oregon, found that sheep grazing without cattle at low stocking rates, reduced the clover fraction in the sward in time, leading eventually to lower total herbage output. Hay et al. (1983) found grazing with or without cattle had more effect on white clover leaf or stolon in the sward than the system of grazing, (set stocking or

rotational systems). At high stocking rates with sheep only there was little difference between grazing systems.

Suckling (1975) on North Island hill country at Te Awa, found that even at a continuous stocking rate of 17.3 sheep/ha, the very closely grazed pasture was susceptible to even short periods of drought, and in the dry summers lost much of its clover and ryegrass. At 7.4 ewes/ha, without cattle, all clover was smothered after five years.

Farmers' experience, lack of subdivision where there is a low clover persistence problem, and research work, suggests there needs to be more subdivision if problems of low clover persistence (and costly oversowing of clovers with difficulties of establishment every 5-10 years) are to be avoided.

3. Subdivision: its role in tussock country management

One of the main advantages of increased subdivision on tussock country is that there are greatly increased options open in stock management. These can be listed briefly.

3.1 Increased options in stock management

1. More frequent drenching of animals to control internal parasites or to provide mineral supplements is possible. Where there is a 20 mile drive to muster sheep from one end of a block to a gate at the other end, stock are not handled often, (mainly shearing and fall musters).
2. More control of footrot is possible as sheep are able to be handled much more easily. Sheep can be run through a footrot bath at the gate whenever sheep are shifted from one block to another. Increased handling of stock allows more frequent inspection of sheep for signs of lameness and ready access to them for foot paring, culling etc. Footrot is becoming a big problem on some farms and the only way to get on top of it is by improved stock management. One farmer with more intensive subdivision considers the first call on his time is his stock. He is able to vaccinate, drench hoggets every two weeks and carry out intensive programmes to get rid of footrot. The manager of a farm with only a few blocks typically is limited to shifting stock depending on climate, relative growth and environmental differences between blocks (see section 6.1). Where the sheep are tended infrequently it is usually too late for any worthwhile action to be taken on footrot that season. It is a lot easier to run a mob down to the yards to treat them if it doesn't take two or three men three days to muster them, but only one man and his dogs, (preferably by different routes to and from the yards).
3. More control over lambing and calving date with more subdivision.

There are some farms that are not able to control lambing or calving dates very closely and are thus deprived of one of the main management controls in allocation of feed. Sometimes early and late lambing mobs are separated, and this cannot be done without adequate subdivision. Allison and Kelly (1978) found that two-tooth Merino ewes were best

mated on small paddocks with three rams per 100 ewes. More sophisticated stock management becomes possible with increased subdivision.

4. Some farmers are able to have a two tier flock system: on a Central Otago farm, Border Leicester x Merino, or Merinos are run on the country most suited to the different breeds. Adequate subdivision is needed for mating management and at lambing. The Border Leicester cross has been described as a "gross" feeder that produces well under good conditions. A two flock system better suits the variability on a farm than one flock. Merinos are thought to do better on the blocks where there is plenty of "scope" and soils are free draining. Perendales are often used on rougher country as they are good foragers.
5. With a change in weather, well sheltered lambing blocks could be used. Features such as natural hill shelter, well sheltered tussock blocks can be saved for the crucial lambing period. One farmer thought provision of sheltered paddocks added 10-15% to his lamb survival. There are numerous recent reports in farming journals on the advantages of shelter to the new-born lamb (see section 10.3).
6. With more subdivision farmers are able to plan ahead and some estimates of feed availability and how long it will last are possible. The more sophisticated systems can even use a feed budget (see 3.3). Very large blocks can be most variable and it would be almost impossible to assess the available herbage on these if a feed budget was desired. Typically with large blocks (see 6.1), the stock, and not the farmer, determine the level of feed intake. Allocation of feed both in quality and quantity over the year is more possible with increased subdivision. Allocation of feed, such as preferential feeding of six year old ewes with poor teeth, is possible with more fences. More complex grazing management with old gummy ewes grazing ahead of other sheep on longer grass is possible. Old ewes can get quite adequate intakes provided grass is long enough, (Coop and Abrahamson, 1973).
7. The main advantage however, could be the increased options in grazing management. With only a few blocks there is only one type of grazing management possible, but with increased subdivision other options,

such as rotational grazing (short time on, longer time off) could be considered (see Chapter 6). More conventional set stocking can also be practised just as easily with more subdivision if a change in management is desired. The farmer is not necessarily committed to rotational grazing because there are more fences. With more subdivision options such as all-grass wintering are possible. Feed can be saved and rationed on blocks over the winter. This is only possible if there are enough blocks to allow controlled feeding over the restricted feed period.

8. Some farmers are able to diversify to become stud farmers - this is only possible where intensive subdivision is done to allow mating of small mobs, and preparation of stud sheep for sale. The higher price paid for the animals compensates for a sometimes lower utilisation in efforts to achieve good stock performance of the stud sheep. Higher prices for stock also compensate for increased need for subdivision. The breeding of own replacement rams is also possible. The commercial sheep flock or cattle can be used to clean up excess feed after the stud sheep, to some extent.
9. Increased subdivision allows the option of selection for superior genetic merit in animals. Cooperative breeding schemes require selection of high producing animals for a central nucleus flock, and this is only possible with some intensive subdivision to allow identification of animals. One farmer was able to identify older cows with an average of 120% calving for the central flock.

3.2 Subdivision effects on feed utilisation

Reasonable levels of subdivision allow a 'clean-up' of the pastures at least once a year, when the roughage and standing feed is eaten right down to "prepare" pasture for the next season. This practice is used by farmers on all types of grazing systems. Where there are large blocks, not enough stock pressure can be applied to achieve uniform grazing, and the blocks are not cleaned up sufficiently before the next season. Where pasture cannot be cleaned up adequately, there can be less feed that season and also the next season, as shown in the study of Clarke (1977). Farmers' experiences suggest that pasture production and quality will decline, but recover following appropriate management. The usual practice is to mob stock ewes immediately after weaning to clean up any feed not utilised

during lambing, when high stock performance is required. Farmers are usually aware of the need for this clean up. One farmer in Canterbury thought he had increased carrying capacity on a block by 50% by ensuring a good clean up, and even borrowed sheep from neighbours to apply good stock pressure in early January. Some work by G. Scales (Norwester, 1980) showed a 40-50% increase in hogget growth rate after weaning on "well prepared" pastures compared to "crummy, badly prepared" pastures.

Comments by farmers give some indication of block size to achieve an adequate control. A typical maximum size for an efficient clean up could be about 40 ha, and one farmer thought the block was not too large if sheep were able to clean it up in a few days. However, this farmer considered if sheep had been on the block too long and "they had been knocked too hard", he would consider giving them a break on better feed and then returning the sheep to eat down the block even further. Block and mob size are discussed further in section 6.9. Where the potential for reversion exists, inadequately subdivided blocks usually revert to scrub and fern quite quickly. The maximum size of the mob of cattle and sheep the farmer can achieve will determine how quickly the roughage can be eaten off, and hence the size of blocks required: obviously if there is a large mob of 6000 sheep then less subdivision is required. It should be remembered that ewe liveweight and condition should not fall too much over the summer period, to allow reasonable liveweight at mating.

3.3 Allocation of feed with more subdivision

One of the main aims of more subdivision is to allocate the feed grown so that stock will produce the greatest return. Subdivision of a large undeveloped high country block would restrict feed intake at one time in the year so there are adequate intakes in another period. Subdivision of improved country is of a much higher priority than subdivision of unimproved: apart from much greater pasture production, the oversown species need controlled grazing to ensure persistence (see 2.5). On an extensive, unimproved block, an experienced shepherd can often assess a suitable stocking rate to achieve even utilisation of the grazed species and can carefully adjust stock numbers on the block by adding or subtracting stock at intervals. Increased subdivision would probably not add much precision in this situation. This grazing management is suitable provided the block is of similar landscape-soil plant units, so that overgrazing of some areas (eg. sunny aspects) does not occur.

On improved blocks, with increased subdivision, valuable feed of good quality can be saved for the most important periods of the year and allocated to the most suitable class of stock. As suggested in section 4.4, with greater proportions of a run being improved, it becomes more essential to subdivide to provide a feed bank for other periods of the year. Stock nutrition needs to be controlled, at the same time as pastures should be managed correctly. When 'cleaning up' dry sunny ewe country in January - February the risk is that if a dry autumn is experienced, regrowth when it rains (April-May) will be less than if roughage had been left, (especially at mid-altitude 800 to 1000m). In the more developed situation, standing crops of hay are not present as more feed is being utilised. Subdivision is needed to compensate for this where previously standing roughage was available as a reserve on large blocks.

3.4 Fencing before or after grassland improvement

Whether to fence before or after aerial oversowing and topdressing depends on the amount of roughage present (whether the block needs to be cleaned out before oversowing), or the time taken for a response. Where a block has been heavily grazed, then oversowing and topdressing can proceed and subdivision can wait until the pasture production has increased. Where there is already substantial pasture production, then subdivision before oversowing and topdressing could be essential to prevent overshadowing of clovers and competition, and allow even utilisation of the feed. Normally subdivision should be completed by the second autumn after oversowing and topdressing, but this will depend on the season.

Some farmers have suggested they could double production just by fencing, without any oversowing and topdressing. Their farms have medium to high fertility soils, (yellow grey earths). However, they admitted this would only apply to their situation - the more fertile the soil, the better the return from fencing. The value of subdivision on unimproved blocks increases with fertility, but in the typical high country situation e.g. on Class VII soils, would not give much return on its own.

In the two years before an unfenced area was oversown and topdressed on part of a high country summer range, (Abrahamson *et al.*, 1982, 1989), there was little feed wastage. A different situation arose in the two years after oversowing, when there was good utilisation on the improved areas, but poor utilisation on the unimproved part of the block. Aerial oversowing without

fencing an area of a block can lead to feed wastage on the unimproved part of the block, because stock concentrate on the improved area.

The decision not to fence off improved areas on a block could depend on relative costs of fencing, compared to the value of feed expected to be unused on the rest of the block. Where a block has only small pockets of good soil, aerial oversowing and topdressing the good part of a block and leaving it unfenced could be a better option than fencing it off, especially if conservation criteria are applied also to the unimproved area.

3.5 Benefits of subdivision alone

Subdivision could be of more importance in obtaining better utilisation of feed than the grazing method employed (see Chapter 5). If there are 20-40 ha sized blocks, mobs of stock are generally too large to be set stocked for long periods, and have to be shifted more frequently. Classes of stock such as two-tooth ewes are kept in their own mobs and would not take long to graze down a 20 ha paddock.

Suckling (1975) in trials at Te Awa suggested stocking rates were more important than grazing method. High levels of subdivision usually occur with higher stocking rates, partly because of the mob size factor mentioned above, and possibly because of the closer attention the smaller paddocks get from the farmer in his normal stock handling activities. It seems reasonable to assume that with smaller blocks the farmer automatically becomes more conscious of the differences between blocks in the levels of utilisation. Parker and McCall (1986) found in a survey of N.I. hill farmers that subdivision alone would not improve productivity. Other factors were important, and full use needs to be made of fences if subdivision is to be a good investment. Whether more subdivision is required for grazing management control is discussed in 6.6. Combining mobs should also be considered to reduce the subdivision requirements or as an alternative to subdivision (Squire, 1985).

3.6 Access

Good access is essential for laying out fencing gear, fence erection, maintenance, and for grazing management. Access by tracks to increased subdivision needs to be established early - there is not much point in putting up more fences if the advantages of subdivision in more frequent stock handling are not realised. However, an alternative - access by

private aeroplane is another option, especially where the shape of the property or some other feature prevents ready access. However the safety aspects and risks of flying should be considered, as shown by the recent fatal air accident of a runholder interviewed in this survey.

3.7 Extent of subdivision

Block size will be determined by the type of grazing management. As discussed in choice of cultivation or oversowing and topdressing improvement methods, once a high producing pasture is established by cultivation, careful management is needed to maintain it, often through intensive subdivision. It is better to subdivide the best producing areas first and then move on to the other areas. As discussed before, the criterion for satisfactory levels of subdivision is even utilisation over a block - and this depends on the type of grazing system. However, in a rotational grazing system where the maximum stocking rate during each grazing period is only 12 s.u./ha, the grazing pressure is not adequate for even utilisation and can lead to problems of feed wastage and clover loss. Oversown blocks can be split in half and then further subdivided later by cheaper forms of fencing, such as electric fences, which are quite adequate in most situations. One farmer found very small blocks could cause stock movement problems, especially at lambing.

3.8 Type and position of fences

The appropriate Aglink publication or sales organisations would be the best sources for information on the wide range of standard or electric fences now available.. Successful four wire electric fences (or even three wire) are currently being used in the tussock country, with an earth included if it is thought an extra contact between the animal and the ground is required. However, farmers comment that animals need to be trained to electric fences, and this could account for some of the mistrust some farmers have in electric fences. Cost of electric fences is considerably less than that of the conventional type fence, and could allow more fencing for the same amount of capital. However maintenance costs can be higher, especially on uneven topography, requiring closer spacings and tiedowns. There is not much point in building a conventional fence and then electrifying it; there is no saving in costs and the extra wires are not needed. "All grass" fences, although popular until recently are not now as

popular as three or four wire electric fences, often on insul timber. One farmer suggested the sheep which persisted in breaking through electric fences could be culled to reduce the problem of breakthroughs of mobs. Solar panels are successfully used to power electric fences where a power source is not readily available.

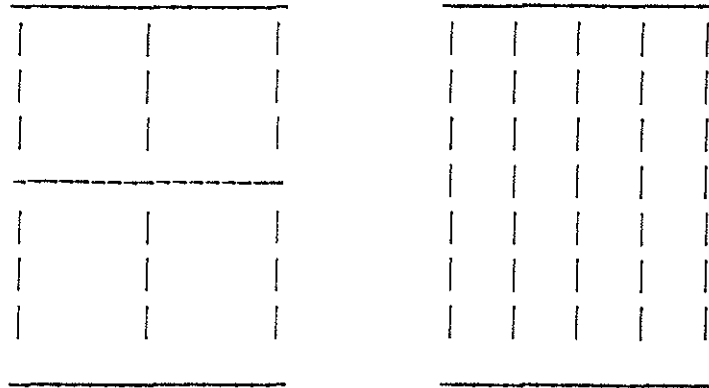
The position of fences can be an important decision. A good aerial photo can be very useful, as sunny and shady aspects can be identified, and in some photos taken at certain times of the year, better classes of soils can be identified by differences in shading on the map. The predominantly sunny and shady faces need to be fenced off separately, although this can often be difficult to do because of the variability within a block. Sometimes a farm has wetter areas that provide useful grazing during dry summers, and these can be fenced off to save them for the drier period. Usually runholders feed off the shady frost-prone aspects before winter and save the sunnier lower aspects for periods of maximum snow risk (late June to end of July). A farmer commented that before subdividing, he used to burn roughage on the shady aspect every two or three years while the sunny aspect got eaten out. Now he is able to graze the shady aspect with stock and maintain a better pasture. One farmer had objections to rotational grazing, (i.e. he meant closer subdivision), because he believed sheep should have free access to shelter in gullies. He maintained sheep would "die against the fences" in his environment if they were fenced off from the gullies. This view is supported by Lynch and Alexander, (1973), who observed sheep and cattle moving downwind in cold, wet and windy weather. Strategic placement of fences may assist newly shorn sheep to survive. Ewes shorn pre-lamb also need shelter in gullies, etc., which may not be available in a closely subdivided run.

As discussed later, the need for sheltered blocks during adverse weather could influence grazing date. Blocks may have to be made larger to include shelter if this is an important factor. Fencing off sunny/shady aspects does not always work: a farmer removed the fence at the bottom of a gully because it "interfered with natural movements of sheep, and they did not previously go down to the bottom fence much at all, but after fence removal grazed the block more evenly." Another farmer who had trouble maintaining fences across creeks solved the problem by not fencing across creeks, but followed contours around. Even though the blocks were unusual shapes, the fences were secure.

Some farmers are considering decentralisation: the formation of a unit on another part of the farm independent of the main unit. This arrangement can involve a separate management unit completely or just involve another set of yards and facilities. The distance for stock to travel can be too large and another set of yards are needed, or a fully decentralised style of management can be considered where responsibility is delegated for management of the other unit.

Where blocks have been subdivided sufficiently, use of a central lane is an advantage, as stock movement can be independent of paddocks on either side, avoiding the transfer of stock through a series of gates. Blocks can be positioned so that they 'feed' into a lane system (and yards), to facilitate stock management. Block size can often be limited by the physical topography; eg. it is often not possible to contour fence around steep faces. To facilitate mustering, fences should preferably be on ridges so that the fence can be seen, and thus any stock moving up or down the fence can be readily seen. Blocks should be square where topography permits, as long rectangles (except lanes) require more fencing. This can be shown in the following diagram, where the squares uses 2 fences while the rectangles use 3 for the same areas.

Diagram to show the effect of square paddocks or long rectangles



4 Grassland improvement - cultivation or aerial oversowing and topdressing

4.1 Situations where cultivation is preferred to aerial oversowing and topdressing

4.1.1 Establishment of high producing pastures by cultivation

Generally farmers suggest it takes one or two years to establish a high producing pasture by cultivation, but about five to ten years by oversowing and suitable grazing management. One North Canterbury hill farm in a rainfall of about 2400 mm suggested there was better grass establishment, less weed reversion and better scrub control (e.g. broom) by cultivation. The stocking rate could reach 10 s.u./ha by cultivation, but only 6 s.u./ha by aerial oversowing. Four farmers suggested the main reason for cultivation was the faster and better establishment of a high producing pasture. One farmer suggested there was less root competition for the establishment of grasses with cultivation and suggested this was one of the reasons why production after cultivation was three or four times that of oversowing. Recent research work shows pasture structures are slow to change; Radcliffe et al. (1977) found that transplanted grasses (perennial ryegrass, cocksfoot) did not produce as well as resident grasses such as browntop (Agrostis capillaris), which were probably better adapted to low soil P and N levels, despite adequate P + S dressing. Clark and Lambert (1982) found on North Island pastures at Ballantrae, that even after seven years of carefully controlled rotational grazing the ryegrass formed only 30 percent of the grasses present. Tight grazing control needed to establish a higher producing grass (such as ryegrass) in a pasture may be beyond the capability of some farmers, as even in the research situation Clark and Lambert showed only modest improvement. Certainly intensive subdivision would be needed for any chance of success. Cultivation is sometimes regarded as a short cut to high producing pastures. On at least two hill farms, pastures established by cultivation on medium to high fertility soils appeared to show a ryegrass dominance, even to the exclusion of clover, but this was not observed in any situation where aerial oversowing had been done. Direct drilling in spring into pasture is also an alternative and can provide feed in the following autumn when cultivated paddocks are still in fallow.

4.1.2 Cultivation of scrub or weeds

Another situation where cultivation is preferred to aerial oversowing is when weeds or scrub is a problem. Nassella tussock where present (three farms out of about 91), can be very difficult to identify amongst other short tussocks. Cultivation is usually resorted to where possible, to clear the ground and identify young seedlings. Where rushes and red tussocks (Chionochloa rubra) were present, often on wet ground, cultivation was generally used. Red tussocks were considered of low feed value and difficult to control by other means, although cattle appeared to eat them after the first grazing. These plants were on damper patches of ground, sometimes in large areas (e.g. Lees Valley) and appeared to be on productive soil because of high moisture regimes, usually at the foot of slopes.

Matagouri, when a barrier for stock movement, and the cause of discomfort to humans prompted at least two farmers to cultivate all their available land. One North Canterbury farmer suggested the area taken up by even a sparse association of matagouri could be quite considerable, preventing access of animals to feed unless there was a shortage of herbage.

4.2 Flat land area limitations

The decision to cultivate can depend on the balance of type of land on the property: if there is not much flat land available, the maximum use of this is usually made by cultivation and more intensive use. On some properties stocking rates of 10 s.u./ha are maintained on a small flat area, while large areas of winter grazed country are still unimproved. Some high country properties have a shortage of winter feed, and all available land is cultivated to provide enough conserved feed. One high country farm in Marlborough was fortunate to have a large area of Class III land available. The runholder believed the only way to fully utilize this land was to cultivate it and establish high producing pastures.

Cultivation and establishment of lucerne on some high country properties produce high annual yields of herbage, (e.g. MacKenzie Basin). In these situations (especially where there is irrigation water or water that the deep lucerne tap roots can have access to), cultivation can be the best alternative.

4.3 Cultivation: an expensive alternative

Cultivation alternatives are expensive and a large capital outlay is needed on machinery. One farmer in Central Otago suggested he could buy in enough barley for winter feed more cheaply than if he had to cultivate for winter crops and provide capital for machinery. As cultivation is costly in relation to aerial oversowing, cultivated areas are managed more carefully than some of the other parts of the farm. Careful grazing is essential to maintain high producing swards. Types of grazing management will be discussed later.

The next in priority of grazing control are the oversown areas and last are the unimproved. It is a costly exercise to cultivate out of scrub only to find it revert back within a few years, as one North Canterbury farmer has experienced. Under a set stocking system and where there has not been close pasture control, there was a need for pasture renewal every ten years on a Central Otago farm, but on some other farms with closer pasture control a high producing pasture is maintained indefinitely, without further cultivation. Cultivation for winter crops of brassicas to feed hoggets well in addition to quicker establishment of pasture were the reasons for a Central Otago farmer using cultivation. He considered the gain in stock performance worthwhile even if reasonable quality pasture needed to be cultivated each year.

4.4 Strategic use of improved pastures

The use of aerial oversown or cultivated pastures at different times of the year can sometimes be the only control the farmer has on the quality of feed available to his animals. The decision when to use his improved country can be the closest some farmers get to budgeting their feed, and is often one of their most important decisions in stock management. The area available of improved country has a large effect on the feed quality available on a property, and it is important to recognise critical and non-critical periods in the feeding of animals.

A North Canterbury farmer budgets the feed so that his sheep are grazing improved areas in the period before and during lambing. He arranges his rotation so that the sheep arrive on these areas at the critical periods. In the U.K. one of the main recommendations to hill country farmers has been to save their improved areas for the critical periods, such as flushing and lambing time, to get the best response and use out of their improved land. The suggestion by Coop (1964) that ewes only need to spend 8 months out of 12 at maintenance still appears appropriate. The poorer

quality feed is best used during the maintenance period. The higher quality feed can be used to achieve weight gains and milk production or for periods during later pregnancy when the capacity of the sheep's rumen is limited by the foetus. The critical use of improved areas will depend on what proportion of the farm is improved. If only a small part is improved it becomes increasingly important to get the best use out of the improved area. Some means of estimating how long feed will last is important, to ensure the high quality feed is available for the critical periods. In the U.K., where only small areas may be developed, ewes with twins are drafted onto improved areas, and ewes with single lambs needing lower feed intakes are maintained on poorer quality feed. One North Canterbury farmer prefers to keep flocks separate, and lambs one mob of sheep on unimproved and another on improved areas, accepting a lower performance on the unimproved, as he considers a change in diet takes too long to adjust if sheep are changed from one type of feed to another.

4.5 Improved pastures need subdivision

Where aerial oversowing areas had not been fenced off from the unimproved, two farmers noticed an improvement in the performance of cattle and sheep, but not an increase in stock numbers: it appears there had been a substitution of improved feed for the unimproved similar to that in the high country summer range observed by Abrahamson et al. (1982, 1989). Where areas were fenced off, one South Canterbury farmer now has 60 percent lambs fat off the mother when previously he had store lambs.

Where large parts of a farm have been improved there can be more demand for the use of run-off areas in dry years. Stock carrying capacity could have increased several times and this places more importance on a reserve area, perhaps of Class VII or VIII to be used during feed shortages. One North Canterbury farmer who had access to unimproved tussock country was the only one in his area who did not have to destock in time of drought. As discussed later, subdivision becomes more important as more of the farm becomes improved, so that feed can be allocated from one period to another. Alternatives to this, such as a deliberate policy of understocking to allow for the dry seasons are discussed later in Chapter 5.

4.6 Other benefits of aerial oversowing and topdressing

One Central Otago farmer suggested oversowing did not pay because it not

only provided more feed at the times of the year (spring and early summer) when he already had a surplus, but also did not alleviate shortages during other times of the year. Another runholder suggested oversown pastures stay greener in autumn and grow 2-4 weeks earlier in spring depending on the age of the oversowing and topdressing. An interesting comment by a farmer who had been topdressing and oversowing for some time was that the seasonal dip in feed was not alleviated until the improvement was well advanced, soil fertility had been increased, and clovers had been established for some time and were providing nitrogen to stimulate grass production.

The availability of improved areas allows the option of all grass wintering. Unimproved or semi-improved pastures are probably not suitable for grass wintering (see Chapter 9), as persistence of feed through the winter may be variable. Higher green herbage levels at the start of winter are best for successful all-grass wintering, (Abrahamson and Talbot, 1986). These levels are more likely to be achieved on improved pasture.

4.7 Other criteria in cultivation or aerial improvement decision

Some soils are naturally too steep, rocky or have natural obstacles that prevent cultivation. Lighter soils (e.g. MacKenzie soils) that are susceptible to wind blow and severe frost lift and have severe moisture stress in summer are not cultivated and are left with tussock cover. Better areas in a block are sometimes cultivated; especially the heavier, deeper soils, and where a permanent vegetative cover can be established these are usually suitable for cultivating. Where ground is cultivated, tussocks are lost, so the arguments for keeping tussocks also have relevance to the decision to cultivate or oversow and topdress. In higher rainfall areas (1000 mm or more), the retention of tussocks does not seem so important, although even in these areas there are reasons for not cultivating (see Chapter 10).

Where cultivation is preferred over aerial oversowing and topdressing a reasonable level of production from those soils is expected. In North Canterbury cultivation of yellow grey earths appears suitable and some well-established ryegrass white clover pastures give a good return, provided a suitable grazing management is employed with annual stocking rates of more than 18 s.u. per ha being achieved on a few farms.

Farmers' comments and practices clearly show that there is still a need for

cultivation of some soils, particularly those of higher fertility, where quick establishment can be expected, or where there is a persistent weed problem.

5. Choice of grazing management system: set stocking and rotational grazing systems reviewed

Grazing management is no different from the management of any enterprise - as with a successful business grazing management needs to have clear, well-defined objectives and suitable decisions made at the optimum time. These objectives can be quite simple in concept e.g. "efficient utilization", or some other description. The objectives need to be defined at the outset of any comparison of grazing systems, whether set stocking (continuous), semi-rotational or rotational. The major objectives are described and are followed by an explanation why these objectives are the most important ones. The grazing management systems (mainly set-stocking or rotational grazing) are then assessed by reference to research work and how they fit in with the farmers' opinions and practices.

5.1 Objectives of good grazing management

The system that best fits objectives will be the preferred choice. However, it should be stressed the objectives can be flexible, and could change depending on the circumstances, with one objective "traded-off" against another. The importance of some objectives could increase at certain periods of the year, e.g. set stocking is usually practised over lambing and until weaning. Avoiding shifting stress and mismothering of lambs may be major objectives superceding pasture control. After weaning pasture control may be a main objective. Choice of a grazing system at a certain time of year or stage of development could depend on the priority placed on each objective: at initial stages of development a high utilization of accumulated roughage is important so that the pasture moves out of a developing into a developed phase, and it would not be possible to maintain animal intakes of high quality pasture. Some main objectives in successful grazing management and the importance of these are discussed as below.

1. Pasture of a good quality and high digestibility should be available to the animal, as stock performance is a direct function of intake and digestibility.
2. An ensured supply of feed best suited to the animals' needs and for optimum performance throughout the year.
3. Maintenance of the best producing pasture species that can be sustained.

4. Grazing management to achieve the maximum growth of readily digestible plant material.
5. Most economic use of labour and resources to ensure continuance of the enterprise, both in the long term and short term.
6. Good utilization of feed grown.
7. Grazing system fits in with the capabilities of the manager and other possible limitations; there is no use proposing a system if it doesn't fit in with other aims in life.

5.2.1 Importance of grazing management objectives

1. Pasture of good quality and high digestibility available.

One of the main factors affecting feed quality is the proportion of green material present in the diet. Quality of feed is also the main determinant of productivity levels. Rattray (1978) found sheep select green material mainly and the proportion of green material appears critical in affecting liveweight gain and ovulation rate in sheep in summer and autumn. There is a correlation coefficient of $r = .98$ for the regression of digestibility percentage on green material percentage. This means that 96% ($.98^2 \times 100$) of variations in liveweight gain and ovulation rate in the trial were accounted for by the green material % and other factors only accounted for 4% of the results. During and Webby (1980) in trials with hoggets at Whatawhata found a high correlation of green standing dry matter after grazing and rate of liveweight gain, with $r^2 \times 100 = 82\%$, but $r^2 \times 100 = 67\%$ for total dry matter, which included dead matter as well. Green herbage maintains a constant high digestibility throughout winter and the % green of the herbage is a good indicator of herbage digestibility, (Abrahamson and Talbot, 1986).

Digestibility or feed quality has an important effect on voluntary intake by animals: Smetham (1973) found digestibility is the main determinant of forage intake of ruminants. Digestibility of forage is usually defined thus:

$$\text{digestibility \%} = \frac{(\text{kg DM. eaten}) - (\text{kg DM. faeces})}{(\text{kg DM. eaten})} \times 100$$

More recent units of feed value include the metabolisable energy units, M.J.M.E./kg.D.M. (megajoules of metabolisable energy per kg of dry matter), which allows for loss of urine and gas in addition to the faeces. The relative values of feeds can be obtained from tables as in Ulyatt *et al.* (1980), the Lincoln College Farm Budget Manual or Milligan (1981). However there can be significant differences of intake of plants of the same digestibility, (Ulyatt, 1978), and in general the intake of clovers is higher than grasses of the same digestibility. Variation in intake could account for up to 70% of the differences in feeding values (feeding value is the effect on animal liveweight gain). Ulyatt (1978) describes the

relative feeding values of some pasture species; there is a large decline of feeding value of browntop (*Agrostis capillaris*) from spring to early summer (100 to 83). The feeding value of perennial rye (Ruanui) was 100 and the more persistent the strain, the lower the feeding value of the ryegrass. Legumes (Huia 186) have a high feeding value.

Pastures can become dry and mature in summer, with a high proportion of dead material, low soluble carbohydrate and protein, and low digestibility, with consequent reduced voluntary intake and efficiency of utilization, (Ulyatt, 1978). Late winter digestibility of pastures is usually high, (unless frosted or dead material is present).

Ulyatt (1978) also found if pasture had more leaf present than stems, there was a much better feeding value. He describes the decline of digestibility of lucerne as it becomes more mature; there would be similar trends in grasses. The decline of digestibility is caused by an increase of cellulose, lignin and hemicellulose in the stems with a slower increase in the leaves. The levels of readily fermentable carbohydrates (soluble sugars, starch, pectin) decrease slowly in the stems and are constant in the leaves; crude protein levels decline more rapidly in the stems than the leaves. Leaf is a more valuable component of pasture and the advantages in keeping a pasture in the vegetative state with as much leaf as possible appears important: Smetham (1973) suggests that grazing can return the pasture components to a physiologically young stage of growth, and when the grass plant continues to grow past ear emergence stage, digestibility can fall to quite low levels of 60% or less. The benefits of keeping pastures in a vegetative state were shown by Goold et al. (1982) who used a growth retardant on ryegrass/white clover pastures and obtained large differences in the growth rate of lambs by not allowing the reproductive stage of ryegrass to develop.

Maintaining a pasture of high digestibility could mean keeping a higher proportion of species such as Huia white clover in the pasture; John and Lancashire (1981) found relative feeding value of Ruanui was 52 compared to Huia at 100, for weaned hoggets fed ad. lib. Munro and Davies (1976) found white clover resulted in a superior conversion rate to animal production compared with other plant species that couldn't be accounted for by the difference of 3.7 digestibility units; there could be higher utilisation of the digested nutrients.

5.2.2 Feed supply best suited to the animals' needs and performance

Feeding requirements at different times of the year are discussed elsewhere (see Chapter 7 and Chapter 4). There should be a realisation that stock can be kept at a maintenance level for much of the year provided that feed can be increased at critical periods such as at flushing time of ewes before mating and before and during the lambing until weaning. Feeding stock on high quality feed during a period when only maintenance level is required and then running short of feed in critical periods should obviously be avoided. Conservation methods and winter feeding would need to be considered carefully in a grazing management system - this will be discussed in the section on wintering stock. Residual herbage mass (the amount of herbage left after grazing) is discussed in a later section and is useful in assessing the severity of grazing and selectivity allowed the animals.

5.2.3 Persistence of the best producing pasture species.

Scott (1979) suggested "most of the pasture plants are alike in that they can survive over the full range of temperature, moisture and fertility conditions and achieve at least 50% of the potential yield on most sites. In this sense the difference between species is not as great as might be anticipated e.g. between browntop and ryegrass in low and high fertility situation..... However, only one or two species will realise the full potential of a site having a particular combination of temperature, moisture and fertility. Thus to farm close to the biological potential there must be consideration of the pasture species used."

Radcliffe et al. (1977) showed that where fertility is low the production of adventive species such as browntop and sweet vernal are no different from ryegrasses. The "resident" grasses were probably better adapted to low soil P + N levels, despite adequate P + S topdressing.

Brougham et al. (1974) in a survey of pastures in the Manawatu found levels of annual pasture production from 2140 kg DM/ha to 10800 kg DM/ha, with white clover making a low contribution to results in both situations. The low producing pastures contained chewings fescue (Festuca rubra), sweet vernal, (Anthoxanthum odoratum), browntop and Danthonia, while the high producing pastures had high proportions of ryegrass, crested dogstail and white clover. It is important to understand the composition of the pasture being grazed to apply proper grazing management; Smetham (1973), referring

to effect of poorer quality pasture on animal performance, concludes (referring to the effect of poor quality pasture on animal performance), "...it is no use expecting rotational grazing to work on a pasture consisting for instance of chewings fescue, *Notodanthonia* species, and *Poa pratensis* and where ryegrass and white clover contribute less than 30 percent of the sward between them" (referring to effect of poorer quality pasture on animal performance). Although there has been no survey of pastures in the South Island similar to that in the Manawatu, observation on the 91 farm visits in this study would suggest that even on pastures that have been topdressed for considerable periods the ryegrass component did not form the main part of the pasture species present. As discussed in 4.1, Clark and Lambert (1982) on North Island hill country found that even after seven years of tightly controlled rotational grazing, only 30 percent of the pasture was ryegrass.

It is important to use species that will make best use of the higher fertility soils - and also, as discussed in the feed quality objective, some species have better feeding value than others e.g. Lancashire and Ulyatt (1974) compared Ruanui and browntop and although flowering on both species was suppressed by grazing, with good feed utilization on both pastures, there were lower liveweight gains of young sheep on browntop than on ryegrass. These effects were attributed to greater stem and stolon development and poorer leaf growth in browntop pasture than in ryegrass. Digestibility of browntop in February was 49.0 percent while that of ryegrass was 60.0 percent.

5.2.4 Maximum growth of plant material.

One important concept in obtaining maximum growth of pasture is to use as much of the available light as possible for pasture growth. The L.A.I. or leaf area index, is the ratio of leaf area to that of the ground area. The critical LAI occurs when 95% of light is absorbed by the pasture or crop. Brougham (1958) suggests a L.A.I. of 4.5 - 5.5 is necessary in mid-summer for 95 percent of incident light to be absorbed, while in winter the critical L.A.I. is only about 3. Hard continuous grazing (to an LAI of 1.0) produced higher intakes of herbage than leniently grazed swards (LAI of 3.0) because more herbage was harvested on the continuously grazed sward, (Parsons et al, 1983a, 1983b). Maximum intakes per hectare were maintained at lower LAI's than the optimum for photosynthesis. Ernst et

al. (1980) in a discussion of rotational compared to continuous grazing, suggested that photosynthetic activity on a well-managed continuously grazed area may not conform to classical theory. In contrast to paddocks in a rotational system they suggest the continuously grazed pasture contains a high quantity of young herbage with a high potential for assimilatory activity, and refer to Koblet (1979) who found in dense, intensively grazed swards, because of high radiation efficiency, the pastures attain daily growth rates close to a maximum with a leaf area index of 2 to 3, and at a relatively low sward height. The often mentioned advantages on L.A.I. by letting a sward increase in height may not be realised in practice. Milligan (1981) suggests there is no point in allowing pre-grazing dry matter levels to exceed 2500 kg of DM/ha on North Island pastures. Cattle and sheep can maintain adequate intakes at this level.

The amount of regrowth of plants after grazing or cutting can have large effects on pasture production. Smetham (1973) concludes that "the whole subject of factors affecting regrowth is far from clearly understood, particularly in grasses. Plant species present have large effects on this, e.g. as well as better tolerance of treading; more prostrate grasses Ruanui and Ariki, Huia white clover and subterranean clover are for this reason higher producing under close and continuous grazing than the more upright Paroa and Manawa ryegrasses or Turoa red clover. Plants of prostrate growth have more shoot and leaf area left behind after grazing to facilitate recovery." The effect could thus be complex and unpredictable, depending to some extent on the botanical composition of the pasture. Milligan (1981) presents data of Brougham, (1980), showing that white clover repeatedly grazed all year round from 7.5 to 2.5 cm yielded considerably more than when not grazed so hard. Total dry matter production from Manawa ryegrass, white clover, cocksfoot, and red clover repeatedly grazed from 7.5 cm to 2.5 cm in winter and then 18 cm to 7.5 cm the rest of the year yielded almost 15000 kg DM/ha, which was almost 1800 kg DM/ha more than any other treatment. Repeated grazing to low levels of 2.5 cm in summer and to high levels in winter gave only 9800 kg DM/ha. Although it was not suggested by Milligan, it would seem likely that this range of heights could be present under both a set stocked or rotationally grazed system, with the only difference being that with set stocked the pasture would constantly fluctuate between these levels over the year, while on rotational grazing the pasture would suddenly change from one height to the other. If the advantage of grazing to this height was caused by

advantageous light interception, then both continuous and rotational could be similar. Cutting experiments to simulate rotational grazing or continuous stocking showed that when the data were combined there was a maximum yield (12500 kg DM/ha) in a ryegrass-white clover sward when average annual stubble biomass was between 1600 - 2000 kg DM/ha, (Harris,1978).

In a review of the effects of defoliation on plant vigour, production and carbohydrate reserves, Trlica and Singh (1979) have established that frequency, intensity and season of defoliation can explain most plant responses to defoliation. Plants are affected more by defoliation at certain phenological stages of development than others, and it appears from the literature there is a wide range of times for different species. Depletion of reserves in palatable perennials by grazing could shift the competitive balance towards non-palatable species and result in a change in community composition (and this could affect the pasture composition, discussed in objective 5.2.3).

Perennial ryegrass, browntop (Agrostis tenuis Sibth) and white clover pastures were studied by Chapman and Clark (1984) under rotational or set stocking at 12.8 ewes per hectare on N.Island hill country. They found little difference in amount of herbage grown between the two systems, (which could be predicted from the work of Suckling at Te Awa, previously cited). The effect demonstrated the compensatory mechanisms in pastures (tiller densities, etc.,). Chapman and Clark suggested a combination of set stocking and rotational grazing would be most effective in hill country.

5.2.5 Economic use of labour and resources.

Farmers' comments and practices on this will suggest how these are affected by grazing management. The survival of the business ultimately depends on short and long term profits; grazing management has to fit in within this framework.

5.2.6 Even utilisation of feed grown

If a pasture is in a green vegetative state, and there has not been an accumulation of old or dead material or reproductive tillers of grasses, then it is safe to assume that utilisation is good. Holmes (1980) has suggested that "well established and well-managed pastures, stocked at the appropriate rate should not become weed-infested or stemmy"; i.e. if feed quality is properly maintained then feed utilisation should also be satisfactory.

One of the most important factors in feed utilisation is the correct stocking rate, which will be discussed later. Cattle can have a marked effect on utilisation and this is discussed in the complementary role of cattle. Variability within a block and especially large blocks, can be considerable, and the objective should be to get as even a utilisation over the block as possible, without some parts becoming rank, and other parts being grazed too short.

Brougham (1970) suggests "research is needed into the utilisation aspect of agronomic studies - and in a large number of studies the measured difference in DM production between grazing trials was due to dead matter accumulation over the reproductive period of growth". Efficient utilisation relies on using the pasture when it is at its most nutritious stage of growth. Brougham (1970) suggests also "we need to know losses due to tissue senescence under spelling and we need to evaluate dead matter accumulation", (as well as treading loss, fouling, dung and urine and acceptability to stock). Pasture can be permitted to accumulate dry matter if some other objective becomes more important, such as the allocation of feed from autumn to winter. The choice of a grazing management system could be dependent on an economic comparison of different methods, with some loss in feed quality or quantity acceptable, provided that a reasonable quantity of feed can be carried through to the period when there is a feed shortage.

5.2.7 Other considerations.

Grazing management fits in with the capabilities of the manager and other possible limitations. It would be no use proposing a system if it meant that very frequent stock shifts would mean a keen golfer would miss out on his Saturday afternoon golf. Other aspirations, apart from maximum animal production need to be considered for a successful grazing management. A successful grazing management system is one that works, that is acceptable to a farmer, and when the decisions made at the correct time produce results. If it is not acceptable it will not be adopted - reasons given for not adopting a grazing management system may not necessarily be the real ones, rather some feeling or "hunch" that the new method would be unsuitable in some way. It is hoped to show that the stated disadvantages of some systems are more apparent than real.

The grazing management system should include provision of 'safe' pastures as one of the priorities. Safe pastures are pastures which have sufficiently low levels of larvae of internal parasites (which affect weaned lambs), to prevent an increase in parasite numbers while being grazed by lambs. Ross (1982) has described methods for increasing the amount of safe pasture. These include:

- increasing the numbers of two-tooths retained
- using hay or silage regrowth
- using cattle
- producing safe pasture by drenching lactating ewes

Safe pastures can be divided into two groups.

(a) Summer phase safe pasture - pasture not grazed by ewes and lambs from lambing to weaning. This is required for 12 weeks from late November to late February.

(b) Autumn phase safe pasture - This is grazed with ewes and lambs between August and December, (lambing to weaning). It is 'spelled' from lambs for 12 weeks, starting at weaning and then used by lambs again as 'safe' pasture in early March.

It is important to aim for well-grown hoggets as once they enter the ewe flock in the high country they are unlikely to gain weight unless they are barren, (Coop, 1973). In the high country the maximum liveweights do not exceed 40 kg. Poorer feeding of hoggets in the winter can be compensated for by increased feeding in the spring-summer period before their first mating, (Drew et al, 1973). Ideally hoggets should be 50kg by their first mating. Thompson (1971) found hoggets lost weight in the high country from late June to early September but showed fast growth rates in spring.

5.3 Comparison of set stocking and rotational grazing - research work reviewed

There is a need to define what is meant by rotational grazing. Smetham (1973) defines true rotational grazing when stock are on a block no longer than 24 hours. In South Island hill and high country, stock can be on a block for two weeks or longer and still be on what is commonly termed rotational grazing, although in this situation animals can regrazed the pasture. Voisin (1959) stresses the need for not grazing regrowth within one occupation of a paddock and suggests ideally it should not be occupied more than four days at one grazing with 20-30 days between grazings.

It is beyond the scope of this work to examine all, or even a part of the trial work done on the comparative advantages of different managements. However, recent reviews have covered a large number of trials, and as Ernst et al. (1980) suggested, it can be very difficult to assess the relevance or general applicability of trial results as they often apply to only one situation and set of circumstances and cannot be transferred through space and time.

Firstly, evidence suggests that rotational grazing is only marginally superior to set (continuous) stocking and then only at high stocking rates. Moore and Biddiscombe (1954) found in Australia that on both sown and native pastures, continuous year-long grazing is not shown to be at a disadvantage with rotational grazing.

Myers (1972) found no field experiments to date had established that rotational grazing of pasture led to really substantial gains of animal production, and suggested continuous set stocking was the best management system, provided that it was flexible. Milligan (1981) found rotational grazing was only superior to set stocking in per head performance and production per ha at higher stocking rates, (14 ewes/ha in his situation), and was better "mainly because it allows feed banks to be built up."

Suckling (1975) referred to Lambourne (1956) and McMeekan (1956) who found little difference between set stocking and rotational grazing at lower stocking rates. Even at extreme differences in grazing method there were relatively small effects on efficiency, and McMeekan (1956) concluded that by far the most important factor affecting animal efficiency was rate of stocking. Smetham (1973) suggested "it was almost impossible to divorce the effects of stocking rate and methods of grazing, since with rotational grazing there is an inevitable 15-30 times increase of stocking rate on each hectare when grazing is proceeding, and the advantage obtained by rotational grazing appeared to stem from this fact alone". Smetham referred to Cooper (1960) who suggested the advantage of rotational grazing in terms of stock productivity to stem from

- (a) the better quality herbage produced and
- (b) the rationing of feed.

Hay et al. (1979) suggested rotational grazing allows precise allocation of herbage throughout the year, maintenance of sown species in the sward, more even distribution of dung and urine, exploitation of new bred pasture genotypes, and ease of assessing the future available feed reserves. Ernst

et al. (1980) concluded in a comparison of set stocking and continuous grazing of cattle "that in a majority of comparisons it was not possible to ascertain from published information, reasons why one system of management was marginally superior to the other. Conclusions drawn from data is perhaps not that on balance there is little difference between the two systems, but there are circumstances when one of the two is more productive". They suggest therefore they should try to identify these (circumstances) and construct management guidelines that enable the farmer to avoid problem points in whichever grazing system suits him and his farm circumstances best. This suggestion appears to be similar to that made by Milligan (1981), who after considerable experience in grazing management in the North Island of New Zealand concluded that "the decision to rotate or not will vary with the season and class of stock and the feed situation. Good managers will also vary their grazing management decisions between years to capitalise on good seasons and reduce the effects of poor seasons."

The lack of difference between set stocking and rotational grazing was discussed by Ernst et al. (1980) who cited Hodgson and Wade (1978) who found annual herbage accumulation is relatively insensitive to variations in grazing managements or to variations in stocking rates likely to be of practical interest. They argued that although varying pasture managements may produce swards with substantially different leaf areas and consequent differences in photosynthetic activity, the whole sward has considerable powers of compensation in number of tillers and size of leaf primordia, rates of death and decay, rather than through changes in current photosynthetic activity, with high numbers of tillers in a well-maintained continuous grazing system, contrasting with the steady fall seen in both monthly cutting and rotational grazing systems. The "apparent plasticity of the plant allows high levels of pasture production to be achieved under a range of grazing systems". Milligan (1981) suggested that for optimum quantity and quality in a practical situation on North Island farms, herbage mass of pastures should be maintained within the 1100 - 2500 kg dm/ha range under any system of grazing, or pasture production may be reduced. This infers that no great difference in DM production should be expected from either system as regards feed production both in quality and quantity. Recently, Hodgson and Maxwell (1984) with continuously grazed swards showed that from 1000 to 2500 kg OM/ha (organic matter, of about 2-8 cm sward surface height), the net rate of herbage production is insensitive to herbage mass. In a high country situation, Allan (1985) showed stocking

rates were more important than type of grazing management in achieving increases in liveweight gain per hectare.

6. Grazing systems in the tussock grasslands and apparent success of these systems

The main objectives of good grazing management were defined earlier: to produce pasture of high quality supplied at the correct time of the year, ensuring optimum utilization, whilst maintaining suitable plant species.

The survey found some situations which were common to several runholders. The runholders' apparent success with their chosen systems of management were assessed. The criteria for success was an apparent ability to fulfill some of the major objectives in good grazing management as outlined above; the observed state of pasture, observation of the animals at the time of visit, and useful observations by the runholders themselves on the likely success of their chosen grazing management systems in their situation.

6.1 Extensive grazing systems

The first situation to be discussed is that of an extensive grazing hill or high country property with a low level of subdivision, typically of only 5 to 20 blocks. There is no alternative grazing management possible apart from set stocking, as options are restricted by the number of blocks available. Decisions on stock movements are largely made out of climatic considerations and basic management considerations. Where even sunny, shady aspects cannot be fenced off, even utilisation is not possible. Grazing pressure is not high enough to ensure even use of a block, palatable plants are overgrazed and stock may stay on a block for six months or more. There therefore can be problems with persistence of oversown species and with continued rejection of woody undesirable species.

In this situation, few of the suggested objectives for good grazing management are fulfilled. There are often seeding paddocks of browntop, sweet vernal, etc., which do much for the scenic value of a landscape, but little for feed quality, utilisation and animal performance. Stocking rates are not sufficient and usually subdivision is inadequate to allow enough stock to be concentrated at any one time to control growth and keep the pastures in a vegetative state. Often burning every few years seems to be required to get stock to enter and stay in 'long' undergrazed areas and it appears there is no other option, as stock are not controlling the feed. Other unpalatable species, such as silver tussocks can increase and become

a weed problem as stock are selective and are not forced to eat the undesirable species.

Stock do not have easy access to green material (and as discussed earlier, green material can account for most of liveweight differences) and the development of reproductive tillers prevents fresh leafy pasture growth. Accumulation of roughage shades the new seasons' growth and aids the spread of species such as browntop. The animals may be forced to eat poorer quality feed because of the deterioration of the pasture, and lower stock performance in wool weights and liveweight gain are the consequence.

Where there is inadequate subdivision and stock have been able to graze uncontrolled, the animals have decided what and when to eat and not the farmer; there can be an allocation of feed problem, with the bottom of a pasture grazed out and the best quality feed eaten perhaps when only maintenance was required, while good quality feed is not available at critical periods. In this situation too much of the farm could be set stocked, and more subdivision, or a limited form of rotational grazing could improve the feed situation.

6.2 Apparently successful grazing management

Observations made on some hill and high country farms suggest that there are quite a number of farms in the survey that are fulfilling the objectives of a successful grazing management. These are what might be called "traditionally" operated farms that may employ some mob stocking after weaning to clean up some blocks, and where stock can be set stocked for quite long or short periods, or where only a limited form of rotational grazing is being practised. Some of these farms can be quite well subdivided, although not perhaps intensively enough to go into an intensive rotationally grazed system. These successful farms appear to be well run, with good stock performance, (often very good), and with good quality pasture which appears to be in the range of dry matter suggested by Milligan (1981), of 1100 to 2500 kg dm/ha before grazing. Often as many as half the stock units are in cattle. The success of their system could sometimes rely on the ability of cattle to remove the "top" that is left after sheep grazing.

There is concern amongst some of these farmers that they are missing out on something and perhaps are not getting the maximum they would get from their

farm with their grazing methods. There is an understandable reluctance on their part to undergo a lot more subdivision, (necessary to change to an intensive rotational grazing system), and to change to frequent stock shifts when they think they are doing quite nicely as they are. These farmers generally appear to be able to accurately assess the number of sheep (and cattle) required to control the pasture on a block, and are prepared to make the necessary adjustments. Often these farms are not wholly set stocked, but the farmer uses several blocks in a longer rotation. He may increase the utilisation by removing sheep or cattle only after the more inaccessible feed had gone from amongst the tussocks or matagouri bushes, and as discussed later, considerable stockmanship and skill is practised in judging longer term trends in animal and pasture condition.

Cattle can make a large difference in these situations and appear essential to obtain better utilisation of the blocks.

Although these farms are not rotationally grazed in the true rotational grazing sense, of short time on long time off, they are not usually wholly set stocked for the whole year. The disadvantage of continuous grazing according to Ernst et al. (1980) is that "stock piling of grass which is an inherent feature of rotational management --- is not really possible under continuous grazing." However usually part of the farm at least is not grazed at anyone time, and some form of rationing even on a set-stocked and rotationally grazed systems found in one season an advantage for rotational grazing when there was a severe feed shortage in winter, but under normal conditions of stocking etc to be expected on farms, set stocking would be superior to rotational grazing. These farmers who already appear to fulfil the objectives of good grazing management may achieve only marginal benefits by changing to another more intensive system.

6.3 Importance of stocking rate in grazing systems

Firstly, it is clear from the reviews discussed earlier, and from other work that any difference between rotational grazing and set stocking would only tend to show at high stocking rates. Clark and Lambert (1982) found in a six year study of set stocking vs rotational grazing at different fertilizer inputs, that most of the effect of management could be obtained by increasing the stocking rate. Suckling (1975) on North Island hill

country at Te Awa, found that it was most important to stock at rates that ensured full utilization of pasture growth. Undergrazing allows the animal to become selective and the less palatable species which are not readily eaten in the early spring become coarse and stemmy and may then be completely rejected. Smetham (1973) refers to "patchy grazing and the need to adjust stocking rate continuously during grazing - in practice this adjustment is not made as much as it should be - with rapid ingress of flat weeds, weed grasses and resultant lower production". Ernst et al. (1980) cites Castle and Watson (1973) who describe undergrazing in both rotationally and continuously grazed pastures, "when mosaics form in the early season - undergrazed have a reduction in tiller density and a production of aerial tillers - the reduction of tiller numbers is of particular significance to a continuously grazed sward which is reliant on a high tiller population. Subsequent defoliation removes the aerial tillers, reducing tiller density and in extreme cases leaving open, bare patches in pasture".

Ernst et al. (1980) cite McMeekan and Walshe (1963), who achieved advantages for rotational grazing only at high stocking rates. Those farmers who appear to have successful grazing management must have correct stocking rates, or pastures would show evidence of uneven utilisation.

It is important to establish what the long term stocking rate will be. A few apparently successful farmers stocked for the "poor" years, and achieved an average high stock performance. They could think back further perhaps than more recent arrivals in the district and could remember a drought year a few years back. In one case the farmer was going against pressure from a discussion group to increase stock numbers. If the relationship of total physical production and stocking rate for sheep was similar to that as described by A.T.G. MacArthur, Lincoln College (pers. comm.) for dairy cows, then reducing stocking rate to a bit below the optimum would only have a relatively small effect on total physical production. Taylor and Mars (1979) found there was strong evidence to suggest that high stock performance in the South Island high country is closely associated with high net profits and suggest great benefits can be gained from improving stock performance alone, (even without an increase in stock numbers).

Stocking for the poor years also ensures continuation of breeding stock - if fertility or some other factor had improved by selection and good

nutrition it would be disastrous to "crash" in the poor year and have to sell the higher performance stock and then possibly have to buy in stock of uncertain breeding quality. Breeding ewes can take more than one season to get over a severe loss in body weight during feed shortages, and stock performance could suffer the following season. One farmer suggested he could get the same income by having 300 less sheep, (\$6,000 less of capital costs at that time) - a considerable saving. The four farmers with a deliberate policy of understocking all had high stock performance and also made use of cattle to keep on top of the feed, (mostly set stocking with some semi-rotational grazing).

6.4 Change in pasture species by grazing management

A reason sometimes suggested for changing to an intensive rotational grazing system is that a shift in pasture species to a dominant ryegrass/white clover pasture is only possible under this system. The trial by Clark and Lambert (1982), (discussed earlier), suggested that progress by grazing management in changing proportions of species in a pasture is slow, and would only be possible under similar controlled conditions to those in the trial, and hence may not be possible on an average commercial farm. Although not measured, impressions gained from the survey would suggest pasture species (and probably also soil fertility) had not advanced very far into the ryegrass/white clover phase, as described by Boswell and Crawford, (1978). Although pasture quality and other objectives contributing to successful grazing management were being attained, the pure ryegrass/white clover pasture was not seen on the farms included in the visits unless the pasture had been established by cultivation. It could be that the ideal of changing pasture composition by grazing management is not achieved in practice, and changing a grazing management for this purpose alone may be unwarranted. Woolshed holding paddocks may show some composition changes to ryegrass - white-clover, but these would be mostly in response to grazing pressure again. M. Smetham (pers. comm.) has suggested from his experience in Central Otago that ryegrass - white-clover spreads into OSTD hard tussock about 9 years after program initiation and a stocking rate of 5-10 su per ha during (periodic) grazing.

If a farmer who was apparently successful with his grazing management were to try to change to all rotational grazing, he may not obtain much increase in production. As described earlier - the factors of leaf area, frequency

of grazing and regrowth of plants on pasture production, do not show unqualified benefits for rotational grazing, and certainly there does not seem to be enough evidence to change to another system where the objectives of successful grazing management described earlier are being fulfilled.

Earlier in this chapter situations where set stocking appeared unsuccessful were described. Set stocking appeared successful when there was more subdivision, careful control of stocking rate, some allocation of feed where the whole farm was not being stocked at one time, good stock performance (and not overstocking), use of cattle, and apparent fulfillment of objectives of good grazing management.

6.5 Use of rotational grazing in the tussock grasslands

The situations where rotational grazing is used successfully, how these systems operate, and some of the reasons why farmers have success with the rotational grazing method, but may not have success with the set stocking method are discussed.

6.5.1 Rotational grazing on cultivated areas

One type of hill and high country farm where rotational grazing is apparently successful can be described. Typically ryegrass, white clover pastures had been established by cultivation on medium to high fertility soils on the property, and it is this part of the property that is rotationally grazed. One farmer had managed his pasture so that even clovers had decreased, leaving almost a pure sward of ryegrass - the development of pastures mentioned earlier had progressed to the final stage where higher fertility levels, (especially nitrogen levels), had suppressed the clovers. Frequent application of fertilizers appeared to be an essential part of this management; one farmer found grassing down only lasted three years and reverted to browntop because of insufficient fertility to maintain the high producing pastures when fertility was not maintained. One farmer commented that browntop can be a problem but "if he kept on the stock and controlled it" he could keep a good ryegrass pasture, and also thought if he didn't create any stock camps he could keep on top of it. Avoidance of stock camps meant his level of subdivision, mob size, placement of fences, etc were adequate; this farmer had 47 smaller blocks and three larger ones.

Rotational grazing to the purists means shifting stock every 24 hours, but in practical situations even two weeks on at a time can be assumed to be rotational grazing. Of the farmers interviewed, 18 practised some form of rotational grazing, although some of these farmers used longer grazing intervals such as two weeks on at a time. Usually only part of the farms was rotationally grazed; this was usually the cultivated blocks (as explained later, of about 20 ha).

The previous comment on controlling browntop could be a key statement. Boswell and Crawford (1978) commented on the stage of development of pastures and the effect of grazing; in the initial stages of development cattle opened the pastures up better than sheep where there was browntop and this led to better clover development and then better ryegrass development. Harris (1974) on hill country continuously stocked at 10-15 sheep/ha, found a rapid reversion to browntop. He suggested "lax rotationally grazed" caused the more prostrate browntop to be shaded by ryegrass white clover pastures, and stressed the need for adequate subdivision and the need to be also out of the initial stage of development now involving control of secondary regrowth of browntop, with a good base of ryegrass in the sward and soil fertility not seriously limiting growth of white clover. He also suggested browntop is useful in low to medium fertility soils until conditions were ready to move into a ryegrass dominant pasture. Further evidence to suggest that a good ryegrass base is needed in the pasture before a response from change in grazing management is evident, comes from Radcliffe (1973), who suggested (in a comparison of mob stocking vs. set stocking), "the apparent failure of different grazing systems to markedly modify composition suggests the pasture composition in New Zealand hill country is unlikely to be markedly influenced solely by grazing management under the stocking rates considered, but where pastures have been improved and contain appreciable quantities of ryegrass, constant hard grazing (at least within the first few years) will improve the cover of this more productive grass and reduce the cover of the less productive flatweeds."

Boswell and Crawford (1978) found they could get the whole range of composition of pastures in a developing hill block and this was essentially a consequence of limited managerial control, with a wide range of herbage production, 400% from 3300 kg DM/ha to 13200 kg DM/ha between developed and undeveloped. They suggested "short periods of set stocking" can promote ryegrass growth at the expense of browntop, but that in more developed

pastures prolonged set stocking can be expected to favour the ingress of browntop. The apparent success of farmers using rotational grazing could be the predominant use of developed pastures that had got past the initial stage of development.

6.5.2 Rotational grazing in development phase

One of the main differences between the rotational and set stocking systems is the capacity in rotational grazing to force animals to eat the feed, and the ability to be able to control regrowth of undesirable species such as sweet brier, matagouri, etc. Some of the farms are using rotational grazing to develop their pasture to eat off the roughage in the first 2-3 years of developing and improving a pasture, as well as depending on cattle to clean up the accumulated feed from an unimproved state. Allan (1985) compared set stocking and rotational grazing at Tara Hills, and this work would appear to apply to the developmental phase, where higher grazing pressures were applied in the early stages of development to reduce the roughage.

It is apparent in this trial as well as in other comparisons that high stocking rates are needed in both types of grazing management to get good utilization. As suggested earlier, some of the more traditionally set stocked systems observed on farms probably use a reasonably high ratio of cattle to achieve higher utilization of rank feed to "take up the slack in the system". Cattle were not included in the Tara Hills study, and it would have been interesting to have seen a similar trial with cattle included, although as stated in the introduction on grazing management, it may be too much to expect any single trial to provide all the answers and usually could do this only for a specific situation.

Rotational grazing can be useful in applying more stock grazing pressure at critical times: a large number of stock can be used to clean up the feed. However, stock performance can suffer if animals are confined to low quality feed continuously. The experience of Armstrong (1980) from Limestone Glen, North Canterbury, with breeding cows used for pasture development, demonstrates the effect of poor quality feed on breeding stock. Smetham (1973) suggests it is best to clean up feed with a class of animal that does not require a high quality feed. The majority of farms, even those mostly set stocked, mob stock immediately after the ewes are weaned, to clean up some blocks. There is a great advantage in being able

to wean early and control the feed as early as possible. Several farmers use a Romney flock that usually grazes on irrigated land or wetter country to clean up some of the hill areas that are grazed by the Halfbred or Corriedale ewes the rest of the year. Romneys are thought to be more suitable for cleaning off roughage than the Merino-based breeds and are successfully used in North Island rotational grazing. One farmer on a semi-rotational grazing system puts on sheep after cattle for a few days, and then removes the sheep to let the block "sweeten up a bit" so that more pasture can grow while he feeds the sheep on a block with a higher quality feed for a short period. Then he returns the sheep to the 30 ha block to finally graze it down. He considers the sheep would be "knocked too hard" if they had to do it all in one grazing. The effect on stock performance of developing a block was evident in the grazing trials at Tara Hills in the first season, when performance of the hoggets had to be sacrificed the first year of the trial to prepare the blocks. Both on set stocked and rotationally grazed systems there are advantages in preparing pastures as shown by Norwester (1980) and discussed earlier.

6.6 Decisions on shifting stock and choice of grazing management system

One farmer who shifts his sheep on average every four days, suggested there should be no delay when sheep are due to be moved. A difference of even half a day can make quite a difference to available feed on a block when there is a large mob on a small block. The extent of utilisation can be readily seen and the "end point" for a decision on shifting stock is obvious in this type of rotational grazing. The desired level of feed to be left can be readily quantified, either by a visual estimation or by more sophisticated methods such as feed budgeting (estimation of kg DM/ha, discussed later). A person unskilled in stock management can be trained to assess the feed left and shift sheep accordingly. A manager can specify when stock need to be shifted and instruct an employee to do so, without the manager himself having to rely on his own skilled subjective assessments which are required in a set stocking system. However, this does not necessarily mean that the set stocking method is inferior to the rotational grazing system, in assessing correct stocking loads, pasture and animal condition, but it does suggest that considerable stockmanship and skill is required to make longer term decisions for the more traditional set stocking systems.

In a comparison of set stocking and rotational grazing systems, Ernst et al. (1980) suggested that "sufficient herbage supply, particularly during

mid season, was more difficult under continuous than rotational grazing. Decisions upon initial stocking density, the proportion of the total area to be conserved, and requisite stages at which to expand the grazing area are critical in this respect..." and they stress that "continuous grazing requires considerable management skill if the factors pasture and animal are to be maintained in equilibrium". It is apparent from the farm visits that a method can work well for one manager and appear to be a successful grazing management, but not appear suitable for another manager; this can often lead to highly polarised views on the advantage of each system, with sometimes efforts made to convert others to their own systems and meeting an understandable resistance. The manager feels (instinctively and correctly sometimes) that he would not get much benefit from a change in grazing management. Where a manager appears to have difficulty in the longer term decisions and is not achieving good pasture control and other objectives of good grazing management, then the extra expense required for more intensive rotational grazing and sometimes extra effort in shifting stock more frequently could be justified. The decision to undertake these management changes could well depend on the manager's assessment of the situation and his personal preference for rotational grazing or set stocking.

Milligan (1981) suggests rotational grazing should be used where the feed supply is short or when there is a need to accumulate a bank of feed, as well as when the stock are needing only a maintenance feed supply. Some form of rotational grazing is needed for systems such as "all grass wintering", and some rotational grazing may need to be integrated into the set stocking system for "all grass wintering" to be possible.

6.7 Objections to a rotational grazing system

Farmers gave several reasons why intensive rotational grazing would not work on their properties and why they preferred set stocking. One farmer suggested that rotational grazing would not be suitable on his farm as areas are best used at certain times of the year, and his impression of rotational grazing is that grazing starts in one corner and progresses around in a fixed cycle regardless of seasonal growth and characteristics of the property. However, apparently successful rotational grazing managers graze the property in different broad groups or areas, according to the special features of each area: wetter swamp areas are saved for the dry summer when N.W. winds can be a problem; cultivated flats; dry flat

run-off; low altitude improved hill of sunny aspect for early spring grazing; mid-altitude areas for summer and autumn grazing (not improved); and high altitude areas only for restricted periods in the summer. The farmer who thought rotational grazing would not work also found on his coastal Canterbury property that fencing off more intensively could cause trouble with stock survival: sheep huddled up against the fences instead of having access to natural shelter in gullies because of poorly sited fences. The seasonal pattern of pasture production on hill and high country can often be similar to that as described for Tara Hills research station (Anon., 1977) where "sunny and shady faces dictated the seasonal pattern of grazing. The sunny faces were the first to provide feed in spring so that the feed comes away early, but usually by January these faces dry up and provide little or no feed. The shady faces hold their moisture much longer".

Another reason why rotational grazing is not acceptable is that it is thought that there would be a considerable increase in labour requirements. However, one farmer on a semi-rotational system finds he can shift the sheep himself, as the sheep are used to being shifted around, whereas before he required two to three men to muster on a fully set stocked system. Milligan (1981) found on North Island farms that "sheep accustomed to frequent shifts move through gates with little hassle". The opinion was expressed by several farmers that the extra expense and time involved in going from grazing for two weeks on at a time down to four or five days would be unacceptable. Two farmers were concerned that more work during the weekend would be required and this was the main reason why they were not interested in intensive rotational grazing. Certainly from the discussion and review of the grazing systems they are probably quite justified in raising this objection: more frequent shifts than two week intervals may not give a great deal more production, and shifts of stock more frequently than three or four days is not acceptable to most tussock country farmers.

Another reason given why rotational grazing is not practised is that animals would eat out the tussocks. However stock can be removed before the tussocks are grazed down too hard. If the post-grazing herbage levels were maintained above 400-500 kg DM/ha as suggested by Milligan (1981) then there would be less chance of grazing out tussocks. The end point when stock are removed would depend on the degree of utilisation required. This is where the residual dry matter method of Milligan (1981) can be useful

(as discussed in feed allocation decisions). One farmer interviewed suggested that he tries to leave 30-40% of feed behind during flushing, and this can be eaten at a later period when greater utilisation is required. Another farmer on semi-rotational grazing thinks he "will not lose tussocks as he removes the stock before they are eaten down too hard." Some farmers observed tussocks were grazed in addition to a high clover diet on developed pastures and one runholder suggested tussocks would be grazed but not killed. This topic is discussed further in Chapter 10.

6.8 Stock handling with rotational grazing

Experiences of some farmers already using some rotational grazing could indicate how to handle large mobs of sheep. One farmer suggested moving sheep uphill through gateways can help stock movement, so that sheep do not get smothered. Two farmers open gateways with one day of grazing left to go, and let the sheep trickle through. After the one day, the rest of the sheep are shifted through. Farmers find that sheep become used to being shifted more frequently, and mobs of even 6000 can be moved quickly. Emmerson (1981) who rotationally grazes Merinos on a Central Otago high country run, described how the stock were moved: "stock were caught on the camp, and it usually took only half an hour to drive them to the next block. Stock were free-moving and educated to the procedure because of the regular shifting. At gateways it is simply a matter of opening it and allowing the lead to move through. It is important to stand there and regulate the flow. Quiet heading dogs work the back. About 6000 ewes normally move through a gate in 7-8 minutes."

Some advantages in running sheep in different mobs in a rotational grazing system were

- separate out light sheep so that they did not have to compete with the others
- old ewes (7-8 year olds) were run on their own before the main ewes grazed the blocks and were fed on longer grass
- old or thinner sheep were drafted off during the winter so they did not lose too much condition
- two tooth sheep if they had not done so well were kept in their own mob
- on two farms hoggets were either run on the "good" areas all the time, or were grazed ahead of the main mob of ewes.

Smith and Dawson (1979) have suggested for North Island hill country, a major grazing mob after ewe weaning could also include rising two tooth

ewes, rams and dry cows in addition to the ewes, while ewe hoggets and cows with calves may be run together and are treated as priority stock. Priority stock are not expected to eat a high proportion of the feed in any one grazing, and should be followed by the main mob to obtain better utilisation and pasture control.

There did not appear to be much attention being paid in tussock country to providing "safe" pastures of low levels of infective larvae of internal parasites for hoggets. A grazing method that allows provision of "safe" pastures immediately after weaning lambs and then again 12 weeks later would appear to be difficult to devise, especially on tussock country with the seasonal and climatic variations already present on the property. Thompson and Jagger (1977) suggest that high worm burdens will quickly develop on pastures that are unsafe, and despite regular drenching, lamb growth will be affected. Some suggestions made for provision of safe pastures have been included in section 5.2.7.

6.9 Subdivision requirements of rotational grazing

The level of subdivision required for rotational grazing will depend on the maximum size of mobs that are available and the duration of each grazing desired by management. The time chosen for the duration of a grazing will determine the ultimate level of subdivision desired on a property. Generally tussock country farmers considered that shifts more frequent than four to five days were too labour intensive and uneconomic in that more fencing was required; a more commonly acceptable interval was one to two weeks. One farmer with 100 blocks thought it would be better to shift every two days but decided it would be uneconomic even though he had enough blocks to do it.

The desirable length of rotation in the winter also determines the level of subdivision required. One North Canterbury farmer suggested a 40 day rotation was best, although longer rotations where it was colder would be needed. Another North Canterbury farmer was aiming for a 60 day rotation, between grazings while another farmer was able to achieve a 90 day rotation with 32 hill blocks. Milligan suggests the length of time between grazings depends on pasture growth rates after grazing; eg. for 1400-1500 kg DM/ha before grazing and 400 kg DM/ha after grazing, with pasture growth rates of 15 kg DM/ ha/day then days between grazings are $1400 \text{ minus } 400 \text{ divided by } 15 = 65 \text{ days approximately.}$

Some comments point to the suitable size of blocks. There appears to be a grouping of block sizes into either cultivated blocks or oversown and topdressed. The cultivated blocks range from eight hectares up to about 24 ha, with a median of about 20 ha. Reasons why there is such a narrow range of cultivated block sizes possibly stem from the practicalities of breaking in the new block; one farmer breaks in 18 ha of new grass each year and would thus need to fence it off from other blocks and treat it separately to protect the new grass and allow separate grazing.

The more intensive subdivision on cultivated areas is probably done more out of consideration for convenience of cultivating the 20 ha block than for more effective utilisation.

However, 50 or 500 ha can be oversown and topdressed at one time, with the only restriction being the cost to the farmer and with the greater convenience of aerial application, subdivision could tend to be neglected.

Twenty six farmers were included in the block size comparison; the other farmers did not use rotational grazing to any great extent. Some comments by these farmers indicate reasons why the oversown and topdressed blocks have been subdivided to their present level. Two farmers thought they needed 85-100 sheep/ha at each grazing to keep on top of young matagouri or sweet brier and one of these with a mob size of 3000 thought 40 ha blocks, (75 sheep per hectare) were the maximum size. Another farmer thought 20 ha blocks were needed to control gorse (90 sheep/ha). Another hill country farmer with 40 ha blocks was hoping to reduce them to 20 ha as sheep "eat out the good patches and are done too hard on the rest of the feed". Another hill farmer thought 80-120 ha blocks were suitable for oversown areas (but 20 ha for cultivated areas).

The size of the mobs of sheep farmers were prepared to stock appeared to be related to their maximum size of their oversown blocks. Generally, if a maximum size of 3,000 sheep in a mob was acceptable, then suitable size of blocks were about half those where 5-6,000 sheep in a mob were grazed - that is about 40 ha for the former and 80 ha for the latter. Only 26 farmers have subdivision similar to the levels above, while the majority have subdivided much less, (Appendix 1). Until more convincing evidence appears to show that more frequent shifts than 4-5 days are required, the above desired levels of subdivision as stated by the farmers are probably

ideals to aim for. A fence down the middle of each block could greatly increase the subdivision if future work suggested the expense was justified.

One farmer has defined the suitable sized blocks by "serviceable" units that could be grazed down in a reasonable time e.g. a few days, without affecting the sheep too much, while controlling some of the less palatable species such as young matagouri, etc. Cultivated blocks could also be regarded as "servicable" areas, and if they produce approximately twice that of oversown and topdressed areas as farmers suggest they do, then the level of subdivision corresponds to the expected level of feed produced.

6.10 Breed of sheep and mob sizes

Farmers' comments on mob sizes and effect of sheep breeds suggest there is a maximum size of mob that any farmer is prepared to graze. There appear to be some problems with the Halfbreds or Corriedales in large mobs. One farmer found that a mob of 1,500 Corriedales was the most he was prepared to graze and was not prepared to put e.g. 4,000 in a mob as there was "too much pressure". One farmer currently stocking with a maximum of 4,000 Corriedales in a mob thought they "could not stand the pace"; (both these farmers had some footrot problems). Another farmer was changing to Perendales as the Halfbreds had footrot problems with 1,100 mm rainfall and ryegrass - white clover pastures on the cultivated areas. Another farmer is also changing from Corriedales to Perendales as his farm is more intensively developed (also with footrot problems). Another farmer thought a maximum of 4,000 Corriedales in a mob was desirable - any larger was "too big to handle". Two farmers on similar types of soils had trouble with stock damaging pastures in the winter, the "soil packs down too much" and they thought they needed less than 2,000 sheep in a mob. One farmer was changing to Border Leicester x Romney on cultivated areas near the front of his property and confining Merinos to the less developed areas. Two farmers thought that Romneys were "useful foragers and cleaned up everything", and one farmer used 3,000-4,000 in a mob on the hill to clean up after the Corriedale ewes (the Romneys were usually grazed on the wetter cultivated flats or irrigated areas).

One farmer with stock shifts every few days and 32 hill blocks suggested he "could not hammer the country enough" with the Corriedales and would be able to put on twice as many stock if he had Perendales (to get higher

utilisation). The sheep on some of these rotationally-grazed farms are expected to do the work of cattle in cleaning up the blocks. Whatever the cause, the sheep appeared to have some stock health or behaviour problems. The farmers' experiences all suggest that more intensive management of Halfbred and Corriedale flocks above mob sizes of 3000 or so could present problems. It could be suggested that where stock health problems are apparent at mobs greater than 3,000 then the mob sizes should certainly be reduced. Clark (1980) found that when a mob of young sheep were stocked at 2,200/ha they moved and grazed, but when increased to 3,000/ha they stopped grazing in the midst of plenty and did not resume eating until the stocking rate was reduced to 1,700/ha. The grazing pressures normally seen on the 26 farms visited were much less than those reported by Clark, but even so suggested that breed and mob size need to be carefully watched for any problems.

7. Role of cattle in tussock country management

7.1 Advantages of cattle in tussock country management

Cattle fill an important role in tussock country management; use of cattle in grazing management could determine the success or otherwise of a grazing system.

Cattle are useful tools to "prepare" pastures for sheep, and are usually regarded as "roughage" eaters. One hill farmer regarded cattle as essential in spring to control roughage where the block was not subdivided or improved enough. In some apparently successful set stocked or semi-rotational systems cattle were used to clean up roughage. One North Canterbury hill farmer was stocked (semi-rotationally grazed) at 17 s.u./ha on his improved areas (mostly established by cultivation) with half the stock units cattle and the rest sheep. Cattle are useful to eat down roughage such as fern, and eat regrowth after burning. Suckling (1975) at Te Awa on North Island hill country found cattle were essential even at very high sheep stocking rates where most of the feed was utilised. Where there were no cattle, pastures deteriorated, and patches of rushes and weeds persisted.

Cattle are generally regarded as complementary feeders on tussock country; they can eat feed that sheep won't eat, especially in gullies. Cattle need a certain minimum height of pasture to be able to graze, and will be forced to eat patches of longer growth if sheep have kept the rest of the pasture short. In grazing trials at Te Awa, all weeds, even toe-toe were grazed by cattle when the grass was short. Studies at Grasslands Research Institute at Hurley (Ernst *et al.* 1980) have shown beef cows get maximum intake at a grazing height of 7 cm, but 80% of maximum intake at a grazing height of 5 cm; cattle require greater heights of pasture to maintain intake. Cattle are useful where there could be low feed utilisation with sheep only. A stud sheep farmer interviewed makes good use of cattle to keep pastures in reasonable condition as he did not want to restrict the nutrition of his stud sheep by making them eat the pasture down too low. One farmer uses dry cattle to run with hoggets which need to have a good selection of higher quality feed available. The cattle are useful for cleaning up rank growth that can develop at lower grazing pressures. Suckling (1975) at Te Awa found that at all stocking levels (except at the highest level of 17.3 s.u./ha) the ewe weights, daily gains and weaning weight of lambs, wool

yields per ewe and per ha were all higher with cattle than without them, and optimum stocking rate (with cattle) was 12.4 ewes/ha, with 2.4 ee. in cattle. At 16.4 ewes/ha there was practically no need for cattle, except for short periods in the wetter summers.

Cattle can be useful to eat accumulated roughage in the development stages of a farm. Some farmers interviewed suggested it takes two or three years before roughage is eaten off "to trim off the dead material" after the block has been improved. Cattle are essential to give more even utilisation where the stocking rate, subdivision, and grazing management with sheep are not achieving this. This is shown in the results of grazing trials at Tara Hills where stock performances of wether hoggets were low in the first two seasons. Once this initial stage of development is past, control of pastures is not as difficult. In some more developed situations, especially where some form of rotational grazing is practised, the need for cattle may not be so important.

Three farmers are dropping cattle from their properties as they consider their development has reached the stage where cattle are competing with sheep for the same feed, and with their close control of feed utilisation by their rotational grazing and high grazing pressures at each grazing they feel they can control the pastures with sheep alone. In some of these situations extra feed has to be provided for cattle in the winter; the standing roughage that used to allow cattle some feed in winter is not present, and with the high prices paid for calves (pre 1984) and lower returns on capital for cattle than sheep, cattle numbers are being decreased. One farmer suggested that with the capital cost of sheep at \$20/s.u. and cattle at \$50/s.u. cattle needed to be complementary in feeding habits or they would not be profitable. One farmer suggested that if extra hay had to be provided to feed cattle in the winter, cattle numbers were too high. One farmer with a well subdivided property and apparent good feed utilisation, had one third of his stock units in cattle and fed poorer quality meadow hay as a maintenance ration over the winter. Another farmer with cultivated areas surrounded by grass on steep faces that grew rank, made good use of cattle in cleaning up these areas and was able to use them for winter feed. A runholder suggested that following cattle grazing, clover is increased, even in unimproved prior to OSTD. Sheep select clover and overgraze it whereas cattle are not as selective.

7.2 Cattle effect on pastures: review of research work

Cattle can have an important effect on the botanical composition of pastures. At Te Awa (Suckling 1975) on sheep-alone paddocks, browntop content of pastures ranged from 21.6% at the lowest stocking rate down to 10.7% at the highest stocking rate. Where cattle were grazed with sheep there was no such inverse relationship of browntop content and stocking rates; the ryegrass and crested dogstail fraction of the sward showed a positive correlation with stocking rates in sheep alone paddocks, i.e. this fraction increased as stocking rate increased and was generally much higher where cattle were grazed with sheep (up to 44.3% for a four year average in one paddock heavily stocked with sheep and cattle). A similar but less pronounced situation existed for clovers. Cattle also had a significant effect on dead plant material present at Te Awa: at 7.4 ewes/ha, dead material averaged 54.1% of the sheep alone pasture and 23.2% of the pasture grazed by sheep and cattle; at 16.1 ewes/ha it was 32.3 for sheep alone and 22.9% for sheep and cattle. Boswell and Crawford (1978) found cattle caused a lower density of ryegrass tillers than with sheep alone on more developed pastures but the effect depended on the stage of development. Where there was a dense mat of browntop, cattle opened it up better than sheep and allowed better clover development and this led eventually to more ryegrass development in the pasture.

Overseas research work and farmers' experience show similar effects of cattle on pastures. Peart (1962) (referred to by Nolan and Connolly, 1977) had an 18-37% increase in output per unit area on hill grassland in Scotland when steers were introduced. Dudzinski and Arnold (1973) found steers ate more stem and there was usually more dead material in their diet when feed was in short supply, but the sheep diet had more dead material when feed was plentiful, and sheep had increased proportions of clover in the diet when amounts of available herbage were small. The cattle were able to remove dead herbage and improve the sheep diet.

Sheep can also have a complementary effect on steers, as van Keuren and Parker (1967) found on more developed areas that steers would eat short grass (with lowered intake and liveweight gain) in preference to eating herbage near dungpats, and an advantage could be expected by adding sheep to steers. Beattie (1980) in inquiries of graziers in southern states of Australia found one head of cattle to 20-30 sheep did not depress sheep carrying capacity (1 cow = 4 s.u. - see below) at 500-625 mm rainfall; or one head of cattle to 10-15 sheep at greater than 625 mm rainfall. Australian experience is very similar to that in New Zealand; cattle graze

swamps and eat rushes in wetter parts of the season while sheep eat the remaining herbage when the ground becomes dry and they have access; in good rainfall country, coarser grasses thrive, and high stocking rates of cattle (and sheep) are needed to control the grasses and provide larger areas that sheep can graze. Cattle in Wales make a vital contribution to the sward (Rees, 1976) even though one third of costs are for the sheep and two thirds for cattle while two thirds of returns are from sheep and one third of returns are from cattle; cattle are used to clear all the remaining roughage from the previous year. In the United Kingdom, Conway (1976) found after ten years on old permanent pasture, the percentage of lambs drafted fat were better for the mixed cattle and sheep and there was a similar advantage whether the sheep to cattle ratio was 3:1 or 4.5:1. In New Zealand, Frengley (1974) has suggested pasture control is difficult over the period of seed head emergence with ewes and lambs set stocked when digestibility is declining, especially on hill country, and in most instances cattle are used for this purpose.

Boswell and Cranshaw (1978) compared cattle and sheep grazed together or separately on ryegrass/white clover pastures under a rotational grazing system. Sheep grazed with cattle gained an average of 122 g/head day over nine months; sheep grazed as followers gained 60 g/head/day. Cattle liveweight tended to be greater from cattle leaders (.87 kg/head/day) than other treatments (.65 kg/head/day). Pasture production and utilisation were improved by simultaneous mixed grazing, and the benefits of increased liveweight gains of sheep in simultaneously grazed pastures more than compensated for the apparently poorer cattle growth in these treatments (compared with cattle as leaders). Most significantly pastures grazed only by sheep appeared to have a limited production owing to the poor persistence of white clover. The vigour of the clover was affected both by its failure to compete with ryegrass in the early life of the pasture and by the severe selective grazing the surviving plants are subjected to. The better utilisation of pasture by simultaneous mixed grazing led to a more even quality of pasture and a better balanced ryegrass/clover composition than other treatments. The ratio of cattle: sheep was less important than the type of management, with the greatest animal gain expected from the 33:66 ratio within simultaneously grazed treatments. Boswell and Cranshaw (1978) refer to Monteath et al. (1976) and Boswell (1977) who found pasture production declines under cattle grazing alone, and also Bennett et al. (1970) and Hamilton (1976) who found the benefits of mixed grazing are likely to be found in sheep liveweight performance rather than cattle.

7.3 Cattle grazing management and nutrition

Cattle nutrition like that of sheep needs to be carefully controlled to achieve sustained performance. One farmer maintains pregnant cows on standing roughage over winter while still having good stock performance (he regarded provision of mineral blocks essential in his management). Langlands and Donald (1978) found urea and molasses supplements to cattle increased weight gains on native pasture, but made no difference on improved pastures. Lortsche et al. (1975) found cattle can make compensatory growth in alpine regions in spring and can fully compensate (if well fed) for a period on poor native pasture, without any lasting effect. Hughes et al. (1971) concluded young cattle are less able to compensate for lower winter feed than adults, but significant economies can be made in the winter feeding of older stock as they make good growth later on spring-summer pasture.

Where cattle are used solely as roughage eaters and are not provided with some quality feed for periods when these are needed, their performance can suffer. The reports of poor stock performance at Limestone Glen, North Canterbury (Armstrong 1980) suggest the use of cattle for developing pastures needs to be monitored closely; in the situations where only low quality feed is available, dry stock may be required. A farmer near Limestone Glen in North Canterbury had a 30-40% calving drop when cattle were kept mostly on poor quality roughage. One farmer interviewed with good cattle performance feeds cows well before mating (and suggests he can get an increase of 20% calving by good feeding). He also has close control of calving dates so that feed is available when calving is due, and considers calving date had a big effect on the next year's cattle performance. Another farmer feeds cattle well in autumn and builds up their condition so they can "keep going better" through the winter when they are only being fed roughage. Another farmer on a well developed property had 120% calving even though the cows were used to clear up rough pastures over the winter, while another farmer on a semi-rotationally stocked farm suggested that if cattle were fat in the winter they were being fed too well.

At a grazing management seminar Talbot (1981a) gave relative stocking rates which supplied feed requirements of a beef breeding cow:

weaning early	2
winter	3
calving - weaning	6
average for year	4

the average for the year of 4 s.u. is different from the 6 s.u. normally used for a beef cow and this more recent estimate is based on information on feed requirements of cattle in Scott et al. (undated). The relative stocking rates above indicate feeding level calving-weaning should be three times that after weaning.

The relative stocking rate estimated for ewes was 0.7 all year except ewes and lambs until weaning at 1.6. Any further detail on relative stocking rate in practice would tend to be too complicated and possibly "no-one would use it" as Talbot (1981) suggested. The above approximations provide some guideline for cattle feeding levels. More sophisticated systems, such as estimation of kg DM/ha of available feed, are not often used in tussock grassland management (discussed in section on feed budgeting later).

Cattle management on hill and high country appears to follow the pattern suggested by Hight (1968); mature Aberdeen Angus cows in good condition in late autumn can lose 10% of their weight in winter until eight weeks before calving (or can be fed to maintain weight). Three weeks before calving is too late to start an increase of feeding. Cattle are then fed better to recover liveweight loss and are fed well to weaning. Hight suggested the cows that need better feeding during winter can be regularly drafted off (and this practice is sometimes observed on farms with sheep); this helps avoid losing too much condition in the tail-end of the mob. Young cows and older cows in light condition need to be looked after more than mature cows, which can be done hard most of the winter. Cows poorly fed before and after calving can cause an increase of dry cows the following season, but as stock are usually well fed in November and December when there is usually surplus feed available, this is not so much of a problem.

One farmer gives his cattle the "first pick" of grazing. Cattle are grazed ahead of the ewes, and with high liveweights he achieved 100% calving. Cattle need a minimum height for grazing, and for high intakes pasture needs to be above 7-9 cm (Jackson, 1976, Ernst et al. 1980). This farmer could also be preparing "safe" pastures by cleaning off parasitic larvae that can have marked effects on sheep performance. Even steers grazing

with sheep showed a 50% reduction in nematodirus larvae affecting the sheep the following year (Black, 1960). McNulty et al. (1982) obtained 6 kg more liveweight gain on "safe" pastures of low number of larvae than on contaminated pasture in their first season comparing growth rates of hoggets on "safe" and contaminated pasture. The safe pastures in the previous trial had not been grazed by young stock the previous year.

Cattle only are used on some properties with severe snow risk problems - having longer legs than sheep and good cold resistance they are able to survive deep snowfalls and live off roughage such as snow tussocks if necessary. There have even been reports from overseas that cattle can use snow for a water supply. Cattle are sometimes used on a cold, south-facing part of a property in winter and early spring. Research work also shows that cattle are able to withstand cold stress very well (Joyce, 1968): a full coat on a steer has the same insulation as that of a full fleece on a sheep.

Cattle can cause damage to wet soils. Hughes (1969) suggested cattle should not be used when soils were too wet. Suckling (1975) at Te Awa found treading damage serious in winter at the high stocking rates. Recent work by Hayward (1980) shows damage to stream beds has a very significant effect on soil erosion, and in the catchment studied, had more effect than any other factors. Where cattle graze mostly near the stream beds, care needs to be taken to see that there is not too much damage to the stream bed, thereby accelerating erosion.

Bedell (1984) discussed cattle grazing in riparian zones (areas near streams and rivers) and concluded that cattle grazing in these zones will need to be managed more carefully in the future (in USA). Factors that need to be considered include (1) how badly damaged is the riparian zone, (2) how rapidly is restoration required, (3) if grazing by livestock is to be excluded, at what point can it be used in habitat manipulation, (4) what are the critical values for recreation, fisheries, and other wildlife habitat uses.?

The range of management options suggested ranged from a do nothing option, to provision of access to water where needed while fencing off a streamside corridor for habitat preservation, or in some cases complete exclusion of stock.

Farmers commented that cattle can clean out the stream beds and make bare cattle tracks around the hills. Cattle are not grazed on steep icy slopes as they can slip, or when calving the calf can slip down the hill and

become separated from the cow. Some pastures are not suitable for cattle because of risk of bloat; e.g. some red clover swards or some recently OSTD pastures that are clover dominant need to be carefully grazed. Pasture species such as Naku Lotus with high tannin content are reported not to have the same tendency to cause bloat problems.

Most farmers like to breed their own calves, so that they don't have to depend on the current market prices for calves. Store cattle are useful sometimes in the more extensive situations as they can be bought and sold easily, whereas management of sheep is not so flexible because of buying in possible footrot problems, or animal behavioural problems (as discussed earlier). More cattle are sometimes bought to clean up excess feed in one season and perhaps sold the next season if conditions return to normal.

Hughes et al. (1971) deal with some of the details in cattle management. This discussion has stressed the continuing need for cattle on most tussock country grazing properties as a valuable aid in pasture management. The comments by some farmers that they eventually are dropping cattle because they are no longer complementary to sheep, could have far-reaching effects on the pastoral industry in the future.

8. Decisions on feed allocation in tussock country; set stocking and rotational grazing systems

The decision-making process on when to shift stock, the method and experience in assessing animal and pasture trends are some of the more important decisions faced by the farm manager (and experience can be more important than theory).

The herbage available in partly or fully rotational grazing systems can be assessed by the residual dry matter technique (Milligan, 1981) or by an assessment of pasture allowances. Feed budgeting, which involves estimations of pasture allowance in kg DM/ha, has not been adopted to much extent in the hill and high country. Of the 91 farmers interviewed, only one was using a system of assessment of pasture allowance. Reasons given for non-use were similar to those suggested by Milligan (1981) for the North Island as drawbacks to the pasture allowance technique: i.e. effective areas of blocks (even small ones) are not accurately known, as well as other reasons. Several farmers suggested only rough estimates can be made of grazeable areas as bare ground, rocks, scrub, tussock and large variations of growth within a block all make assessment of pasture availability very difficult. Only one farmer thought he was able to successfully estimate the available dry matter and he chose this method because he preferred to work with figures and preferred an objective method.

The use of sheep grazing days (or half grazing days) appears more acceptable to tussock country managers than attempting to measure pasture allowances. The method of feed budgeting and required pasture growth curves are described by Milligan (1981) who also describes the residual dry matter technique which involves shifting animals when they have grazed down to a particular level of pasture for the desired production. A similar method in principle to the last method is currently used by some of the farmers interviewed although none of them actually quantified their decisions in kg DM/ha. Several managers who appeared to maintain good quality pastures and have good stock performance made their decisions on when to shift the stock when a certain utilisation was achieved. One farmer demonstrated how he decided when he was to shift sheep by poking in amongst matagouri bushes and around tussocks. The stock have progressive difficulty in obtaining feed from amongst the matagouri and tussocks and

the feed left in these inaccessible places at the end of grazing period appears to give a reliable indication of how much utilisation there has been and when sheep need to be shifted.

Decisions on grazing management in the hill and high country are based on longer term trends in animal and pasture condition. Subjective assessments are made by the manager using his past experience and skills in stockmanship to make his decisions. Sometimes these properties have all the indications of a successful grazing management - maintenance of good pasture quality, without accumulation of dead material and good stock performance. The manager appears to have "got it together" in a system that suits him. It is apparent that these successful systems do not necessarily have to be along the lines of the more quantitative systems which have numerical values involved in decisions. It could almost be described as an "art" opposed to a "science". One system may not necessarily be superior to the other and if a grazing management method and means of making decisions is successful then there should be no reason for changing to another system.

However, there appear to be some advantages of the more quantitative methods for making grazing management decisions that are not present in the more subjective methods.

Feed budgeting or estimation of grazing days available can indicate how much feed will be available within the next period and sometimes an annual feed supply can be calculated. A feed budget (or any other budget for that matter) should be revised depending on how the season is progressing. Although this practice was not seen in hill or high country, one farmer on lowland maintains rainfall records and is able to predict in advance of other farmers what his feed situation will be. An advantage occurs when he needs to sell or buy stock in that he is able to "get in first" before the main rush. He can also conserve more pasture, hay, silage etc or increase/decrease stock feed intakes according to his predicted availability of feed. Having some estimate written down of feed availability disciplines the manager to take notice of necessary courses of action earlier than he would otherwise and hence make decisions earlier.

The manager using feed budgeting was able to work out pre- and post-grazing levels of feed, and arrive at an estimate of the profitability of his grassland improvement, similar to the comparisons made in other types of

business. Use of grazing charts for each block, with stock unit days, can give a good indication of pasture improvement, especially if the block is scored after each grazing, depending on whether sheep were there about right, too long, or if unutilised feed remained. Stock units multiplied by a stock unit allowance (eg. 0.7 for maintenance, 1.6 for lambs at foot), gives an idea of the herbage (DM) consumed. However, it should be pointed out that just because the profitability was being measured it would not automatically mean that business was more profitable than where the progress was not being monitored. Farming is still very much an art and will continue to rely on good managers' skills for success. Some of these more rigorously controlled systems of grazing management could also be more successful with those farmers who have difficulty in the more subjective skills needed for good stockmanship, whether their difficulty is caused by lack of experience or skill and who have not "got it altogether" as some seem to have done.

Another advantage of feed budgeting or any other objective method is that a relatively unskilled person can be instructed to put it in operation; this advantage also applies to the residual dry matter technique. It can be explained clearly to another person what level of feed is required before the stock are shifted and demonstrated what level of pasture corresponds to a figure e.g. 400 or 500 kg dm/ha residual dry matter. A similar trend of setting guidelines for employees can be seen in other types of business: guidelines are set out and an employee can be instructed to follow these, without reliance on the manager's presence or the employee's need for subjective skills.

As there is more "science" and less "art" in the more objective methods, some of the more relevant research work on pasture allowance effect on animal production can be related by the manager to his situation. Unfortunately only one hill and high country farmer out of 91 was using estimates of kg dm/ha and it is difficult for most farmers to relate to some of the research work done in the past few years based on pasture allowances. These often only have meaning to scientists and advisors and not to the farmers, who base their grazing management decisions on their own subjective assessments of when to shift stock.

Stock weighing is increasing as farmers realise the benefit in assisting grazing management decisions. However most farmers rely on their subjective assessment of how the animals are doing in their long term decisions. One

farmer who has recently started to weigh his sheep became quite surprised at the live weight. He found it was difficult to visually assess whether woolly sheep had gained or lost weight. He was now able to draft off lighter sheep and treat them differently from the main mob. However, the availability of data does not necessarily mean the more subjective method is inferior. Stock weighing however can add more feedback to the manager and increase his awareness of what is happening to his stock. Some managers may be able assess stock condition even at infrequent intervals, but there are probably a lot of farmers who would benefit from some additional measurement. Having a number available may bring instant recognition of a problem, and also allow comparisons with target weights at different times of the year.

Condition scoring of stock is another method of estimating stock condition and is widely used by United Kingdom advisors and farmers and also in Australia, but not in New Zealand, (except for research purposes and more recently in the dairy industry). The amount of fat, thickness of skin, protrusion of vertebrae (and lumbar processes) is felt by the thumb and fingers over the backbone of a sheep. A score of 1-5 (gradations of half units) is given, and a sample of the flock is scored. Condition scoring has an added advantage over weighing in that only stock condition and not body size is measured; it can be useful also in late pregnancy. Jeffries (1961) describes the successful use of condition scoring on strong wool Merinos and Corriedales in Australia. Russel et al. (1969) found a higher correlation between the condition score and fat content (of slaughtered ewes) than between liveweight and fat content. One great advantage of condition scoring is that there is no need for any equipment. The manager does not have to buy a set of scales, but only has to step into the yards and practice condition scoring.

Condition scoring was used by the author to measure sheep condition changes of a flock of sheep in the two month period before lambing. The average condition score of these sheep (which were fed well), was unchanged over this period while the ewes gained an average 11.8 ± 2.5kg. Weighing over this period was not able to indicate real changes in sheep condition.

A combination of condition scoring and weighing could give an indication of which sheep were bearing twins. In the above flock, 88% of ewes which had gained 13 kg or more in the two months before lambing had twins; if the ewes gained less than 10.5kg then 31% of these ewes had twins; between 11 and 13kg gain, 88% of ewes losing condition had twins and 25% of ewes gaining condition had twins.

There has been slow adoption of stock weighing in the hill and high country; condition scoring could at least provide an interim technique until sheep weighing becomes more widespread.

Grazing management decisions in the tussock country are still relatively unsophisticated and usually rely on the manager's good stockmanship and subjective skills. Dry matter assessments were made only by one manager of 91 farms visited, although stock grazing days were used more often. It appears that it will be some time yet before any more detailed systems of feed allocation will be adopted in tussock country; this also would infer that detailed research work which relies on the manager's feed budgeting estimates has little immediate application in tussock country. More broad recommendations such as those used in the United Kingdom where specific use is suggested for improved areas compared to unimproved, may be the closest control of feed allocation some farmers can achieve at present.

9. Wintering stock - options for tussock country

Feed needs to be transferred from the period when there is excess to the period when there is a deficiency, and provision needs to be made for these deficits, more particularly in the high country where the growing season is short.

Choice of a suitable system may depend on how much of the farm is unploughable stepland and how much of the farm has land suitable for purposes such as hay or silage conservation.

9.1 Winter feed crops and silage

Choice of winter feed crops grown could depend on the pasture renewal programme. Where an area of pasture is renewed each year then the chance is often taken to grow a winter feed crop at the same time. One farmer thought he grew his hoggets out well by supplying a winter feed of turnips, and attributed an increase in his lambing percentage from 90% to 110% to this. However, two farmers commented that pasture renewal was not needed if grazing management successfully maintained a vigorous pasture. Another farmer grew turnips for his stud Corriedale hoggets which were full-sized sheep and were very well grown. Hoggets in the high country need to be well grown, as there is often little opportunity for much further growth as adult sheep (Coop and Clark, 1966). The practice of growing winter feed crops, although expensive, may be justified if an increase in lifetime animal performance is achieved.

It was pointed out in the feed allocation discussion that most farmers do not assess dry matter availability in a formal feed budgeting system. Sometimes the only control is the quality of feed available and stock may not be fed well at the correct times of the year. If a reasonable quality winter feed crop is grown then priority stock such as hoggets can be well fed. Types of winter feed crops that can be grown have been summarised by Nicol and Barry (1980): brassica crops are a very high quality winter feed. Benefits were obtained from feeding hay (of any quality) with the crops.

Four hill country farmers (of the 91) successfully used silage for winter feed. Two of these farmers used wilted silage and were enthusiastic about its use; the appearance and smell was quite different from that usually associated with silage. Wilted silages from the two farms were tested by

the Animal Science dept., Lincoln College; the one with a sweet smell and friable non-sticky appearance had about 65% digestibility of dry matter, while the other sample which had been exposed to some rain, and had a less pleasant smell was less digestible (56%). The objections of smell, texture, commonly raised against higher moisture silage, do not apply to wilted silage, which has the added advantage of being more acceptable to stock than the higher moisture type. One farmer thought he could make silage in his environment where he could not normally make hay as mists often prevented successful drying of hay.

The type of conservation chosen can often depend on the capital commitments: if a farmer already has an expensive baler he may be reluctant to go into silage as well. However it may not be as expensive to acquire the equipment as it seems: one farmer thought he had enough equipment with a secondhand double chop harvester and a bin to go on the back, as well as his usual hay mower and windrower. Loading out wilted silage for feeding appeared to be a simple matter as it was done with a fork-lift on the tractor and was quite easy compared with the need to sometimes cut out high moisture silage from a stack.

Barry et al. (1980) suggested a dry matter content about 35% for wilted silage was suitable, as research work had shown there was little increase in animal intake beyond 35% DM content for grass silages offered to cattle; there is no need to dry it out any further before ensiling. A dry matter of 35% corresponds to a moisture content of 65%. If a farmer wanted a check he could dry out a 1 kg sample of wilted pasture overnight in a domestic oven at 100⁰C, and dry matter percentage would equal dry weight (g) divided by 10. The lower limit for successful silage fermentation would appear to be about 26% dry matter below which pasture was too wet; below this the fermentation quality declined, and additives did not improve the quality of the silage (Haig, 1980).

Some farms have limited access in the winter and it is not possible to feed out conserved supplementary feeds. They are then forced to rely on pasture transferred as a standing feed source from one period to another.

9.2 Wintering on saved pasture

Several farmers rely on saved pasture over the winter and this is commonly termed "all-grass wintering". Thompson (1971) in a comparison of hogget

rearing found sunny improved tussock blocks are the cheapest and easiest method of winter feeding, while a root crop is the cheapest form of supplementary feed and is the most likely to give liveweight gains. Before all-grass wintering can be considered, there have to be suitable areas on the property for this to be possible. Obviously where snow can lie for considerable periods on flat areas e.g. some of the Mackenzie plains, it is not possible to transfer feed in a standing form from the growing season to the long winter period. However, on sunny aspects on many properties there is a great potential for an all-grass wintering system.

One farmer using all-grass wintering suggested that he had a considerable saving in labour, and sheep needed to be shifted only every one or two weeks, where previously he was committed to feeding out hay every second day. He also had made a saving in capital by not requiring a tractor and baler with all the extra work of carting and stacking hay at the busiest period of the year. In an economic analysis of grass wintering at Forest Range Station (Lindis Pass), Talbot (1981b) suggested there would have to be a loss of over 50% of the DM saved since January, before a change from the present all-grass wintering system was considered, and stock would have to be increased 20% after the change. Trial work at Mesopotamia (Allan *et al.*, 1976) on semi-improved country showed that the total yield of live material in mid-August was less than 100 kg DM/ha, and long spelling from December resulted in a considerable wastage of herbage, particularly on the sunny aspect. The low survival of live plant material at Mesopotamia should be a cause for concern, particularly since all-grass wintering is practised on quite a few hill and high country farms.

Investigations by the author into pasture quality at Forest Range Station, Central Otago showed that in one block in mid-August 1981, there was 1600 kg of DM/ha which consisted of 62% grasses, 25% legumes and 13% other species (herbs weeds). The average digestibility of nine samples collected from the block was 56.2% - an average digestibility probably equal to or better than average quality hay. Measurements the following winter showed that almost half of the green herbage present in June was utilised during grazing in winter. Little if any dead herbage was eaten, even with large mobs of sheep (Abrahamson and Talbot, 1980). Higher altitude blocks and blocks with low levels of accumulated herbage should be grazed early in winter, as green herbage survives winter better in blocks where there is greater green herbage mass to protect the lower layers of herbage in a sward.

Forest Range has about 16 blocks shut up (usually from mid-January) for all-grass wintering, and these are fed for four months, with stock grazing each block for a week at a time. Mostly, the farms using all-grass wintering also practise some rotation, so that blocks can be shut up and a bank of feed saved. Sufficient blocks are needed for this. Typically stock are shifted on and left until the pasture is well eaten down. For the period between mating and until a few weeks before lambing, ewes need only maintenance levels of feeding, and lower quality feeds are adequate for this purpose (provided quality does not drop too low to restrict intake to below maintenance levels, as Macrae and O'Connor (1970) found with sheep pen-fed with tall tussocks).

One farmer in North Canterbury suggested that he did not get any winter growth above an altitude of 470 m. The trials at Mesopotamia were at about 500 m, so that at these altitudes the only feed available will be that saved before winter. Sunny aspects produce more than areas on the flat; farmers' comments suggest there is considerable winter growth on these areas even above 500 m altitude.

Vartha and Clifford (1971) concluded in a study of survival of improved species into winter that few of the species that are oversown in tussock grassland can be satisfactorily conserved as standing herbage for use in late winter. Clovers, particularly white clover, are "frosted off" early in winter. Their trials were run on terraces near Lake Pukaki (Mackenzie Country). It was suggested earlier that grass wintering is not always possible on some of these areas and large amounts of conserved feed may be the only option. That pasture survives and provides sufficient winter feed on some hill and high country properties is evident by the apparent success of these grass wintering systems. This suggests there is a need for further study into finding out what species persist, and quality of feed available on these farms. From the work of Abrahamson and Talbot (1986), it is apparent that clovers, grasses and other species show no difference in susceptibility to being frosted off - saving green palatable herbage of any species should be a primary objective. It is apparent grass-wintering is not suitable in some areas and attention should be focussed on the areas where it does work and find out why. Scott (1979) suggested there is the possibility of winter pasture growth and all-grass wintering in the lowlands, but this contrasts strongly with the period of 3-5 months of no growth in the high country, necessitating the use of conserved feed. Vartha and Clifford (1971) also suggested that saving unimproved tussock

grassland for winter feeding was not successful, both because of poor quality feed and an increased requirement for hay feeding.

Improved pasture needs to be saved from January on, depending on how much winter growth is expected. Those managers who are hesitant about moving completely into an all-grass wintering system could consider using only a small area each year: the sunniest block could be saved and only a part of winter feed requirements could be met by this block, with the rest met by the more traditional methods. If proved unsuccessful because of climate, the economic loss of feeding from only one block would not be too great. On the other hand if it is successful the area could be extended gradually to less favoured blocks. Consideration also needs to be given to choice of areas grazed while the wintering blocks are shut up; one manager thought he was better grazing his unimproved range country from mid-January or even February on - he had been grazing the unimproved lower altitude areas which were to provide his winter feed before this. Although there was a lot of feed quality lost on the summer range because of the late grazing, his prime consideration was to graze the improved areas properly with correct grazing pressure in the spring and early summer, and use these areas for grass wintering by spelling from mid-January or February onwards. As the feed shortage period in hill and high country is generally in the winter, considerable dry matter and quality loss in summer is acceptable over summer on unimproved country provided all-grass wintering is successfully done on some of the improved areas.

It is important to select an area where there can be an assured growth in the period before winter, especially if growth over winter is limited. It is common to have drier country on the front of the property at lower altitudes e.g. in Marlborough, where there are sometimes droughts, but assured growth needs choice of a suitable area with a consistent rainfall, even if at a higher altitude. If not already improved then some of the mid-altitude blocks with adequate rainfall and sunny aspects can be oversown and topdressed and saved for grass wintering, while high altitude areas can be grazed while the feed-bank is accumulating on the grass-wintering areas and the lower blocks are spelled during the dry periods in late summer. If there are some autumn rains then the dry lower altitude blocks can be used in winter as well as the grass-wintering blocks, and may even provide some growth of good quality feed during winter in the first few weeks before lambing, or provide valuable flushing feed in autumn.

Grass wintering may be possible on some better drained soils on some properties. Three farmers experienced problems with some soils: these were mostly a clay-type soil that pugged badly during winter. Stock have to be removed after a day on these soils or else serious pugging occurs. More subdivision may be required if stock grazed these pastures for only short periods. Ernst et al. (1980) cite Wade (1979) who showed how high grazing severity and wet conditions reduced ryegrass tiller densities in the U.K. One farmer suggested that in wet conditions sheep could only graze for a short period as pasture became soiled and he relied on the rain to wash off soil between grazings. Grazing for the duration of one day should do little damage to grass tillers.

The level of subdivision discussed previously in Section 3.7 will partly depend on whether some growth during winter can be expected. If no growth is expected then sufficient blocks are needed for only one grazing over the winter on each block. Some lower altitude areas e.g. in North Canterbury can usually be expected to provide two grazings with a 30-40 day interval between grazings. As feed needs to be rationed over this period (no farmers have the resources to feed ad libitum over the winter) rotational grazing (when only one block is grazed at any one time) is preferable to set stocking.

Several managers with all-grass wintering systems also keep some reserve feed amounting to two season's hay supply. Some backstop to meet pasture growth deficits appears essential. Hay (and grain) keep for several years provided they go into storage at low percentage moistures and care is taken in storage to keep the hay or grain dry.

9.3 Nitrogen fertiliser on pastures to increase early spring feed

Another winter feed option used by two North Canterbury farmers was to apply nitrogen fertiliser to the best pastures to obtain extra growth in late autumn and early spring. Hoggets are break-fed by one farmer for two hours a day in the winter at a total cost (in 1980) of \$300 for 1300 hoggets. Another farmer assessed the feed supply for the period before and during lambing well in advance and applied nitrogen fertiliser to boost pasture growth if he thought there was going to be a shortage. G.C. Cossens (pers. comm.) supplied information on the effect of nitrogen on clover pasture where rainfall was over 600 mm and altitude below 300 m. The

responses to N were very similar no matter where the work was done (in Otago). His results are presented in the following table. Pasture production increases are shown for an application of 25 kg N/ha on pastures with clover present.

Pasture production increases (kg DM herbage/kg N) for application of N fertiliser

Application time

<u>(a)in Spring</u>	The Extra Growth (kg DM/kgN) for						(May 1989)	
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	net gain	kg DM
in early August	3	7	11	0	-9	-	12	13.2
September	-	11	11	-1	-8	-	13	12.2
October	-	-	15	4	-	-	19	8.3

<u>(b)in Autumn</u>							cents per	
	Feb.	Mar.	Apr.	May	June	July	net gain	kg DM
in early February	11	3	0	-	-	-	14	11.3
March	-	6	4	2	-1	-	11	14.4
April	-	-	4	4	1	0	9	17.6

Note that a 25 kg bale of lucerne could cost \$10 (40c per kg DM) in May 1989, and green grass is preferable to hay.

Response to N fertiliser was linear up to 75 kg N, that is, there would be decreasing yields of DM/kg N compared to the above, when more than 75 kg N/ha was applied.

Cossens noted that the seasonal yields per month are cumulative: in spring, if August growth is not used the total extra growth by the end of September is (3 + 7) = 10 kg DM/kg N. The current price of bagged ammonium sulphate (May, 1988) was \$333/tonne, and at 21% nitrogen in ammonium sulphate, nitrogen costs about \$1.58/kg of N. The responses of pasture growth to 1 kg N given by Cossens can be used in assessment of this winter feeding

option. With the present costs of baling hay the use of N fertiliser is a useful alternative to boost winter feed production. There is also much less labour required in feeding nitrogen boosted pastures than feeding out hay. The addition of sulphate with the ammonium sulphate is an added advantage. Recent research work (Syers, 1982) suggests that developed grass-clover pastures may be in a nitrogen deficiency because of uneven distribution and high concentration of urine patches and consequent losses from the system and also the inability of the soil to hold the urine nitrogen.

9.4 Wintering on hay, grain, and effect of lambing dates

Some managers have no option but to conserve hay, silage, etc. as the option of all-grass wintering is not available for reasons outlined earlier. The period when hay is fed out is important: meadow hay is not good enough for lambing ewes, as voluntary intake is reduced with the smaller rumen size of the pregnant ewe and constriction caused by the foetus. Poorer quality hay is best fed over the non-critical period of the year when maintenance only is needed as there is no advantage in using the high quality hay (e.g. good lucerne) when only maintenance levels are required. One farmer used barley straw successfully for maintenance of cattle over winter. As wethers produce good wool on maintenance levels they usually come at the end of the line in feed quality requirements.

Some of the labour requirements for feeding out hay can be reduced by using the new systems available e.g. big round bales, and automatic systems of feeding out. A wide range of types are available and choice of a system appears to be based on personal preferences.

Conservation of hay and silage also assists in the control of pasture quality. Seed head control on a farm can be partly achieved by grazing, partly by silage (or hay) conservation and if seed heads are dense on the remainder it should be topped (McDonald 1984).

Grain feeding was regarded by one high country farmer as his best alternative. Buying in enough barley for his winter feed allowed him to save on capital costs of a tractor and hay-making equipment, and labour costs. Feeding out barley on standing browntop "cleaned up" blocks of roughage over the winter, especially if slices of hay were placed on the roughage. Hay was fed out the first day when sheep packed down the snow

and then grain was fed out on the packed snow the following day. Only a small amount was fed for the first two weeks and after that the full amount of 225 g of barley/day/ewe. Another Central Otago farmer uses 110-220 g/ewe/day and one bale of hay/100 sheep. The sheep need gradual introduction to the grain; grain feeding needs to be planned well in advance of the snow. Feeding of oats at Hakataramea has been described in (Anon, 1963): the manager described oat feeding as the greatest break-through in closing the gap between summer and winter carrying capacity on the property.

Finally, important considerations in provision of winter feed are the lambing (and calving) dates. Frengley (1974) found that delay of the lambing date by one day reduced winter feed requirements by 1%; (lambing 10 days later meant 10% less winter feed was required). One Central Otago high country manager was shifting the lambing date back one week each year to help the winter feed situation. Another high country farmer lambs in mid to late October, about three weeks later than others in his district. Rattray (1978) suggested there were three main considerations when setting a lambing date: the onset of spring growth; timing and duration of a summer drought; occurrence of the autumn flush of feed.

10. Value of tussocks; research work and survey opinions

10.1 Retention or elimination of short tussocks: factors influencing decisions

There are commonly three main types of short tussocks in the S.I. high country - fescue tussock or hard tussock (Festuca novae-zelandiae), silver tussock (Poa laevis) and blue tussock (Poa Colensoi). Usually fescue tussock is on lighter, drier soils and at higher altitudes, and silver tussock on wetter, heavier soils at lower altitudes. However areas can be mixed, and some areas where one species would be expected have only the other species present. Blue tussocks are generally found at the higher altitudes although they can be widespread on high country runs.

All farmers suggested tussocks should be retained on "dry light soils and it is a waste of time to develop them" on these soils. Where it is too dry for much plant production, e.g. Acheron soils in the Mackenzie basin, the best that can be done is to try to retain the tussocks. The short tussocks such as fescue tussocks are physiologically adapted to survive in some of the dry situations. Research workers have come to the same conclusions. Saxby (1961) suggested much of the conversion of tussock grassland to unimproved pastures has been successful, but in some cases, especially where there has been no build up in soil fertility it may not be advantageous (to develop); Hercus (1954) found good establishment of oversown species on shady slopes and in good cover, but on some bare exposed slopes there were no exotic species that could establish and survive after oversowing and topdressing; Dunbar (1974) found all tussock species were adapted to acid soils, and also in the absence of nitrogen and phosphorus, native species (three short tussocks and Notodanthonia species) were able to grow better than Yorkshire fog.

Some of the more fertile soils (e.g. brown grey earths) in the high country are cultivated (and tussocks removed) to establish high producing species, such as lucerne or ryegrass/white clover, especially where there is a possibility of irrigation. Under these conditions farmers consider that a good vegetative cover can be established with a low risk of soil wind-blow. There are advantages in the introduction of new species on these soils. O'Connor (1960) compared the relative growth of native grasses with that of some higher-producing introduced species. The relative growth of fescue tussock at Castle Hill was 4.0 and cocksfoot (Dactylis glomerata) 7.8

tussock at Castle Hill was 4.0 and cocksfoot (Dactylis glomerata) 7.8 (under reasonable fertility conditions). The leaf length growth of Festuca n.z. was 2.8 while cocksfoot was 3.3. Poa colensoi was significantly better than Festuca n.z. for tiller rating only. Healy (1969) suggests that with their low inherent level of production the native grasses place a low ceiling on carrying capacity.

Where lucerne has been established successfully it can make a major contribution to the feed supply on the run, as shown by some of the hay tonnages cut on high country lucerne stands. Lucerne is able to tap extra sources of ground water not available to more shallow rooted plants. Removal of tussocks is required for this establishment.

O'Connor (1960) did not recommend cultivation of flats (in the high country) which were of low fertility and could blow away (e.g. Castle Hill basin, North Canterbury). Where a good permanent vegetative cover can be established then there are not so many objections to removing tussocks. Some of the high country yellow-brown earths are risky to cultivate because of the possibility of wind erosion, and are best left in tussocks. These soils provide a difficult environment for plant growth and the plants present can be in a delicate balance: any major disturbance to this balance where plant cover may be difficult to re-establish could have permanent effects on the environment. Cockayne (1916) has suggested that the tussock growth form is the only one that is capable of remaining dominant over montane tussock grasslands. These comments were made before the advent of aerial oversowing and topdressing.

One farmer with some more fertile volcanic soils (as well as lower fertility areas) suggested there is a natural progression to better types of grasses, and tussocks do not compete in a higher fertility situation. This opinion is similar to that of Daly (1973) who suggested the problem (of whether to keep tussocks or not) may solve itself as tussocks will fade out as stock grazing pressure and grass competition increases.

One farmer in reasonable rainfall hill country suggested that as long as fertilisers are available for hill country he would not need tussocks, but if there was a possibility of future shortages, then he would have to reconsider the value of tussocks. At present he can maintain the higher producing cultivated pastures, but thinks he would have to change his methods (to less cultivation) if fertilisers became unavailable in the

future. Tussocks may be one of the species to be retained for the future if New Zealand agriculture had to change to a low input system, because of limited supplies of phosphorus and economic considerations, as suggested by Abrahamson and Darkey,(1988).

The grain growing belt in N.Z. was dominated in its natural state by tussock grassland (Levy, 1951) and there are still similar tussock covered soils in the South Island. It could be argued that if removal of tussocks on these areas was originally considered suitable, what objection would there be to removal of these tussocks on the hills? The risk of soil erosion and other factors are the major differences between tussock covered plains and hills and these will be discussed later.

Where rainfall and fertility (from topdressing) are higher tussocks can grow too luxuriantly. One property in Canterbury has dense silver tussocks which prevent other more palatable feed growing in the moderate rainfall (1000-1500 mm) soils; the farmer finds it difficult to control the growth of these tussocks after his applications of fertiliser (with set stocking at only 3 s.u./ha). He regards the silver tussock as a weed, and would much prefer a more palatable type of feed.

Several farmers only cultivate where there is a scrub problem and will leave tussocks on "good clean areas". Scrub covered areas are cultivated in preference to the tussock areas which are already providing some feed. One farmer in Marlborough cultivates all the areas he can because of past experiences with the spread of matagouri. Areas had been oversown in the past and matagouri had been allowed to increase (probably because of inadequate grazing control) and to avoid a recurrence he preferred to cultivate areas with any matagouri present. However, he would not cultivate clean tussock areas.

Some farmers prefer to cultivate tussocks because of the expected quicker establishment of a pasture (see section 4.1.1). They consider it takes 10 years by aerial oversowing and topdressing to achieve what establishment through cultivation does in one or two years. High stocking rates are often maintained on pastures established by cultivation (up to 9 s.u./ha on oversown areas on fertile soils and about twice that on cultivated areas). One farmer in a 1500-1750 mm rainfall considered that if he wanted to achieve the higher stock carrying capacity he was aiming for, he would not be able to keep tussocks; he currently had about 18 s.u./ha on his

cultivated areas. A farmer in the same area thought that where there were tussocks and matagouri, too much ground area was taken up by them to compensate for any benefits of tussock, and he cultivates all areas where slope permits. Generally only soils of reasonable fertility such as Haldon Hill soils (Y.G. earths or better) are cultivated, probably because only these show a reasonable return.

On two farms Nassella tussocks were difficult to identify from other short tussocks and the initial cultivation provided a rigorous control of seedlings. On a pasture bare of tussocks, any seedlings could be noticed easily, reducing the time involved in seedling eradication. It usually takes two to three years for Nassella to grow again on the cultivated area. Cultivation is very expensive, and two farmers who have cultivated reasonably large areas of tussock and scrub suggest that at current prices they would develop by aerial oversowing and topdressing. One of these suggested it would be better to develop by intensive subdivision; his farm was one of the most intensively subdivided with an average hill paddock size of 14-16 ha.

A tall tussock, the red tussock (Festuca rubra) is often cultivated as it appears difficult to control by other means such as grazing or fire. It is usually found on heavier, wetter soils that can support permanent pastures or grow a good crop of winter feed. Cultivation can improve aeration of these soils and also help to drain and discourage rushes and plants adapted to wet-soil conditions. However some areas of red tussock are retained as they have conservation values, which may outweigh the benefits thought to be gained from cultivation.

The conclusions from these opinions and research work suggest that:

1. There appears to be unanimous support for keeping short tussocks on poor, light soils where wind-blow is possible. Establishment of plant cover may be difficult, with the tussock ideally suited to this environment.
2. Plant production on good soils that have been cultivated appears to be about twice that on oversown soils. Time for a similar establishment appears to be 2-3 years for cultivation and about 10 years for oversowing and topdressing.

3. Cultivation (i.e. loss of tussocks, as seed source is lost) is sometimes preferred for red tussocks on wetter soils, and also used for control of Nassella tussock.
4. Where there is a reasonable rainfall (1000 mm or more) there are divided opinions on the value of tussocks (see later chapters on reasons for keeping tussocks).
5. Scrub areas are cultivated before tussock areas where there are both on a property, as tussock areas may be the only clear areas providing immediate feed.

10.2 Value of short tussocks for plant shelter, both for microclimate and conserving herbage

Nineteen runholders in the survey thought tussocks were valuable for sheltering feed in a dry summer and in providing a suitable microclimate for growth. (Only runholders interested in the value of tussocks were interviewed). Eight of these farmers mentioned shelter from dry N.W. winds as being important. A high country farmer in Canterbury had trouble with clovers not persisting on sunny faces, and found tussocks provided shelter for them. Two farmers suggested tussocks were useful for sheltering seed, or were useful in regeneration by supplying soil humus (on higher land). Six farmers thought tussocks stopped loss of moisture around the tussock base. One farmer thought he would not cultivate next time as cultivated areas had all dried off in summer, while there was still some green growth in adjacent areas which still had short tussocks. A North Canterbury farmer however, doesn't think the extra feed amongst tussocks compensates for the area taken by the tussock base (but favours retention of tussocks for other reasons such as prevention of erosion).

A study on the effect of silver tussocks on pasture growth between the tussocks was completed in 1984 by N.Covacevich (unpublished) as part of a Ph. D. thesis. Silver tussocks were transplanted near Lincoln College on 0.1 ha at three different densities: dense tussocks at 78000 per hectare, medium density at 22000 per hectare, sparse tussocks at 500 per hectare and a control with pasture only. The relative growth rates of inter-tussock ryegrass-white clover herbage were monitored for a spring, summer and an autumn from February 1984. The relative growth rates in mid-points in the dense tussocks were 1.4% higher than the controls (not significant). The average relative growth rate (RGR) in the medium density tussocks was 6.3% greater than the control, (with one position out of three significantly greater than the control). In the sparse tussocks average RGR was 15% higher than on the control, (significant in three out of five positions). In all the measurements the positions near the tussocks were not different from the controls.

With a loss of only about 0.15% of ground covered by the tussock bases in the sparse density, and a gain of 15% pasture production, there could be quite an advantage in maintaining sparse tussocks. Relative growth rates (percentage per day) at the mid position among the medium and sparse tussocks were 23.5 to 25 compared with 19%/day - a 28% increase at these

mid points greater than the controls. The area of tussock bases measured in North Canterbury hill country was approx. 0.03 m^2 ; these base areas were obtained from the tussock density measurements referred to later in this chapter. The gain in pasture in medium tussocks (6.3%) appeared to be about the same as that lost by the tussock area base (6.6%). There is clearly a loss in production where tussocks are dense, with 25% of the ground covered by the tussock bases.

Runholders interviewed did not differentiate between the effect of tussocks on intertussock plant growth and the effect of tussocks restricting access by stock to green herbage within the tussock, allowing clovers and grasses to reseed themselves and providing a store of feed "in situ", amongst the tussocks.

The amount of feed stored within the base of the tussocks can be quite considerable. In a high country grazing behaviour study (Abrahamson et al. 1982, 1989), low rainfall in December and January 1981 caused a scarcity of feed between tussocks. The author measured intertussock herbage of 180 kg of green DM/ha, which was very short. From six sites on the oversown area there was a mean of 4.2 g of green D.M. in the base of each tussock. Using typical fescue tussock densities measured on blocks of two runs, with 3.4% of the area taken up by 22000 tussocks/ha, and 11.8% of the area with 105000 tussocks/ha, there could be 92 kg DM/ha and 440 kg DM/ha respectively of extra green DM available not grazed by sheep in the base of the tussocks. It is assumed that only grasses and herbs and not the tussock itself would be eaten. In the above grazing study the 180 kg of green herbage in between the tussocks was probably too short to be accessible to the sheep, while the grasses and herbs in the base of the tussocks were quite long. A considerable amount of dead material would have had to be eaten along with the green: the material containing the green herbage plucked by hand from the base of tussocks was 60% dead, with the dead being mostly dead tussock tillers. The high proportion of dead material collected with green could explain why sheep are reluctant to eat the remaining green herbage at the base of the tussock, as selection of only green herbage would have been impossible.

The possible effect of tussocks on the microclimate at or in the base could also explain why there was still some green DM left there, in addition to the difficulty of grazing.

Scott (1961) found (with sheep grazing) that tussocks had a highly significant effect on number of plants in or very near the tussock, but generally there was a lower number of plants at 5 to 15 cm away from the base than would be expected. He suggested that plants were not grazed in the centre of the tussock, and/or root competition between various species was less within the tussock. Zotov (1938) suggested tussocks raise the relative humidity around them, provide shelter in summer, fresh humus to soil and refuge among tussocks for more palatable species. Scott and Wallace (1978) found that only at the most arid sites on Acheron soils were shoot weights (of establishing clover) greatest closest to the tussocks. In more humid regions at 1750mm rainfall e.g. on Cass and Craigieburn soils, there was a trend for increased shoot weights even up to 30cm away from the tussocks. The need to retain plant cover of some form for successful establishment is shown by the very low establishment and growth in bare soil on most sites (Scott and Wallace, 1978).

Tussocks would appear essential in re-establishment of pasture if there was a severe drought, and would also provide a seed source of clovers and grasses within the base of the tussocks should the inter-tussock vegetation completely die out.

Radcliffe (1974) found cocksfoot plant growth in inter-tussock spaces amongst dense tussocks greater than in sparse tussocks in the first spring harvest. Radcliffe (1974) also measured air temperatures amongst the tussocks, with maximum temperatures lower and minimum temperatures higher, in dense than in sparse tussocks, with effects more marked in winter than summer.

Fourteen other farmers, and three of the first nineteen thought tussocks were of value for the winter and early spring period. Three farmers stressed the importance of tussocks in providing a good microclimate for plant growth in early spring. Radcliffe (1974) found that soil temperatures in the top 25 mm of soil were $1^{\circ} - 2^{\circ}$ C colder in sparse tussocks than in dense tussocks over winter. A difference of only $1^{\circ} - 2^{\circ}$ C may not seem great, but could have quite a significant effect on pasture growth in early spring (or late autumn). Alcock and Lovett (1968) found that soil temperatures at 10 cm were the main factors influencing growth of ryegrass on hill soils in Wales over this period, and Anon. (1979) showed the effect of altitude (and decrease of temperature) caused a five percent decrease in yield for each 30 m rise in altitude in spring. Marshall (1967) found

shelter belts caused a maximum difference of 2⁰ C (and tussocks could show a similar reduction in wind speed to shelter belts, as discussed in shelter effects on animals) and he suggested the greatest effect on perennial crops would be at the beginning and end of the growing season when temperatures in unsheltered areas approach the threshold for growth.

In addition to the effect on microclimate near tussocks, seven farmers thought tussocks had other advantages in winter. Tussocks were thought to prevent sheep from eating all the feed; one farmer described how sheep eat the grass and clover close to the tussock in autumn, and in desperation later on eat the grass and clover and even the tussock itself. One farmer thought the grasses left after snow melted provided useful grazing. Seven other farmers described how tussocks are able to "break" the snow; provide a break in the carpet of snow, and this allows the wind to get in to melt the snow earlier than if it were all flat ground. Snow can melt two to six weeks earlier around tussocks than where there are no tussocks. One farmer suggested stock were able to get a pick of feed before the snow melted by nuzzling around the base of the tussock where there were gaps in the snow. One farmer who uses all-grass wintering relies on tussocks to help break the snow and provide access to feed for the sheep.

One farmer suggested that if tussocks were lost, matagouri bushes (Discaria toumatou) would be useful in providing a similar microclimate to that of tussocks and have the same effect on restricting accessibility of feed. Other farmers have also said that matagouri can restrict animals' access to feed and effectively transfer standing feed from one period to another; feed amongst the matagouri bushes will only be eaten when a high utilisation is desired. Two farmers use the remaining feed amongst tussocks and matagouri bushes as an index of utilisation: they get down on their hands and knees and poke around the bushes to see how much is left and how difficult it would be to eat, and shift the stock according to the desired level of utilisation.

Tussocks are thought to provide shelter for the establishment of clovers (three farmers) and dry summers were suggested to be critical periods. Zotov (1938) suggested tussocks may even be needed before other species can be sown. Clifford (1975) and Hercus (1954) obtained good establishment of clover under vegetative cover, and Ludecke and Molloy (1966) found that results were very poor after burning or hard grazing (Cardrona Valley, Central Otago). It seems important to retain tussocks especially if there

is any possibility that the oversowing and topdressing needs to be repeated. Lowther (1976) found many plants were uprooted by frost heave and the few left were unthrifty and low-producing when tussocks were removed by cultivation. As discussed later, in chapter 10.7, fescue tussock markedly reduced the diurnal range of soil temperatures at 2.5 cm, insulated the soil, and counteracted needle ice formation. In the high country environment frost heave in winter can usually cause high mortality of plants by breaking off the roots, resulting in dessication of the oversown species. Primault (1979) describes the general effect of a straw mulch in protection of live plant tissue underneath. Peripheral ice crystals form on the top layer of straw causing the air inside the litter cover to become much drier. The live plant tissue loses water and lower temperatures are required for the plant tissue to freeze. The threshold of the entire plant is proportionately lower and the plant is less likely to freeze. The protection of tussock (or tussock litter) may reduce the frosting-off of susceptible plants, such as clovers by the above mechanism.

To summarise, farmers opinions and research work suggest that:

1. Short tussocks provide a better microclimate for clovers and grasses in the summer and store feed "in-situ" for later grazing in the summer.
2. Tussocks improve the microclimate near the tussock base in winter, help to "break" the snow and store inaccessible feed for emergency winter use.
3. Tussocks (or some permanent plant cover) is needed for successful establishment of oversown species in more difficult environments.
4. Pasture growth rates in between short tussocks can be considerably higher, depending on the density of the tussocks.

10.3 Value of tussocks as shelter for animals

Thirteen farmers thought tussocks provided useful shelter for sheep, mostly during lambing (nine hill country farmers and four high country farmers). One hill country farmer who had cultivated all the ploughable areas and had lost most of his tussocks and scrub suggested his lambing percentage was 95% without shelter and 125% with shelter. After other problems of management had been taken care of, such as nutrition, footrot control, and animal health, he had now reached the stage where lack of shelter was limiting production. He had planted rushes in groups to provide lambing shelter from the cold S.W. winds.

Recent evidence suggests that only shorn ewes actively seek shelter and that shelter has a significant effect on lamb mortalities.

Munro (1962) found that sheltering behaviour by adult sheep in grassy hollows was largely dependent on wind speed exceeding 10.7 metres/second. Lynch and Alexander (1977) showed that recently shorn ewes actively seek shelter in tall phalaris grass. The same authors (1980) found that sheep, shorn up to four weeks before lambing, used shelter consistently at night; sheep shorn eight weeks before lambing made little use of shelter before lambing. They also found that ewes that had access to shelter after shearing became trained to use shelter as a night resting area well beyond the period when they were expected to need shelter. Done-Currie (1980) found partially shorn sheep used shelter more - if ewes were not required to be fully shorn then shearing only some of the wool off could be an alternative. It appears from the literature that adult sheep seek shelter only when newly shorn, or under extreme conditions of wind and cold; (a 10.7 metres/sec wind is quite a strong wind).

Shelter (in general) has significant effects on lamb mortality. Lynch and Alexander (1977) had a higher mortality of Merino twin lambs without shelter (68%) and still quite a high mortality with shelter (31% with phalaris grass shelter and 41% with an artificial shelter of salon). Rennie (1978) found 43% of single and 45% of multiple deaths occurred between birth and three days of age, and of these, most singles (23%) died of dystokia (difficult births usually caused by large lambs) and most of the lamb deaths in the multiples (30%) died of starvation exposure. Dalton (1976) found that below 3.2 kg birth weight the survival rate fell off

rapidly. McCutcheon et al. (1981) suggested the efficient use of shelter and selection for specific birth coat types may have an important role in the future, and even at optimum birth weights mortality may still exceed 10%. It appears that provision of some form of shelter reduces lamb mortality mainly in the first three days of life.

However, it appears that the type of shelter is important: Miller (1967) provided corrugated iron shelters, and lambs sheltered while it was raining, but those lambs that sheltered showed poorer liveweight gains. The ewes were seldom seen in the shelter and wind speed had no significant effect on the sheltering of ewes (but there was some sheltering when weather was warmer and sheep were seeking shade). Liveweight gain was not improved by shelter, and in one season the lambs could have formed weaker bonds with the dams which could have caused the poorer liveweight gains.

It is important to provide a type of shelter that does not reduce the bond of the ewe and lamb. Kilgour and de Langen (1980) suggested the success of the Romney Marsh easy-care ewes could be due to the extra agility of the ewes to reach the lambs (and also a larger size pelvis). Access and close contact with the lamb could possibly improve lamb survival in any flock as well as the easy-care sheep. Spread of tussocks uniformly over a block would appear to provide ideal shelter in this respect.

Farmers' comments suggest that cattle are not affected by cold as much as sheep and this observation is supported by Joyce (1968) who showed that cattle with a full coat were as well insulated as fully-fleeced sheep. Cattle are sometimes grazed on blocks that are exposed to the weather or on shady aspects or on blocks that are susceptible to snow, because they are less affected by cold than sheep. Hughes et al. (1971) suggested that calves can die in southerly storms shortly after birth on some exposed properties, although most runholders try to calve on sheltered blocks.

One main advantage of shelter from vegetation such as tussocks (or scrub) is that the shelter is spread over the whole block, whereas with a shelter belt sheep only use it if they are nearby. Trials run with shelter belts in South Australia found benefits of shelter on lamb mortality, but the ewes had to be shut in 10 m x 20 m yards in the lee of the hedges (Anon, 1976); the ewes did not actively seek shelter for the reasons mentioned previously. (Anon, 1976) also suggested planting phalaris belts (tall grass that grows sometimes to about 1 m high).

There has not been much work done on the value of tussocks for wind reduction. Cresswell and Thomson (1964) in a study of the reduction of wind speeds at different tussock densities found at nine inches above ground there was a reduction of wind speeds among "dense" tussocks to 42% of that at four feet (with 84% on bare ground). This reduction of wind speed of over half is the same as that usually recommended as suitable for a porous shelter belt, with the added advantage that tussocks are spread over the block and are available wherever the ewe would choose to graze.

The silver tussocks used for the pasture growth rates study of M. Covacevich were used subsequently by the author (M. Abrahamson) to measure wind speed reductions behind tussocks at the height of a resting lamb. Wind speeds at 12cm above ground in any position amongst the dense tussocks were reduced to 10% of that at 1.80m. above the ground. Wind speeds amongst medium and sparse tussocks depended on the proximity of the miniature anemometers to the base of the tussocks, with reductions to 10% directly behind the tussock. This reduction occurred at a range of wind speeds (measured up to about 6 m. per second). The shelter effect of a tussock depended on the size of the tussock, with the cross-sectional area of reduced wind speed behind the tussock about the same as the base and height of the tussock. Small tussocks that had been grazed hard did not appear to give enough shelter for a lamb. A noticeable reduction in wind was also observed for at least 50 cm beyond the base of the tussock in line with the wind direction. A series of measurements of wind profiles in different tussock densities showed that shelter effect within a group of tussocks appears to be a summation of the effects of individual tussocks. If individual tussocks were the same size at the base as a resting lamb then it appears that there would be sufficient shelter for new-born lambs in a sparse density of tussocks.

Pasture of different lengths were also included in the above trial. At 700 kg DM/ha (mostly green herbage), the wind speed reduction at 12 cm was about 66% of that at 1.80 m. Pasture of 1900 kg DM/ha, which included standing stalks of dead herbage, (53% dead in the dried herbage), reduced wind speed to about 22% of that at 1.80 m. In situations where tussocks have been lost, then there could be big increases in shelter for newborn lambs by lambing in a block where there is some pasture cover. The pasture cover (kg dry matter of herbage, kg DM/ha) was closely correlated with the shelter provided at 12cm above the ground. Pasture of 2200 kg DM/ha would

provide the same shelter as that obtained directly behind a tussock.

For the more technically oriented readers, the unpublished correlations are as follows:

A multiple regression with two variables, x = herbage (kg DM/ha), y = wind speed at 1.80m above ground, z = windspeed at 12cm above ground as % of that at 1.80m :

$$z = 95.43 - 0.04x - 0.60y, \quad r^2 = 0.92, \quad 8 \text{ levels of } x, \quad 19 \text{ sets of wind speed measurements above pasture (without tussocks present).}$$

The linear regression of z = windspeed at 12cm above ground as % of that at 1.80m , and x = herbage as above, was:

$$z = 92.91 - 0.04x, \quad r^2 = 0.91, \quad \text{for the same set of data as for the multiple regression.}$$

It is apparent that the herbage effect on wind speed at 12cm occurs at a wide range of wind speeds (1.5 m per sec. to 6 m per sec. for the above data) and the reduction in wind can be expected even at higher wind speeds; (6 m/sec. is about 13.4 mph). Also the effect is linear over the above range of pasture levels so that if more pasture is available at lambing, then more shelter is provided for the lamb.

Perhaps ewes lambing in a paddock of plenty is what nature really intended - lambs would have shelter from wind, be hidden from predators (in the wild), and the ewe would have plenty of feed at the most important time. Man may have interfered with the natural arrangements to suit himself, with consequent losses of young stock and lower lamb growth rates where pasture availability is low.

Two farmers interviewed commented that lambs rest among tussocks while the ewes feed; this is confirmation that tussocks are suitable shelter for lambs.

Three farmers thought other forms of shelter were effective; where rocks and gullies and natural shelter are available tussocks may not be needed so much for lambing shelter. Farmers often try to lamb in these sheltered blocks, and even if there are only a few blocks and limited subdivision they will save these blocks for lambing. Where blocks are large, sheep could presumably select sheltered areas, although it is doubtful from the previous discussion if the ewes would seek shelter unless they were recently shorn. It would seem tussocks or similar cover were still best for maintaining close proximity of lamb and ewe unless the natural shelter was

well spread out over the block.

Farmers considered any type of tussock was suitable shelter for sheep; one farmer thought silver tussock ideal but he had some patches of snow tussock that grew too dense for stock movements and were unsuitable for shelter. Another farmer also thought snow tussocks were too dense for sheep movements. As discussed in "Survival of tussocks" the considered ideal tussock density ranged between 5 and 20% of the ground area with the median that most farmers preferred around 10-15% of the ground area covered by tussock with a mean height of silver tussock about 0.4 - 0.5 m.

In conclusion tussocks appear to provide good shelter for sheep and lambs. If lamb deaths could be reduced from 30% down to 10% where there is a reasonable proportion of multiple births, then provision of tussocks for the lambing shelter alone would be well worthwhile. Ewes do not actively seek shelter unless recently shorn shelter should be ideally spread over the block. Lamb losses occur mostly in the three days after birth; tussock blocks should perhaps be saved specifically for lambing, provided that they are not too exposed. The study by the author (unpublished) on effectiveness of tussock and pasture shelter for new-born lambs found that tussocks need to the same size of the resting lamb to shelter the lamb completely. Hard grazed remnants of tussock did not give much shelter. Longer standing pasture, (1900 kg DM per ha), reduced windspeeds to 22% of that at 1.80 m above ground; 2200 kg DM per ha would expect to provide similar shelter as that obtained from tussocks for the newborn lamb.

10.4 Value of tussocks as a feed for animals

Tussocks (mostly short tussocks but sometimes tall tussocks) are regarded as a source of feed during winter by some farmers, either as a feed itself or for its value in saving feed during a snowfall. Eleven high country and six hill country farmers have said they think tussocks are useful to animals in the winter. The reasons were various: six farmers thought stock can get some feed around the tussock base on light snow; the snow melts at the base and the grasses become accessible; the tussock had protected these grasses from being eaten before, but when feed is short stock will clean up the remaining feed, even if it means having to eat some tussock with it. One farmer described how stock burrow down near the tussock and get some feed. The effect of tussocks in snow was described earlier (effect of tussocks on microclimate). Snow will sometimes clear three weeks earlier amongst tussocks than on bare ground. Where the snow has not melted and persists longer, tussocks may be the only feed standing above the snow, and can be some sort of feed where none other is available.

Ten farmers thought they obtained some feed from tussock itself in the winter, mostly silver tussock (Poa laevis) and blue tussock (Poa colensoi). Two Central Otago farmers appeared to rely on tussock for some maintenance feed in the winter and on one of these extensive farms there would be "nothing for the wethers to winter on if there was no tussock". One farmer on all grass wintering (mostly set stocked) relied on tussocks to keep access to feed during winter if there was a snowfall. Another farmer near Kaikoura relied on his clear tussock areas amongst bush blocks for the winter period from April to September and with two or three falls of snow per year plus limited access, the tussocks appeared important for early snow melt and some roughage feed. Four farmers on well developed hill farms (mostly set stocked) thought silver tussocks were useful in winter for cattle feed, although the cattle would have to be hard pressed before they would eat it.

McLeod (1951) described the effect of tussocks ... "sometimes snow lay on the ground for a long time and only the tussocky nature of grasses enabled sheep to get a picking at all... If there's any sort of vegetation underneath they'll bare a series of little tracks here and there leading to tussocks or scrub bushes which they have scratched clear; sometimes though, there is nothing, and they must stand day after day, watching the flats a

couple of thousand feet below where the ground maybe is quite clear." It is apparent that the tussocks (and other standing vegetation) are survival rations and are useful for feed if only because they are the only feed left standing; it is mainly because of their inherent lack of palatability that they have not previously been eaten.

Short tussocks were thought to provide a reserve of feed in a drought situation by eight farmers, although as with the winter reserve it was realised that the tussocks were mostly poor quality roughage. One hill country farmer thought that he lost only 10 cattle in a severe drought as he at least had some silver tussocks left, but a neighbour on a more intensive system lost 30 cattle. He regarded the difference in losses quite considerable and enough to make it worthwhile to keep the tussocks. Another hill country farmer with a reserve of undeveloped tussock was the only farmer in his district who did not have to destock during a drought. As well as the cost of destocking, problems of replacement of stock, with possible footrot problems, loss in price when selling stock on a depressed market and behavioural problems of bought-in sheep on hills were incentives to retain tussocks.

Most research work on feeding value of tussocks has been confined to the tall tussocks (see section 10.5). Feeding trials indicate the poor quality of tall tussocks. The recent work by Dryden and Archie (1980) showed that digestibility of dry matter of fescue tussock (Festuca n.z.) was only 37%, and even when supplements of sulphur, nitrogen, and other minerals were fed, sheep could only eat enough tussock for half maintenance.

The variety of tussocks can affect their acceptability to stock. Red tussocks (Chionochloa rubra) are not eaten readily by stock and are often cultivated out on the wet soils where they are common. However, where stock (mainly cattle) have been forced to eat down the red tussock and the tussock has become short, the more digestible regrowth will be more readily grazed. One high country farmer with dense red tussock on a wet slope found two cows died on it; they could not obtain enough feed to survive off quite a large area.

Silver tussock (Poa laevis) appears to be more acceptable to stock than red tussock, although one farmer found animals could die of starvation if left too long. Usually silver tussock is eaten only if there is a feed shortage, or a more controlled grazing is practised, with more subdivision.

One high country farmer found silver tussock was eaten readily by cattle when seed heads were present. Although farmers report that silver tussock is sometimes eaten, no farmers mentioned fescue tussock as a feed source although it is certainly grazed, as sometimes seen in a developing or developed situation. Quite often there can be a mixture of fescue and silver tussock on the same property, so the different types may not always be distinguished. Silver tussocks usually are more common on the more fertile soils and areas of higher moisture, while fescue is usually on the drier areas of usually less fertile soils.

Silver tussock usually appears greener than fescue tussock, and this could be one of the reasons why silver appears to be grazed more than fescue tussock. Although silver can appear to be mostly green, animals are still reluctant to graze it. The reason could be the high level of fibre in the silver tussock which can be seen by trying to twist or break off the leaves; this is almost impossible to do by hand (fescue tussock leaves are also difficult to break). Two farmers commented that sheep start to suffer if left on silver tussock too long. Sheep and cattle start to graze the tussock only when palatable feed is gone, and have already achieved high utilisation. One farmer found lambs ate silver tussock in a wet autumn even though there was plenty of fresh pasture available; he suggested the lambs required some fibre (for the same reason that hay is sometimes provided with low dry matter feed). This observation is similar to that of Barr (1981) who found that when animals eat the bark of trees they could be looking for some additional fibre because of the lush growth.

Blue tussock (Poa colensoi) has been variously described as a good feed for stock or unpalatable. Buchanan (1880) found close cropping of blue tussocks after burning, and good recovery after defoliation; only in Central Otago was the palatable form observed; usually blue tussock was in an ungrazed form, especially in poorer and higher altitude areas. Cockayne (1916) considered the feeding value of blue tussock was exaggerated, as he had seen very little evidence of grazing on these tussocks. Petrie (1912) considered blue tussock was a palatable species; the fresh young growth of blue tussock was mainly on the outside of the tufts and was eaten there.

Observation during this survey of blue tussock on some higher altitude unimproved areas of farms in Central Otago and Canterbury showed no signs of their being grazed by stock. Tussocks on these areas had much dead material present amongst the green tillers and had obviously not been eaten

off for many years. However, blue tussock that had either been eaten off (by rabbits) or burnt or was growing on improved areas, showed fresh green tillers and appeared quite different from the tussock in the former situation. Leaves of the fresh green tussock growth broke off easily and were very easy to pluck by hand, in contrast to the mature tillers in the unimproved and ungrazed state. Blue tussock was even observed to be grazed off in preference to fresh alsike clover on a Central Otago run. S.E. Allan (pers. comm.) found that at Tara Hills fresh growth of blue tussock had an even higher in vitro digestibility than white clover in his grazing trials.

Once the growth of dead and mature tillers had been cleared away (e.g. by more intense grazing or fire) then the fresh green tillers were readily eaten. High rabbit populations in Central Otago ate off blue tussock in lower altitude areas in the 1950s and now where these tussocks still persist they provide some good quality feed. Rabbits were apparently more successful than sheep at selecting out green tillers from dead, because of the rabbits' smaller bite size. Sheep have no alternative but to take a mouthful of dead or mature tillers as well as fresh growth and hence are reluctant to graze down blue tussock unless dead or mature tillers are absent.

Short tussocks are useful for protecting feed in winter and as a standing reserve of poor quality roughage in snow and in drought. Research work on pen-fed sheep shows that fescue tussock is a poor quality feed. Red and silver tussocks are usually eaten only when no other feed is available, although the flowering stage of growth can make silver tussock more acceptable. Blue tussock does not appear to be eaten in the unimproved state, but once eaten or burnt off and especially in an improved situation, is readily grazed by stock.

10.5 Value of tall tussocks

Farmers comments and experience on tall tussocks were far outweighed by the considerable scientific research done on snow tussocks. The most common snow tussocks are Chionochloa flavescens or Chionochloa rigida while red tussock (Chionochloa rubra) is another common tall tussock. Tall tussock usually occupies only a part of most properties so their use for grazing by stock may not amount to much. Only where most of a property was covered in tall tussocks was there much discussion about their use and value. In some areas there had been recent discussions with authorities on policies concerning areas that can be susceptible to erosion.

On two farms in Central Otago where tall tussocks formed a substantial part of the farm the managers found tall tussocks were very difficult to control by grazing alone. Animals preferentially grazed small burnt-off patches. Mark (1969) describes how stock converge on burnt areas where tussocks are highly palatable and suggested that grazing in conjunction with fire was the main factor in deterioration of snow tussock grasslands.

O'Connor (1963) found with taller cutting heights there was more growth of snow tussocks; even a light grazing after burning could greatly increase the risk of soil erosion. He also suggested that any system that defoliates snow tussock during the active growing season at high altitudes must depend for justification on the development of a vegetative cover as an alternative to a snow tussock canopy. However, grazing alone would not cause snow tussocks to die as snow tussocks recovered after clipping with no death of tillers: both burning and hard grazing would be needed for tillers to die.

However, Mark (1965a) found repeated clipping killed off tillers of snow tussock and three years after the first clipping a large proportion of the tillers were dead, and the tussock eventually died. Mark suggested the narrow-leaved snow tussock (C. rigida) was ill-equipped to withstand severe grazing for any length of time.

Hughes (1969) stressed that if there is a risk of soil loss then it is best not to burn. The runholder has the dilemma of not being able to graze tall tussocks without burning. O'Connor and Powell (1963) found no general conclusions were possible: whether to burn or not depends on the speed that

ground would be covered by vegetation in relation to the likelihood of erosive agents - these factors vary with the site, weather, stocking and oversowing and topdressing practices. If no legume or fertilisers are applied after burning there is bare ground for 12 months (O'Connor and Lamrechtsen, 1964). O'Connor and Powell (1963) concluded snow tussocks were valuable in protecting the soil from raindrops, wind, insulation from frost and anchoring the soil from surface flow water.

Burning of snow tussock has not always been well timed and controlled. Mark (1965b) has suggested much of the deterioration of snow tussock grassland since European occupation has been due to a combination of fire and grazing. Connor (1965) has suggested there has been a reduction in extent of snow tussock grasslands and an upslope retreat of snow tussock common to all South Island valleys and basins.

One farmer had problems with snow tussock on shady aspects getting too long to be grazed (and this is also observed by farmers with large blocks on lower country, see section 6.1 - extensive grazing systems). Inadequate subdivision and/or lack of grazing pressure causes pasture on shady aspects to grow rank, necessitating a burn off every few years even on previously improved country. However it would seem most unlikely (and undesirable) that snow tussock areas would ever be fenced off enough to achieve a higher utilisation, and this problem of low utilisation of snow tussock areas will probably remain in the high country. Apart from the economics of it the increased stock density, trampling etc. would have disastrous consequences on the erosion susceptible soils.

Two farmers found that snow tussocks will grow too dense on the shady aspects and even make it difficult to move stock through, and several farmers have suggested the tall tussocks need to be burnt every so often. Mark (1969) has suggested if they are to be burnt, three years is not long enough between burning for the snow tussock to recover; five years should be a minimum period or the plant is weakened too much. The effect of snow tussocks on snow melting and microclimate and some opinions on whether snow tussocks should be burnt or not is discussed in the last section on the value of tussocks in erosion prevention, (section 10.7).

Large snow tussocks shade the ground and can prevent establishment of other species around their bases. Scott (1962) measured the amount of light in amongst snow tussocks (planted at spaces of 0.3, 0.6 and 1.2 m apart). Midway between snow tussocks at 0.3 m apart only 5% of light reached the

ground and at 0.6 m, 40% and at 1.2 m, 85%. On the sunny side of the tussocks (1.2 m apart) the light at 0.3 m from the tussock was 95%, while on the shady side, 65%.

Although the canopy of snow tussocks protects the soil, there is little opportunity for other species to grow as well. Under dense snow tussock O'Connor and Lambrechtsen (1964) found the best environment for clovers may be in the tussocks themselves! An area of dense snow tussock after a fire is certainly at risk from erosion unless some other species can be established there as well, as was suggested by O'Connor and Lambrechtsen (1964). Snow tussocks (unlike other tussocks) do not show a response to fertilisers, (O'Connor 1963), so that apparently topdressing snow tussock without other species present will not have much benefit unless other seed is sown as well.

MaCrae and O'Connor (1970) found that the snow tussocks Chionochloa rigida and C. flavescens when fed alone to sheep were not even a good quality roughage diet, with a digestibility of organic matter of 44.0 - 58.6%. Supplementation of the diet with lucerne increased the intake of tussock by 51%. Provision of higher quality feed with tall tussocks increases utilisation as MaCrae and O'Connor almost completely eliminated snow tussocks by oversowing clover and topdressing and grazing sheep in spring and summer. They suggested management of tall tussocks needed to take into account the slow regrowth of the tussock and the adverse effects of repeated defoliation and pointed out the need for carefully designed deferred grazing systems.

Snow tussocks may be valuable in collecting water where they are exposed to mists and rain that would normally blow over. Mark et al. (1980) buried drums under tussocks and the run-off from the bottom of the drums was the "water surplus" which was much greater from untreated snow tussock than from burnt or clipped ones. Where a snow tussock area is primarily important for its effect on water resources of a region and there may be gains from increased interceptions of mist, rain, then there may be advantages in keeping tall tussocks at a reasonable height. However, it should be stressed that increased water interception would only occur with large snow tussocks where extra precipitation is available to be collected. There is currently a debate on the value of tall tussocks for collecting additional precipitation as the amount of water in mists is not thought to be as much as previously assumed, (McSaveney and Whitehouse, 1988). In

addition McSaveney and Whitehouse pointed out that the Otago uplands used in the trials of Mark have low erosion rates because of low frequencies of heavy rains. They also present the observations of Richard Martin (pers. comm.) that burnt-over tussock areas showed no changes in flow characteristics from their previously unburnt state.

Tall tussocks are well adapted to the high country environment. Mark (1975) concludes that "the difference in species (of tall tussocks) in their optimum temperatures for growth, responses to high and low temperatures and adaption to increasing soil moisture stress reflect what is known of the species in their natural habitats. The tolerance of these actively growing plants to sub-freezing conditions and maintenance of a positive carbon balance under such conditions ranks with several Northern Hemisphere alpine species in ecophysiological adaptation to cold environments". Walter (1979) defines the snow tussock area at 750 m to 2000 m altitude and where there is snow for two to three months of the year they are replaced by a taller snow tussock of 1.5 to 2 m high. Connor (1964) found efforts to increase short tussocks (fescue) upslope of 1000 150 m have been disastrous; C. rigida does not increase either. Summer moisture shortage near the lower limits could be the possible limiting factor for presence of tall tussocks. The species of snow tussock present varies with only small changes in aspect and soils (Connor, 1965): Chionochloa flavescens favours coarse-textured soils and sunny aspects while C. rigida favours fine-textured soils and shady aspects. Only a small change in aspect can produce an abrupt change in the dominant snow tussock with small areas of C. flavescens interspersed amongst C. rigida.

This short review briefly touches on some of the large amount of work done on tall tussocks. Perhaps the most important value of tall tussocks not often expressed, is the intrinsic value of the tussock itself and the contribution it makes to visual impressions of alpine areas. The romantic attributes of slopes of waving golden tussocks have a priceless value to those who visit these areas, but unfortunately are not much use for grazing animals without constant modification. Their valuable role in filling an ecological niche not readily filled by other plants, their soil holding properties and ability to accumulate organic matter, places the snow tussock in a unique position in the high country. Control of snow tussocks by grazing or fire appears difficult to achieve and there is a very fine balance between success and failure.

10.6 Survival of tussocks - effect of burning and animals on tussocks (short and tall)

The timing of tussock burning can have quite a considerable effect on their survival. A Marlborough farmer found it was best to burn the short tussocks (when trying to rid his property of scrub amongst them) from the last week in July to the second week in August. At that time of year conditions are too wet to allow the burn to penetrate tussocks and damage them, but allows for the successful burn of rubbish and dead grass. He has managed to keep good control of small manuka, by burning off when the plants were small. If burning is left till later in the spring, there is too much green herbage, or if burnt later still in the summer, there is too much bare ground and not enough time for the ground to be covered by vegetation before it becomes too dry for seedlings. Bare ground exposes soil to wind erosion. Burning tussocks in the autumn can remove protective inter-tussock vegetation that would normally reduce frost-lift. Mark (1965b) found that burning tall tussocks in autumn caused a higher mortality of seedlings than burning in spring. In 1973 McCaskill (1973) reviewed burning and included guidelines of a 1920 Southern Pastoral Lands Commission and those of the Otago Catchment Board (Bain 1970).

Tussocks (and scrub such as matagouri) do not burn well after oversowing and topdressing when most of the roughage and dead litter which carries fire gets cleaned out. The difficulty of controlling matagouri and some other weeds can be quite a problem after improvement has been started, particularly since matagouri responds well to superphosphate. Several farmers have suggested they could control matagouri if burning policies allowed them to burn at times of the year when they could get a hotter fire, but they admit they would probably lose their tussocks at the same time. If matagouri or other woody plants are present, it would be better to plan ahead, burn off well before improvement and then control regrowth of the weeds by stocking at rates of 85 or more s.u./ha at some grazings.

Research work on burning tall tussocks suggests that burning once every five or six years would be satisfactory (see 10.5), provided there was sufficient cover to prevent soil erosion. However, repeated burning (without improvement) usually depletes the soil. O'Connor and Powell (1963) found no increase in minerals in the soil after burning tall tussocks and there was even a decrease in phosphorus, as ash may have been blown to another site. Burning off tussocks every few years to control accumulated

roughage is not good management. The extensive situation where there is limited managerial control apart from burning is discussed in the earlier chapter (section 6.1).

There is a range of opinions on the effect of stock on the survival of tussocks. If tussocks are eaten down too hard they will not persist. This would in general, apply to rosette plants as Klapp (1964) has suggested, when they are allowed to grow tall and then mowed down. The growth habit of tussock does not allow for intensive use. Farmer comments confirm this view: "big mobs of hoggets eat out tussocks"; "most of tussocks will go if stock units are increased"; "tussocks will go if heavily stocked"; "if farmed right would lose tussocks"; "over-wintering on tussocks caused them to go out" (when concentrates were fed on a tussock block). One farmer suggested if there were still some signs of a palatable species such as blue wheat grass (Agropyron scabrum) present amongst the tussocks that grazing pressure had not been too hard to cause tussocks to go out. One high country farmer on an average stocking rate of 4.5 sheep/ha thought there was no reason why short tussocks should fade out.

Whether tussocks persist or not in a rotational grazing situation will probably depend on how hard they are grazed, and the amount of feed left at the end of the grazing period. One farmer who intended to rotationally graze on three or four day shifts, thought he would retain his tussocks by removing sheep before the tussocks had been grazed too hard. It was often said by farmers that if stock had to eat tussocks (and other feed had gone) they would be losing weight anyway and needed to be shifted. Three farmers suggested tussocks would go out on heavy soils and one of these suggested that where there is a fertile soil there is a natural progression to better types of grasses, and tussocks may not be able to compete on the higher fertility soils.

Another situation that can cause short tussocks to go out is lack of grazing; five farmers found lack of grazing caused tussocks to disappear. One farmer set stocked ewes from October to April and was not losing the fescue tussocks, but an ungrazed area over the fence was fast losing tussocks, presumably with grass competition in the ungrazed situation. One farmer who had oversown and topdressed and was unable to control the growth of grasses because of two good seasons and inadequate stock numbers appeared to be losing his tussocks. Another grazed one block in the summer and another block over the fence in the winter. There were healthy tussocks on the summer-grazed block, but only remnants left on the winter-grazed

block. Presumably during the winter when feed was short the tussocks were grazed. One feature noted on some of the blocks where tussocks were sparse was the dense sward of browntop or sweet vernal (Anthoxanthum odoratum). One property in Marlborough where an area had been fenced off for 20 years as a tree reserve and had not been grazed had lost all of the short tussocks, but a grazed block over the fence still had a good tussock density. Over zealous conservationists should take note of these farmer experiences; where grazing is controlled in the improved state then it appears the short tussocks are more likely to survive than where there is complete exclusion of stock.

Relph (1957) has suggested that where there are exotic species present (e.g. sweet vernal, browntop) continuous grazing on short tussocks has no harmful effect on short tussocks. However where there are no exotic species present, it is best to remove all stock from short tussock areas. He found in the Castle Hill basin on lower altitude sunny areas browntop, sweet vernal covered two thirds of the inter-tussock spaces, but on the higher, colder more exposed areas, natives replaced the exotic species.

Farmers thought cattle ate down tussock more than sheep. Four farmers suggested cattle can graze out tussocks; two found cattle were useful in the winter to control silver tussock (Poa laevis) and eat accumulated roughage. One farmer tries not to graze down too hard with cattle as he wants to retain the tussock. If cattle are left on a tussock area too long and the inter-tussock vegetation has become too short to graze, the cattle are then forced to graze the tussocks. Sheep may still be able to obtain a maintenance diet on short pasture but cattle are able to maintain intakes only by grazing the tussocks. If the tussocks are to be retained, then grazing by cattle should be carefully monitored.

Oversowing and topdressing appears to cause tussocks to disappear. Seven farmers thought tussocks were disappearing on the oversown areas, with cattle eating them down more on two farms. One farmer thought oversowing and topdressing "made tussocks sweeter" and caused them to be grazed more, and another thought they were more "palatable". Of the eight farmers who were losing tussocks, one had a rotational grazing system and the rest were set stocked.

Subdivision can also have an effect on the survival of tussocks. One farmer had large blocks with sunny aspects not fenced off from shady, and

was able to show where he had lost tussocks from the favoured sunny areas where there had been apparent stock camps and a fertility transfer (from dung and urine). Sheep were able to select areas in the block and selectively graze these, building up fertility and also grazing off tussocks on these areas. An extreme example of this was seen on a property where the only fence erected for the last 10 -20 years were the outside boundary and two internal fences. On this farm there was an obvious fertility transfer with impoverished areas contrasting with bright green stock camps almost devoid of tussocks.

Tussocks have also gone out where there were signs of overstocking for extended periods. One property that appeared to be carrying too many stock units (mostly cattle), compared with the neighbour's, did not have much tussock left. However the neighbour had practised controlled grazing and with lower grazing pressures still had reasonable tussock cover. Another property that was obviously overstocked, with sheep losing condition over winter and poor stock performance, had been severely grazed during the winter.

Tussocks (both tall and short) are uneaten usually because of the low palatability, high fibre content and inability of stock to separate out green from dead tillers in diet selection. It is usually when stock are forced to graze the less acceptable feed that tussocks are lost. If stock are removed before this happens tussocks would be less likely to be lost. However, as discussed earlier, once the tussocks have been eaten down and the dead material removed they become a more acceptable feed and are in danger of being eaten out. Some factor, perhaps it is the availability of abundant green material present, and lack of variety causing selection of tussocks, or improved nutritive value after oversowing and topdressing, can cause tussocks to be eaten down along with the higher quality feed. Having been grazed down once, they are more likely to be grazed the next time.

O'Connor (1966), found that periodic hard grazing caused short tussocks to disappear, with more effect at higher fertilizer applications. Even at lax grazing, tussock densities were reduced from 24700 tussocks/ha to 18500/ha. However, he concluded that if tussocks were to be retained in some situations they can be saved by reducing grazing pressure, but at the expense of cyclic nitrogen flow and total energy level. It does appear from the evidence of O'Connor that tussocks would be difficult to retain under conditions of high pasture utilisation. In the grazing trials of

Allan (1985) at Tara Hills, efficient utilisation in the first three years of development caused roughage and tussocks to be eaten, and resulted in marked increases in feed quality under rotational grazing and higher stocking rates.

Occasionally silver tussock (Poa laevis) and red tussock (Chionochloa rubra) are considered as weeds: silver tussock responds well to reasonably fertile soils and fertiliser applications, particularly where there is an adequate rainfall. One high country farmer who previously had problems with silver tussock after oversowing and topdressing, is now able to control it by subdividing into 28 ha blocks. Another farmer with more subdivision was able to control red tussock. It generally survived hard grazing, although becoming more sparse. Another farmer suggested he did not have enough grazing pressure to control silver tussock in the periods when it was growing fast, as he had excess feed at that time of year in relation to his winter needs. O'Connor (1966) shows that periodic "lax grazing" at lower levels of fertiliser inputs can increase the density of tussocks (from 24700 to 32100/ha). Where tussock is becoming too dense then grazing pressure by cattle should be increased, subdivision increased or some form of rotational grazing practised to increase use of the lower quality feed. An initial burning may be useful in certain situations, but some of the areas where silver tussock is a problem would probably not burn very well as most of the silver tussock is too green, and would not carry a fire.

Fourteen of those farmers who wanted to keep tussocks were shown a set of photographs of a range of tussock densities and were asked what tussock density they would prefer. Two thought 20% cover of ground area by silver tussocks was too much (65000/tussocks/ha). Most of the farmers thought somewhere between 10-20% cover was suitable (about 30000-65000/ha). Three farmers thought 5% cover was not enough (20000/ha), although one farmer thought 5% would be enough. The use of a set of photographs of tussocks of known densities was a successful method of comparing densities on different properties. A similar method has been used in USA for bunchgrass densities, (Hyder and Sneva, 1960). Tussock base areas and heights were also measured.

Managers of more extensive farms (5 out of the 14) favoured 15-20% cover, while on more closely subdivided hill farms the managers (3) preferred 5-15%.

Summary

The best time to burn tussocks (where necessary for e.g. scrub control) was discussed. Increased grazing pressure grazes out tussocks although if stock are removed early enough tussocks will not be grazed too hard. Tussocks may go out also when they are not grazed enough, probably because of grass competition. Cattle can eat down tussocks more than sheep and oversowing and topdressing can cause stock to eat short tussocks more. Lack of grazing control can cause tussocks to be grazed out on stock camps, or where there has been a general level of overstocking (with loss of animal performance), tussocks may not persist. Periodic hard grazing (O'Connor, 1966) as well as oversowing and topdressing can reduce tussock densities while lax grazing can cause an increase in densities, which is possibly the reason why tussock density can become too high in some situations. It could be concluded from the previous observations that there should be a correct grazing pressure that would ensure survival of tussocks in an oversown pasture, although tussocks may not persist where there is also an abundant supply of green feed in an improved situation.

10.7 The effect of tussocks on soil erosion

Live tussocks (and standing litter) are thought to improve rain infiltration. One farmer suggested that even detached litter can "absorb a lot of water". However Hayward (1980), found that infiltration rates in alpine areas were seldom exceeded (even in extreme storms) with rainfall soaking into the ground and not forming runoff water. There is good infiltration in porous yellow brown earths. Vegetative cover only really controls soil loss and erosion, in storms and not surface runoff as soils are saturated then anyway (Gillies, 1978).

The ideal amount of litter or vegetative cover needed has been described by Brown and Johnston (1979) in U.S.A. where 2,200 kg/ha of straw retarded evaporation, reduced needle ice formation and allowed seedling emergence. They suggested a "rule of thumb" was to have the soil still slightly visible when viewed from above. Ellison (1960), also found litter encouraged rapid infiltration of heavy rain that would otherwise erode the soil. The litter needed in the Australian high country to obtain maximum infiltration was about 10 tonnes/ha in snow tussock (Anon, 1973). Gradwell (1960) suggested 50 mm of litter prevented needle ice formation in the high country.

However, some high country farmers in the survey suggested that there is a disadvantage in too much litter accumulation amongst tall tussocks. These observations are supported by Healy (1969) who suggested if too much dead litter accumulated there could be damage caused by a summer fire, (if a fire was accidentally started). Furthermore too much litter would prevent growth of other species around the base of the tussocks. Weaver and Rowland (1952) found in Nebraska that a heavy mulch prevented development of an understory in big blue stem grass, greatly delayed spring growth and thinned new grass to about one third of their usual number of stems.

The main effect of all tussocks on soil erosion (apart from the effect of litter itself) is thought to be in holding the soil and stopping it from being washed away. One hill country farmer showed how the neighbours property had several slips on moderately steep to very steep soils where cattle had eaten off the silver tussocks, whereas he himself had not had the same troubles on his tussock slopes. Another farmer thought the only value of tussock was to hold the soil (it was of no feed value to the stock); another thought that where there was no erosion risk it was better

to grow feed, but where there was an erosion risk tussocks (snow tussocks) were needed to improve infiltration and hold the soil.

One farmer in Marlborough suggested that large areas in the Marlborough Sounds were down to bare clay subsoil where scrub and natural vegetation had been removed and improved pastures sown. If tussocks had been sown the topsoils would have remained. However there does not appear to have been much research on the relative abilities of different types of vegetation to hold soil. Gradwell (1960) describes how short tussocks are left on residual pillars of soil, while around their bases only the B horizon is left (and eventually the tussocks themselves could be washed away). It has not been established how much better tussock is at holding soil compared with scrub or a good sward of grass. Tussocks are adapted to ecophysiological sites and could be more likely to persist than some of the introduced species.

In extreme conditions where soils can become saturated, slips may occur which no amount of vegetation can control. The plane in which the slip occurs may be well below the zone of root penetration of any vegetation; one farmer suggested that in his higher rainfall area he got more widespread slumps where there was still scrub, than where he had a good pasture. He found only small areas slumped under pasture, but where large areas were held together by scrub and bush roots, these had slumped. The understory in the bush had been removed by grazing, possibly contributing to the slumping. He thought the land was better in good pasture than having bush undergrazed by stock.

A Marlborough farmer described how the tussocks were valuable in holding the shingle line above the bush and preventing shingle washing down, which buries tree roots and kills the trees. He described how the rivers now ran clear even in a storm, since the removal of deer and pigs from the Upper Catchment, where previously they were discoloured, even without a flood. Wraight (1963) describes for the Wairau Catchment, how the slightly modified snowgrass sward is the best possible protection against rain-drop impact and the deep litter layer and deep organic topsoil has value in regulation of the stream flow. Gillies (1978) concluded that removal of snow tussock and conversion of tall tussock grasslands to productive grasslands, much above 1000 m, will have to await new pasture species as clover and lucerne are difficult to maintain.

A good tussock cover can improve water infiltration (although on high country soils infiltration may not be a problem. There was good water infiltration under silver tussock (Poa laevis) in the Snowy Mountains, Australia, with the advantage that these tussocks persisted as they are not heavily grazed by sheep and cattle (Anon, 1957). However, compared to sparse tussock in an unimproved situation, a more productive pasture would have reduced run-off and achieved better infiltration. Toebes et al. (1968) increased carrying capacity from 6.2 to 19.5 stock units/ha by oversowing and topdressing and obtained a reduced maximum run-off flow. Yates and Scarf (1969) found there was less infiltration on unimproved sparse tussock country yellow-brown earths than in more dense improved swards. Hard grazing of an improved small grass catchment improved the surface detention of rainfall by 100% compared with lax grazing. They suggested the unimproved pastures were more open at the base of the plants and had less retardance value than the denser improved swards. These denser swards provided a greater retardance to overland flow, with a consequent increase in time of infiltration opportunity. One high country farmer suggested "a good grass sward will hold water better than unimproved tussock, but if there was a downpour such as 75 mm in three hours then no cover will hold the soil".

A Marlborough farmer suggested that high country soil in its "virgin" state was very loose and showed good infiltration, but once cultivated, the soil packs down hard with poor infiltration. This would suggest that oversowing and topdressing is a more suitable method for improvement than cultivation on those soils where good infiltration is needed. In the discussion on cultivation or oversowing it was concluded that it was not advisable to cultivate some of the high country yellow brown earths because of wind-erosion tendencies.

Besides increasing rainfall infiltration rates and prevention of soil from being washed away, tussocks also affect needle ice formation in winter. Gradwell (1954) found that fescue tussock markedly reduced the diurnal range of soil temperatures at 25 mm soil depth, especially when undefoliated. The rosette-type plants insulated the soil and counteracted needle ice formation. The effect of tussocks on their local environment was discussed previously, and tussocks help establishment of inter-tussock species, thereby further stabilising the soil. The effect of needle ice formation is often seen in the winter in the high country: small pillars of dry powdery soil formed by needle ice formation are exposed to the forces

of erosion, such as wind and raindrops. Three farmers suggested one of the main areas where tussocks were essential was on those lighter soils (e.g. Acheron, Pukaki); often the main vegetation left on these soils over winter may be only fescue tussocks, and even these may be sparse due to the severe environment and the effect of past influences such as rabbits. Wind erosion can be severe in these areas, removing the fluffy soil prepared by frost and needle ice formation and exposing hard pavements between tussocks, making establishment of other plant cover difficult.

These wind erosion-prone soils should not be cultivated unless it was certain some vegetation other than tussock would persist. Another alternative would be to sow tussock seed. This was suggested by a Marlborough farmer as suitable for some of the areas now causing problems in Marlborough. However the success of this would depend on the success of seedling tussock species. Perhaps this suggestion could be looked at seriously. Other grasses are successfully sown, why not tussocks? If more tussocks could be established on some of these light high country soils then more success could be expected with the oversown species and some protection given to the soil in the winter when the other oversown species are not so evident.

Three farmers have suggested that snow tussocks should not be allowed to grow too large and that it would be better if other species could grow around the tussock base as well. The snow tussocks can grow very large and the long leaves sweep the soil constantly around their base, effectively preventing establishment of inter-tussock vegetation. These three farmers suggest the tussocks should be reduced in size, either by carefully controlled burning or by cattle grazing. However, the advantages and disadvantages of burning or not burning tall tussocks have been debated much in the past and will continue to be debated in the future. The following opinions show the current differing views.

Gillies (1978) has suggested that removal of snow tussocks will increase snow mobility, shorten melting time and generally decrease snow depth and since snow tussocks are in the areas important for water collection, these factors are important. However, a farmer thought that if tussocks were not so high and were grazed off by cattle the snow would drift over the tops of the shorter tussocks, collect in gullies several metres deep and it would take a longer time for the snow to melt compared with the situation where snow was spread evenly over the tussocks. The deep drifts would release

water slowly. No farmers however, have advocated the removal of tall tussocks where they are presently growing as they all realise in these environments tall tussocks play an essential role.

To summarise, tussocks (and litter) improve infiltration, prevent soil loss and erosion, reduce ice needle formation, frost lift and soil blow. Some farmers would rather have tall tussocks reduced in size because of fire danger and effect on inter-tussock species. Tussocks are useful in preventing encroachment of scree slopes on bush and provide a vegetative cover to the soil, are not readily eaten by animals and are well adapted to the often harsh environment in which they grow.

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Appendix 1

Level of subdivision of the South Island hill and high country properties visited during the survey in 1980 and 1981, and rainfall groups

Number groups	Total no. of blocks per property				No. of blocks less than 20 ha per property					
	0-10	10-20	20-30	>30	0-10	10-20	20-30	>30	total	
Provinces										
Canterbury		2	4	3	3	3	2	1	9	
hill	*wet									
	*moist	1	4	7	16	6	7	9	6	28
country	*dry									
Canterbury	wet		3	1		4			4	
high	moist		6	2	4	7	2	2	1	12
country	dry									
Otago	wet									
hill	moist		1			1			1	
country	dry		2	1	1	3		1	4	
Otago	wet	3	1	1		4	1		5	
high	moist	2	5	4	2	7	6		13	
country	dry		1	2		2	1		3	
Marlborough	wet			1				1	1	
hill	moist	1	2	2	4	3	3	2	1	9
country	dry									
Marlborough	wet									
high	moist		1	1		2			2	
country	dry									
Total no. of properties									91	

* Moisture classes are the same as those used by Kerr and LeFever (1982).
 wet = > 1000mm rainfall, moist = 560 - 1000mm, dry = < 500mm.

